Regulating financial markets: Costs and trade-offs
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This thesis studies the interactions between the institutional design of financial systems and the financial agents that regulatory institutions supervise. It explores the channels through which financial regulation affects financial agents’ lending, funding, and risk-taking decisions. By introducing regulatory and market penalties for non-compliance with minimum capital requirements, this thesis investigates the responses of bank capital ratios to changes in the regulatory minimum, as envisaged under the recently introduced Basel III framework. It then studies the role of tight regulations for the emergence and the expansion of the shadow banking sector. It shows that attempts to regulate traditional intermediaries more strictly increase the attractiveness of shadow activities, that are not subject to regulations. Finally, the thesis studies potential consequences of supranational financial regulations, such as the banking union in the European Union, in the presence of integrated financial markets. The main result is that although the supranational regulator eliminates cross-border spillovers from defaults of internationally-operating intermediaries, it also negatively affects their risk-taking incentives.

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Regulating Financial Markets: 
Costs and Trade-offs

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Chapter 1

Introduction

Economic literature has identified several channels through which the financial system should matter for economic growth and welfare. First, financial intermediation increases overall well-being by facilitating consumption smoothing (Diamond and Dybvig, 1983). Secondly, both theory and evidence suggest that more developed financial systems relax funding constraints faced by firms (Levine, 2005), thus allowing more of productive investments to be carried out.

At the same time, the financial intermediation process is subject to many frictions, that too affect the economy. In Bernanke and Gertler (1989), Kiyotaki and Moore (1997) shocks to the net worth of financially-constrained agents affect their funding possibilities and the overall investment in the economy. Through their impact on leverage and prices, financial frictions work as an amplification mechanism: Small shocks can have large macroeconomic impact. Empirically, Reinhart and Rogoff (2009) show that financial crises are associated with longer recovery times and larger losses in the GDP than other types of crises.

Reliance on external funding and maturity transformation - key features of financial intermediation - result in moral hazard and information frictions. Leveraged intermediaries have incentives to take on excessive risk (Holmstrom and Tirole, 1997), while the difference between the liquidity of banks’ assets and liabilities makes them sensitive to self-fulfilling runs (Diamond and Dybvig, 1983).

The literature that emerged after the 2007-2009 financial crisis has also stressed the role of financial innovation in generating systemic risks. By enabling diversification of idiosyncratic risks within the financial system, securitization has made it less robust to aggregate shocks (Gennaioli, Shleifer, and Vishny, 2013). Intermediaries’ holdings of correlated assets amplify downward price spirals and deleveraging processes initiated by falling asset valuations when a crisis occurs (Diamond and Rajan, 2011). Cross-
border banking and interbank lending are sources of spillovers from individual defaults in highly integrated financial markets (Allen and Gale (2000), Freixas, Parigi, and Rochet (2000)). At the same time, some studies argue that more systemic risk is simply the price we have to pay for higher mean growth associated with financial integration and innovation (Ranciere, Tornell, and Westermann (2008), Moreira and Savov (2014)).

**Regulation of financial intermediation**

Regulatory interventions in financial systems have focused on correcting existing market inefficiencies. Minimum requirements on banks’ capital-to-assets ratios limit financial sector’s maximum leverage, and are believed to mitigate excessive risk-taking by financial agents. Deposit insurance has succeeded in eliminating panic-based bank runs, while governmental support to troubled financial institutions is normally justified by high social costs of financial intermediaries’ defaults (Dewatripont and Freixas, 2011).

Financial regulation often has unwanted consequences. First, attempts to control more closely, and to regulate more strictly can increase relative attractiveness of new forms of economic activity, not subject to the existing rules. It has been argued that high costs of compliance with regulations increased the attractiveness of shadow banking activities to traditional intermediaries prior to the 2007-2009 crisis (Gorton and Metrick, 2010). The design of the Basel system of capital requirements, where capital charges for different asset classes depend on risk weights imposed by the regulator, is believed to negatively distort banks’ investment decisions (Acharya, Schnabl, and Suarez, 2013). It has been shown that capital requirements under the Basel framework are also pro-cyclical, and thus magnify business cycle fluctuations (Bec and Gollier, 2009).

Another example is the impact of governmental support to the financial system - expected in the case of a crisis - on ex ante incentives of financial agents. It has been argued that a high probability of a regulatory bailout can induce banks to take on more risk. In order to increase the likelihood of being rescued, banks might also strategically coordinate on investments in correlated assets (Acharya and Yorulmazer, 2008). Regulatory protection might negatively affect incentives of financial intermediaries’ clients as well. For example, deposit insurance - while eliminating bank runs - reduces the market-disciplining role of bank debt: Insured creditors do not have a reason to monitor bank’s risk profile.
Financial regulation: Research areas

Despite potential drawbacks, regulation is often preferred to the absence of any supervision. This is especially the case in the financial sector - with its vulnerability to information asymmetries, moral hazard problems, and systemic risk build-up. Also, financial regulation should be seen not as a static, but rather as a dynamic process: Financial innovation, which translates into newer and newer forms of financial activities, seems to make the regulation of financial markets a constant “catching-up” process.

The above considerations make a thorough academic analysis of the interactions between financial institutions and the agents they regulate even more important. The ultimate goal of this thesis is thus to provide insight into the mechanisms through which regulations affect market outcomes, and into the issues that need to be considered when designing new financial regulations. It is our belief that only rules created with the full understanding of the economic interest they control and the economic incentives they stimulate, can make the financial system more transparent and safe.

In the next three chapters we study three different areas of financial regulation: (i) risk-based capital requirements, which are the foundation of modern banking regulations, (ii) the emergence of shadow banking as a response to financial regulations, and (iii) regulation of global, systemically important financial intermediaries.

Risk-based capital requirements. It is now widely accepted that risk-based capital requirements are pro-cyclical (Bec and Gollier, 2009), and thus amplify business cycle fluctuations (Heid, 2007). Following the 2007-2009 crisis, a major overhaul of the system of capital requirements, among other reforms, has been agreed upon and is being currently implemented. In general, capital requirements under Basel III increase, as reflected in the higher base requirement, and in the introduction of a new conservation buffer. Moreover, a first step has been made to create a less pro-cyclical regulatory framework, through the introduction of a countercyclical buffer.

We investigate the proposed regulatory reforms from the perspective of their impact on banks’ actual holdings of common equity. We take the view that regulations have impact on market outcomes not only because they impose constraints on financial agents’ choices of bank capital ratios, but also because of the fear of breaching the rules ex post. In Chapter 2 failing to meet the minimum capital requirement is a negative signal about bank’s financial health, which can be counteracted by costly recapitalization. This gives banks incentives to hold capital in excess of the regulatory minimum ex ante. We show that the existence of those positive capital buffers should be taken into account when, designing, as well as evaluating the impact of new bank
capital regulations.

**Shadow banking and regulatory arbitrage.** The way shadow banking activities were organized prior to the 2007-2009 financial crisis, i.e. through off-balance entities legally independent from the sponsoring institutions, suggests that regulatory arbitrage was an important motive for shadow banking. By moving part of the activities off their balance sheets, financial intermediaries could carry out financial intermediation without having to comply with costly capital and other regulatory requirements (Gorton and Metrick, 2012). Empirically, Acharya and Schnabl (2010) show that in Spain and Portugal - two European countries where capital charges for off-balance exposures were the same as for on-balance items - shadow banking conduits intermediating asset-backed commercial paper were practically non-existent. At the same time, Acharya, Schnabl, and Suarez (2013) argue that most of the credit risk from securitized assets stayed with sponsoring banks.

Regulatory arbitrage is one example of how regulations which solve one market imperfection, can lead to new inefficiencies. We take a closer look at potential economy-wide consequences of regulatory arbitrage, while focusing on the case of shadow banking. In our model in Chapter 3 traditional banks take advantage of regulatory arbitrage and sponsor unregulated off-balance shadow banks, which have an indirect access to governmental protection via a system of guarantees from their sponsors. This distorts banks’ lending decisions and increases costs of regulatory interventions. Our policy recommendations are in line with other recent papers on shadow banking (Harris, Opp, and Opp (2014) and Plantin (2014)) that call for taking into account the regulatory arbitrage possibilities when deciding on minimum capital requirements for regulated financial intermediaries.

**Integrated financial systems.** The recent financial crisis emphasized the importance of coordination of regulatory actions in the presence of highly integrated, global financial markets. For example, the Dexia and Fortis bailouts showed that divergent objectives of national regulators might prolong the resolution process, leading to potentially large efficiency losses. In the Eurozone experiences of regulators during the 2007-2009 crisis resulted in the creation of the banking union, comprising the single resolution and single supervisory mechanisms.

At the same time economic literature has identified several frictions related to regulatory interventions in financial markets. Acharya and Yorulmazer (2007), Farhi and Tirole (2012) argue that banks coordinate on risk and network choices to benefit from larger government guarantees, generating a “too many to fail” problem. In Acharya
(2003) national regulators have incentives to impose less strict bailout policies, in an attempt to make domestic financial intermediaries more competitive on the global market. The role of regulatory cooperation in preventing systemic crises is stressed also by Freixas, Parigi, and Rochet (2000). The literature also recognizes the problem of weak commitment of regulators to liquidating defaulting banks (Mailath and Mester (1994), Freixas (1999), Perotti and Suarez (2002)). We extend this analysis to discuss weak commitment problems for a supranational regulator in Chapter 4 of this thesis.

**Thesis outline**

This thesis is organized as follows. The second Chapter is devoted to the study of bank capital dynamics. Most economic studies assume that a minimum requirement has an effect on banks’ capital decisions only if it binds, i.e. when economic capital preferred by banks in the absence of regulations is below the regulatory threshold. In such case it is usually assumed that banks set their common equity at the level exactly equal to the required minimum ratio. At the same time, however, it is a strong stylized fact that banks hold capital levels in excess of the regulatory minima. Together with prof. Sweder van Wijnbergen, we attempt to fill this gap by introducing regulatory and “market” penalties for not meeting risk-based capital requirements in a partial equilibrium model of financial intermediation. The model yields excess capital that is always positive and increases during times of distress in the economy, which is in line with empirical evidence. We also show that in the presence of ex post violation penalties the conservation buffer under Basel III will not contribute to lowering the procyclicality of capital regulations. The countercyclical buffer proposed under Basel III is then even more desirable as it significantly attenuates fluctuations of actual capital also when the penalties are accounted for.

In Chapter 3 I study regulatory arbitrage and its implications for links between traditional and shadow banks. In the model financial institutions can sell their assets to outside investors for a fee, thus engaging in shadow banking. In order to increase their fee income and the demand for off-balance intermediation, financial institutions offer implicit guarantees to the shadow banking sector. Through deposit insurance the guarantees effectively provide recourse to the regulatory safety net enjoyed by traditional banks. In the model, when the demand for financial assets is high, financial intermediaries expand their own bank investments to increase the value of guarantees and to boost the off-balance intermediation. The traditional banking and the shadow banking sectors both expand, bank defaults are more frequent, and costs of deposit insurance are higher than in the absence of guarantees to the shadow banking sector.
The model offers important policy recommendations. I find that for high social costs of interventions, the welfare-maximizing capital requirement lies below the level optimal in the absence of links between traditional and shadow banks.

The design of regulations in the presence of cross-border interbank linkages is the topic of Chapter 4. Together with Marius A. Zoican, we construct a two-country model of financial intermediation, where banks are subject to moral hazard. In the model, international regulatory coordination limits cross-border bank default contagion, eliminating inefficient liquidations. For particularly low short-term returns, it also stimulates interbank flows. Both effects improve welfare relative to the case with national regulation. An undesirable effect arises for moderate moral hazard, since the supranational regulation encourages risk taking by systemic institutions. If banks hold opaque assets, the net welfare effect of a joint regulation can be negative. A natural interpretation of the supranational regulator in the model is the Banking Union and the Single Resolution Mechanism in the Eurozone. Regarding contributions to the Single Resolution Fund, the model suggests that countries with net creditor financial systems should contribute most to the joint resolution fund, as they are the main beneficiaries of eliminating cross-border spillovers.

Finally, main findings of the thesis are summarized in Chapter 5.
Chapter 2

Capital requirements and bank capital

2.1 Introduction

The 2007-2009 financial crisis showed that the existing system of capital requirements was not sufficient to keep banks from increased risk-taking, and to protect banks from default. The loss absorption capacity of the financial system was widely considered to be too low when the crisis hit. In addition, capital regulations may have even contributed to the severity of the crisis itself: It is widely accepted that risk-based capital requirements are pro-cyclical (Bec and Gollier, 2009), and thus amplify business cycle fluctuations (Blum and Hellwig (1995), Kashyap and Stein (2004), Heid (2007)).

In the light of above considerations a major overhaul of the system of capital requirements, among other reforms, has been agreed upon and is being currently implemented. In general, capital requirements under Basel III increase, as reflected in the higher base requirement, and introduction of a new conservation buffer. Moreover, a first step has been made to create a less pro-cyclical regulatory framework, through introduction of a counter-cyclical buffer. New regulations have also triggered a wide set of questions: Will tightening requirements turn out to be an impediment for economic growth in the long term? Will it delay recovery in the short term? Will it reduce or even eliminate pro-cyclicality of the system?

While answers to these questions require a general equilibrium framework, any general equilibrium effect will be preceded by changes in banks’ actual capital levels. In this chapter we focus entirely on this issue, i.e. we investigate the direct impact of minimum requirements on banks’ capital choices. We believe that a precise analysis of

This chapter is based on joint work with Sweder van Wijnbergen.
actual capital’s dynamics in the presence of capital regulations is a necessary first step towards further welfare analysis and policy implications. For example, if in equilibrium banks’ actual capital responds more than one-to-one to a raise in minimum requirements, the pro-cyclical character of capital regulations will be additionally magnified, which in turn should be taken into account when deciding on changes in regulatory capital ratios.

The literature does not devote much space to a detailed analysis of the relationship between regulatory capital and actual capital: So far it has been standard to assume that a minimum requirement has an effect on banks’ capital decisions only if it binds, i.e. when *economic* capital preferred by banks in the absence of regulations is below the regulatory threshold. In such case it is usually assumed that banks set their common equity at the level exactly equal to the required minimum ratio (Elizalde and Repullo, 2007)\(^1\).

On the contrary, one of the stylized facts is that banks hold own capital in excess of the regulatory minimum. This in turn is explained by banks’ attempts to avoid costly consequences of not meeting capital requirements, such as increased funding costs, lowered ratings, regulatory penalties and compulsory recapitalizations (Lindquist (2004) confirms this hypothesis for Norwegian banks). Still, despite empirical evidence, most of the economic literature assumes zero excess capital buffers. Positive buffers, if introduced, are obtained via capital adjustment costs (Estrella, 2004), fixed ex post fines for not meeting capital requirements (Milne, 2002), or random audits by regulators (Milne and Whalley, 2001). However, while yielding positive excess capital levels, these solutions are mechanical and lack realism in resembling true regulatory procedures used when requirements are violated.

This study attempts to fill the above-mentioned gap in the analysis of capital regulations. We do it by introducing regulatory and “market” penalties for not meeting risk-based capital requirements in a partial equilibrium model of financial intermediation. The partial equilibrium set-up restrains us from the analysis of welfare implications of capital regulations, but we believe it is justified by our focus on the first-order effects of minimum requirements and ex post penalties, which is through their impact on actual capital held by banks. Crucially, our regulatory penalties are temporary and proportional to the size of the violation, which aims at representing properties of the penalties used in regulatory practice. We allow the bank to choose between deposits, subordinate debt, and common equity as funding sources. In order to avoid

\(^1\) Elizalde and Repullo (2007) do obtain positive excess capital for some parameter values, but this is achieved by imposing a severe closing rule on banks. Once the closing rule is relaxed, actual capital is always equal to the maximum of economic capital and regulatory capital).
corner solutions, we introduce a moral hazard friction as in Gertler and Karadi (2011). Introducing subordinate debt allows us to investigate substitution effects of increasing capital requirements, and to look at the impact of capital requirements on the market-disciplining role of risk-sensitive Tier 2 capital.

Our main results are twofold. First, incorporating temporary and proportional penalties for breaching the minimum capital requirement yields actual capital choices in line with those observed empirically. Crucially, bank capital buffers are always positive, and they are counter-cyclical, in line with empirical evidence.

Secondly, we investigate capital requirements currently in force. In our model the countercyclical buffer envisioned under Basel III significantly reduces the pro-cyclicality of capital requirements. Moreover, in the presence of ex post violation penalties the market disciplining role of Tier 2 capital is severely restricted. In fact, increasing the required level of the Tier-2-type of capital (as recently proposed by the European Commission) almost entirely eliminates its market disciplining role in our framework.

This chapter is organized as follows. Section 2.2 presents related literature. Section 2.3 discusses model primitives and the representative bank’s optimization problem. Section 2.4 contains numerical results, in Section 2.5 we calibrate the model to investigate Basel II and Basel III capital requirements, and the role of Tier 2 capital. Section 2.6 concludes.

2.2 Related literature

Several empirical studies confirm that banks keep capital ratios above the regulatory minima. Jokipii and Milne (2008) find that the average capital buffer (above the regulatory minimum) over the period 1997-2004 in a range of European countries varied from 1.46 percentage points in the UK to 9.18 percentage points in Slovakia. Using 1994-2002 data Peura and Keppo (2006) show that also US banks hold actual capital in excess of regulatory capital. Gorton and Rosen (1995), Estt (1997), Salas and Saurina (2002) document that capital buffers depends on a number of factors, such as size and demographic diversity of banks, portfolio risks, ownership structure, and access to capital markets. Ayuso, Perez, and Saurina (2004), Lindquist (2004), and Stolz and Wedow (2005) show that capital buffers of Spanish, Norwegian, and German banks respectively move counter-cyclically over the business cycle. Finally Wall and Peterson (1996) find that bank capital ratios in developed countries increased significantly after first regulatory guidelines were introduced in early 1980s, which implies that banks’ economic capital (i.e. chosen in the absence of any regulations) had lied below the new
There are several other authors that study bank capital dynamics, and attempt to explain observed bank capital buffers. Calem and Rob (1999) look at the impact of bank’s own capital level on the portfolio risk choice. In their model debt funding costs increase for the bank whenever the minimum capital requirement is breached. However, the implied capital buffers are zero for plausible parameter choices. In Elizalde and Repullo (2007) actual bank capital is above the regulatory requirement only when economic capital is higher than the requirement itself.


Our analysis is closest in spirit to the papers by Milne and Whalley (2001), Van den Heuvel (2006), and Peura and Keppo (2006), because of our focus on regulatory penalties as the key mechanism incentivising banks to hold capital buffers in excess of the regulatory minimum. However, we argue that the above papers lack realism in resembling the consequences of breaking capital regulations observed in practice. More precisely, regulatory measures used towards a bank in such case are temporary and aimed at restoring bank’s financial soundness, rather than worsening its condition by taking more capital from it (for example via fines), or shutting it down immediately.

We contribute also to the literature on existing regulatory frameworks. Kashyap and Stein (2004), among many others, point at the pro-cyclical character of current capital requirements, which leads to exacerbated business cycle fluctuations. Gordy (2003) asserts serious flaws in the calculation method of risk-sensitive Basel capital charges. He shows that, while capital charges under Basel framework are known to be portfolio-invariant, conditions necessary for the contribution of a given instrument to the overall Value at Risk to be portfolio-invariant are not satisfied in the real world.

Regarding the structure of capital requirements Barrell, Davis, Fic, and Karim (2011) argue that increasing Tier 2 capital at the expense of Tier 1 capital in banks’ liabilities could induce higher risk-taking. This happens as equity, due to its lower seniority in distress situations, is always a better disciplining tool than debt. Evidence
available from empirical investigation of Tier 2 capital seems to support this critique (Morgan and Stiroh (2005), Krishnan, Ritchken, and Thomson (2005), Francis and Osborne (2009)).

2.3 The Model

2.3.1 Model primitives

Agents in the economy. There are two types of active players in the model: A unit mass of risk-neutral bank shareholders, and a unit mass of risk-neutral investors. Banks serve as intermediaries between investors and firms, which carry out risky investment projects.

Investment opportunities. Banks serve as capital providers to firms. There is a unit mass of firms. Each period the representative firm can carry out a risky project of a unit size, which - if successful - pays a gross return $r$ at the end of the period. As firms do not have own capital, they pledge the whole project return to the banks. With probability $p_t$ the project defaults, in which case the bank is able to recover only a share $\lambda \in [0, 1)$ of the amount lent. Assuming that all banks choose to diversify their portfolios, the period $t$ return from a unit of a firm loans equals $r^b_t = (1 - p_t)r + p_t\lambda$. As long as $r^b_t > 1$ all projects are fully funded from bank loans. As in Elizalde and Repullo (2007) we assume that $p_t$ is a random variable with the distribution derived from the single risk factor model in Vasicek (2002), with mean $\bar{p}$, and with a correlation coefficient $\rho$. The Vasicek (2002) model is the theoretical setting used by the Basel Committee to derive capital charges under Basel II, and under Basel III.

Bank’s balance sheet. The bank finances its intermediation activity from three sources: Deposits $d_t$ that pay a gross interest rate $r^d_t$, subordinate debt $e_t$ that pays a gross interest rate $r^e_t$ conditional on the performance of bank’s assets, and common equity $k_t$. The balance sheet equality is given by

$$1 = k_t + e_t + d_t.$$ (2.1)

While deposits and subordinate debt are collected from investors, common equity is fully funded by bank shareholders. Deposits are fully insured$^2$ by the regulator, making

$^2$ In a richer model this could be motivated by preventing socially costly bank runs by a welfare-maximizing regulator.
the deposit rate $r^d_t$ risk-free. For simplicity we set the deposit rate at $r^d$, fixed over time. The bank defaults and stops operating forever in period $t$ if it is not able to repay depositors, who have priority in return payments:

\[(2.2) \quad r^b_t < r^d_d t.\]

Because of deposit insurance, depositors do not have incentives to control the portfolio risk taken by the bank, reflected in the amount of bank equity $k_t$. This is not the case for subordinate debt owners, whose payments are conditional on bank’s performance: The interest rate paid on subordinate debt $r^e_t$ increases in the probability of the bank’s default. As subordinate debt is always senior to common equity, in order to reduce $r^e_t$ the bank has to lower the default probability by increasing $k_t$.

**Subordinate debt and moral hazard.** The inability to repay bank depositors leads to the bank’s default, and implies a loss of the continuation value for bank shareholders. In the absence of additional mechanisms, each bank has thus incentives to choose a funding structure dominated by subordinate debt, and with a level of common equity that guarantees a sufficiently low cost of subordinate debt $r^e_t$. To avoid a corner solution in the bank’s liabilities structure, we introduce a moral hazard friction between bank shareholders and its creditors. In line with Gertler and Karadi (2011), each period bank’s owners are able to embezzle a fraction $\theta(e_t)$ of bank assets, with the fraction increasing in the amount of subordinate debt.

**Bank capital and capital requirements.** While depositors and subordinate debt owners are paid according to the promised interest rate schedule, shareholders are entitled to dividends that are left once bank creditors have been paid: $n_t = k'_t - k_{t+1}$ stands for bank’s dividends at the end of period $t$. It is the difference between bank capital at the end of period ($k'_t$), and at the beginning of the next period ($k_{t+1}$). The bank also faces a regulatory authority that puts a minimum capital requirement $k_{\text{reg}}$, such that $k_t \geq k_{\text{reg}}$. If bank’s common equity falls below the regulatory level at the end of the period, the intermediary is subject to a penalty. Finally, bank shareholders require an expected return on equity of $r^k$, with $r^k > r^d$ and $r^k > r^e_t$. In this simple way we capture the well-documented preference of financial intermediaries for external funding.

Restricting the size of risky investments, and thus the size of the bank’s balance sheet to 1 considerably simplifies the bank’s optimization problem that has to be solved numerically (Section 2.4): We can treat period $t$ bank’s capital choice as independent
2.3. The Model

from past decisions. It also allows us to avoid considerations of bank capital accumulation over time. The trade-off is that we cannot analyse the impact of capital regulations on the size of bank’s lending activity.

Regulatory penalties. Next to the minimum capital requirement, the regulator can impose a penalty for not meeting the regulatory minimum at the end of the period. Such penalty can be thought of as an attempt to minimize potential confidence losses and market panic caused by the breach of the regulatory requirement, which is usually perceived as a negative signal about bank’s financial health. In the model the penalty takes a form of forced recapitalization, with two alternative penalty specifications discussed in detail in Section 2.3.3.

Timeline. Events that take place in the model are summarized in Figure 2.1.

![Timeline](image)

Figure 2.1: Period t timeline

2.3.2 Bank’s optimization problem

Consider first the representative bank’s optimization problem in the absence of ex post penalties for breaching the minimum capital requirement. Each period, given interest rates \( r, r^d, r^f, r^k \) the bank chooses \( d_t, e_t, \) and \( k_t \) to maximize the current value \( V_t \) of its future dividends, defined as

\[
V_t = E_t \sum_{i=1}^{\infty} \left( \frac{1}{r^k} \right)^i \pi_{t+i} m_{t+i-1},
\]

In Gertler and Karadi (2011) each period a fraction of bankers leaves the market (with their total retained earnings) so that a situation where banks finance their whole lending activity from own funds, thereby bypassing market frictions, never occurs. Modelling the bank’s objective function in line with Gertler and Karadi (2011) would not qualitatively change our main results, while significantly increasing computational complexity.
where future dividends are discounted using bank shareholders’ expected rate of return \( r_k \). Term \( \pi_{t+i} \) represents the probability that the bank will continue to be active (i.e. will not default before) in period \( t+i \) and is equal

\[
\pi_{t+i} = \prod_{s=1}^{i} Pr \left( r^b_{t+i-s} > r^d_{t+i-s} \right).
\]

End-of-period bank capital is equal to the return on bank portfolio minus repayments to depositors \( r^d_d \), and subordinate debt holders \( e'_t \),

\[
(2.4) \quad k'_t = \max \{ r^b_t - e'_t - r^d_d, 0 \}.
\]

Whenever \( k'_t < k_t \) bank shareholders experience a loss. Bank is recapitalized (and thus dividends are negative) when \( k_{t+1} > k'_t \).

**Bank default and subordinate debt interest rate.** Given the realized fraction of defaulted projects \( p_t \) three scenarios are possible:

- **Case I:** \( r^b_t > r^d_d + r^s_e \).
  
  Both depositors and subordinate creditors are paid their gross interest rates (\( e'_t = r^s_e \)) and the bank continues operating in the next period. Shareholders can count on dividends if in addition \( k'_t > k_t \), while the exact size of dividends depends on amount of equity \( k_{t+1} \) shareholders want to invest in \( t+1 \).

- **Case II:** \( r^d_d < r^b_t < r^d_d + r^s_e \).
  
  Returns from loans to firms allow the bank to repay depositors, but are not sufficient to fully repay subordinate debt owners. In this case subordinate creditors receive the remaining part of returns given by

  \[
  e'_t = r^b_t - r^d_d.
  \]

  The common equity falls to zero: \( k'_t = 0 \), and the bank needs to be recapitalized next period.

- **Case III:** \( r^b_t < r^d_d \).
  
  The bank is not able to repay depositors in full. It is closed down by the regulator, and both shareholders and subordinate debt owners lose their capital. Summarizing
all three cases, payments to subordinate creditors are equal

\[
\epsilon^*_t = \begin{cases} 
\min\{r^b_t - r^d_t, r^e_t\} & \text{if no default} \\
0 & \text{if default}
\end{cases}
\]

where the interest rate on subordinate debt \( r^e_t \) satisfies the no-arbitrage condition between deposits and subordinate debt,

\[
E_t \left[ \min\{r^e_t, r^b_t - r^d_t\} \mid r^b_t > r^d_t \right] \times Pr \left( r^b_t > r^d_t \right) = r^d e_t.
\]

The interest rate on subordinate debt is always higher than the interest rate on deposits, as subordinate creditors require compensation for lower payments in the states where \( r^b_t \) is very low \((p_t \) is high). Using equation (2.6) \( r^e_t \) can be derived numerically for each pair of \( d_t \) and \( e_t \).

**Moral hazard and bank’s funding structure.** We introduce a moral hazard friction between bank shareholders and bank creditors, which leads to an endogenous funding structure. Following Gertler and Karadi (2011), we assume that each period bank shareholders are able to embezzle a fraction of its assets, \( \theta(e_t) \), that is increasing in the amount of subordinate debt. One possible justification is that by giving less discretion over payoffs, short-term deposits yield more control over the bank than subordinate debt does.

Capital holders correctly internalize the possibility of a fraud and in order to invest their funds with the bank they impose a leverage constraint on the bank such that

\[
V_t \geq \theta(e_t).
\]

Condition (2.7) says that creditors will only supply funds to the bank if bank owners have no incentive to embezzle bank’s assets: This happens when the bank’s continuation value in period \( t \) exceeds or equals the current value of assets that might be embezzled. We follow Gertler, Kiyotaki, and Queralto (2012) and impose a similar form of \( \theta(e_t) \):

\[
\theta(e_t) = \varepsilon e_t + \frac{\kappa}{2} e^2_t,
\]

which means that the embezzled fraction of assets is a convex function of the subordinate debt’s ratio over bank’s assets, with a minimum at \( e_t = 0 \) (no subordinate debt).

By imposing \( \frac{d\theta}{de_t} = \varepsilon + \kappa e_t > 0 \) the fraction of funds that can be diverted (and thus the
attractiveness of doing so) is increasing with the amount of subordinate debt chosen.

**Economic capital.** We define economic capital as the common equity ratio chosen by the bank in absence of the minimum capital requirement and penalties for breaching it. It is a function of the set of parameters: \( \{ \bar{p}, \lambda, \rho, r^d, r^k, r, \varepsilon, \kappa \}^4 \). In this case the bank’s optimization problem can be expressed as

\[
V_t = \max_{k_t, e_t \in [0,1]} -k_t + \frac{1}{r^k} E_t \left[ \max \left\{ r^b_t - r^d_t - e'_t, 0 \right\} + P_r (r^b_t > r^d_t) V_{t+1} \right],
\]

subject to

\[
V_t \geq \varepsilon e_t + \frac{\kappa}{2} e_t^2,
\]

\[
d_t = 1 - k_t - e_t,
\]

\[
E_t \left[ \min \left\{ r^e_t e_t, r^b_t - r^d_t \right\} \mid r^b_t > r^d_t \right] \times P_r (r^b_t > r^d_t) = r^d e_t.
\]

and where \( e'_t \) is defined as in equation (2.5). The bank’s current period value \( V_t \) consists of three parts: the common equity brought in at the beginning of period by bank shareholders (with a negative sign, as the bank’s objective is to maximize the difference between the end-of period and the beginning-of-period capital), the discounted expected value of end-of-period profits and the discounted expected continuation value \( V_{t+1} \).

**Actual capital.** We define as actual capital bank’s common equity ratio maximizing (2.9) subject to the incentive constraint (2.7), the balance sheet clearing condition, and the minimum capital requirement:

\[
k_t \geq k^{\text{reg}}.
\]

It can be easily shown that as long as \( r^k > r^d \) and \( r^k > r^e_t \) there will be only one reason for actual capital to exceed the regulatory minimum (\( k_t > k^{\text{reg}} \)) in the above set-up: When the *economic* capital ratio preferred by the bank in the absence of regulations exceeds the minimum requirement. In that case actual capital will be set at the level of economic capital. Without any additional mechanisms, if \( k^{\text{reg}} \) is higher than the economic capital ratio, the bank will always choose its actual capital to be equal to the regulatory minimum, implying zero excess capital, as in Elizalde and Repullo (2007).

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4 The capital chosen is also a function of \( r^e_t \), which in turn is a function of other parameters.
2.3.3 Regulatory penalties

In practice most banks hold capital ratios in excess of the minimum required by the regulator. Possible explanations include capital adjustment costs, negative market signalling related to equity issuance (Myers and Majluf, 1984), and regulatory penalties, which we focus on. In the presence of regulatory penalties additional capital lowers the probability of falling under the regulatory minimum, which banks have to satisfy on an ongoing basis.

Regulatory penalties seem to be widely applied in real world. For example, Basel II penalties include intensified monitoring of the bank, management control, restrictions on paying out dividends, and compulsory raising of additional capital (Basel Committee, 2006). These tools do not exist on paper only: The European Banking Authority has undertaken the above-mentioned measures 38 times in Spain and 35 times in Ireland in year 2010 alone. In September 2009 the Fed ordered the AmericanWest Bank to halt its dividend payments and to submit a plan to raise additional capital in response to bank’s Tier 1 capital falling to 3.3%.

We introduce regulatory penalties to the model in the form of compulsory recapitalization. In our model dividends can only be paid out when common equity at the end of the period exceeds the regulatory requirement, so introducing additional constraints on dividend payments as a regulatory penalty is not meaningful within our setting. Also, because we do not consider agency problems between shareholders and bank managers, temporary control over bank’s management has no impact within our framework neither. Finally, intensified bank monitoring can be viewed as imposing extra costs on the bank in our model, and is thus similar to an ex post penalty.

Crucially, the penalty is always temporary and proportional to the size of the minimum requirement violation. These features stay in opposition to the standard way of modelling regulatory penalties in the literature, i.e. via fixed ex post fines. While fines are a more severe penalty than compulsory recapitalization (and thus give stronger incentives to hold positive excess capital), it is difficult to imagine that in reality a regulator would punish a weakly capitalized bank by taking even more capital from it, hence worsening its financial stability and lending possibilities further. Of course, we recognize that raising extra common equity in a situation of financial distress can be very problematic for a bank too. However, recapitalization should increase bank’s fi-

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5 eba.europa.eu, federalreserve.gov.

6 Note that we do not analyse the means by which banks adjust their actual capital ratios: while such adjustments can take place by raising new capital, it is more plausible (and empirically confirmed: see e.g. Adrian and Shin (2010) that banks will choose a cheaper solution and simply reduce the size of lending in response to an increase in minimum capital requirements.
nancial soundness at least in long term. Below we present two alternative specifications of ex post penalties.

**Compulsory recapitalization.** In this set-up, when the ratio of common equity to total assets falls below the regulatory minimum at the end of current period, the minimum capital requirement for next period for the bank is increased to

\[(2.11) \quad k_t' < k_{\text{reg}} \Rightarrow k_{t+1} \geq k_{\text{reg}} + (k_{\text{reg}} - k_t'),\]

where the temporary increase in the minimum requirement is proportional to the size of the violation.

For the bank costs of compulsory recapitalization are proportional to the difference between the cost of common equity and the interest paid on bank debt, since a higher amount of common equity has to be held instead of cheaper deposits, or subordinate debt. In the presence of compulsory recapitalization the bank’s objective is

\[(2.12) \quad V_t = \max_{k_t, e_t \in [0, 1]} -k_t + \frac{1}{r^k}E_t \left[ \max \{r^b_t - r^d d_t - e_t', 0\} - REC_t + Pr(r^b_t > r^d d_t) V_{t+1} \right],\]

subject to the incentive constraint (2.7), the balance sheet clearing condition, the capital requirement (2.10). The additional term \(REC_t\) represents costs of breaching \(k_{\text{reg}}\) at the end of period \(t\), and is equal

\[(2.13) \quad REC_t = Pr(0 \leq k_t' < k_{\text{reg}}) \frac{1}{r^k}E_t \left[ (r^k - r^d)(k_{\text{reg}} - k_t') \mid 0 \leq k_t' \leq k_{\text{reg}} \right].\]

We measure the opportunity cost of additional capital as the difference between the cost of capital \(r^k\), and the deposit interest rate \(r^d\), as in expectations the cost of deposits and subordinate debt is the same. The discount factor \(\frac{1}{r^k}\) is used because the extra cost is incurred in the next period, \(t + 1\).

**Compulsory recapitalization with a “market” penalty.** As an alternative to the penalty (2.13) we consider

\[(2.14) \quad REC'_t = Pr(0 \leq k_t' < k_{\text{reg}}) \frac{1}{r^k} \left[ \sqrt{(r^k - r^d)(k_{\text{reg}} - k_t') \mid 0 \leq k_t' \leq k_{\text{reg}}} \right].\]

Using the squared root of the capital requirement violation implies a higher than one-to-one penalty.\(^7\) The penalty cost is also concave in the shortfall with respect to the

\(^7\) As all the violations are in terms of fractions, squaring them would lower the prescribed penalty significantly.
required capital ratio, i.e. the marginal penalty is decreasing in the size of violation.

We choose this specification as it is a simple way of modelling additional costs of violating capital requirements, for example related to the negative signal about the bank’s financial condition that such violations give to the market. It is also reasonable to expect that after passing the minimum threshold further falls in the capital ratio matter less and less, as they do not possess the same informational value anymore. Alternatively, we could simply multiply the penalty (2.13) by a factor larger than one, but the square root specification allows us to model decreasing marginal costs in the simplest way. The penalty (2.14) is also motivated by the recently expressed opinion of the World Savings Bank Institute on the proposal of a countercyclical buffer under Basel III: “We remain highly sceptical of the fact that banks would be allowed by the market (...) to actually use their buffer when the economic situation deteriorates. We recall the recent experience in the latest crisis when market expectations (...) forbid banks to reduce their capital base. On the contrary, they had to boost it immediately.” (World Savings Banks Institute, 2010).

2.4 Results

In the next two sections we calibrate model parameters to match regulatory settings of Basel II, and Basel III. We then investigate how actual, regulatory, and economic capital vary with changes in a variety of variables, both in the presence and in the absence of ex post regulatory penalties.

Regulatory capital. We model regulatory capital $k_{\text{reg}}$ to resemble Basel Committee’s provisions on Tier 1 capital. Thus, the minimum capital requirement should be risk-sensitive, and calculated for a given confidence level. Under Basel II the confidence level is set at $\alpha = 0.999$, meaning that a bank is expected to not be able to cover its losses and default at most once every thousand years. More precisely, if $p^*$ denotes the threshold fraction of the defaulting firms in the bank’s portfolio for which $Pr(p_t \leq p^*) = 0.999$, then $k_{\text{reg}}$ is set to satisfy $k_{\text{reg}} = \phi(1 - \lambda)p^*$. This is equivalent to setting $k_{\text{reg}} = \phi(1 - \lambda)F^{-1}(0.999)$, where $F(p_t)$ is the large homogeneous portfolio approximation of the loss rate distribution function derived in Vasicek (2002),\(^8\) and

\(^8\) As in our model realizations of $p_t$ are also drawn from the Vasicek (2002) distribution, we implicitly assume that the regulator’s model used to calculate minimum requirements correctly internalizes the true process governing the random variable $p_t$.\)
(2.15) \[ F(p_t) = \Phi \left( \frac{\sqrt{1 - \rho \Phi^{-1}(p_t) - \Phi^{-1}(\bar{p})}}{\sqrt{\rho}} \right). \]

In the above formula \( \rho \) is the systemic risk exposure, \( \bar{p} \) is the individual (unconditional) probability of a loan default and \( \Phi(\cdot) \) is the cdf of the standard normal distribution. The multiplier \( \phi \in [0, 1] \) captures the fraction (\( \phi = 0.5 \) for Basel II) of the total regulatory capital that has to be in the form of common equity. Term \( 1 - \lambda \) represents the size of losses that occur due to loan defaults.

**Numerical Approach.** Policy functions for capital and subordinate debt are continuous and compact-valued correspondences, so the dynamic programming problem given by equation (2.12) has a unique solution. To find that solution we use the Value Function Iteration method with a grid search over a constrained range of control variables. The numerical algorithm is elaborated upon in the Appendix.

**Calibration.** Under Basel rules banks are obliged to report their capital ratios at least every 3 months. Also, banks typically publish their financial statements on a monthly or quarterly basis. Therefore we calibrate our model parameters assuming that one period in the model captures 3-month time span.

In most cases annual values are reported in the literature: Whenever possible we decompose them into quarterly equivalents. For example, we obtain quarterly gross interest rates by applying a simple compounding interest rule. However, under Basel provisions capital requirements are calculated to cover one-year-ahead loan losses with a given probability. Therefore, when calculating \( k_{\text{reg}} \), we use Basel II formulas for corporate exposures of one-year maturity (and thus apply one year default probabilities). In the case of compulsory recapitalization the temporarily higher capital requirement is also assumed to bind for a period of one year.

Following Elizalde and Repullo (2007), the cost of common equity is set to 1.06 on annualized basis. It is the average cost of Tier 1 capital over the period 2002-2009 in six OECD countries obtained by King (2009). The gross interest rate on deposits is set to 1.01 annually (in real terms) and it is assumed to equal the risk-free rate. The average return on bank assets is set to match a 0.01 intermediation margin, as in Elizalde and Repullo (2007).

We set the steady state subordinate debt level \( \bar{e} \) to match - for the case of no capital requirements - the average Tier 2 capital ratio of 4% before Basel II regulations were introduced (Sironi, 2001). For more details on the calibration choices we refer to the
Appendix. A short summary of all calibration choices is given in Table 2.1.

Table 2.1: Key parameter values used in numerical calculations

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\bar{p})</td>
<td>0.02</td>
<td>Basel II for corporate exposures</td>
</tr>
<tr>
<td>(\alpha)</td>
<td>0.999</td>
<td>the Basel II reference level</td>
</tr>
<tr>
<td>(\lambda)</td>
<td>0.55</td>
<td>Basel II provisions for unsecured corporate exposures</td>
</tr>
<tr>
<td>(r)</td>
<td>1.0296</td>
<td>set to match a 0.01 margin over 1.01 annual risk-free interest rate</td>
</tr>
<tr>
<td>(\rho)</td>
<td>0.164</td>
<td>Basel II provisions for corporate and bank exposures</td>
</tr>
<tr>
<td>(\phi)</td>
<td>0.5</td>
<td>Basel II min. share of Tier 1 capital in the total capital requirement</td>
</tr>
<tr>
<td>(r^d)</td>
<td>1.01</td>
<td>gross interest on deposits equal to the risk-free rate (full insurance)</td>
</tr>
<tr>
<td>(r^k)</td>
<td>1.06</td>
<td>King (2009); Maccario et al. (2002)</td>
</tr>
<tr>
<td>(r^e)</td>
<td>varying</td>
<td>numerically solved for from the equation (2.6)</td>
</tr>
<tr>
<td>(\varepsilon)</td>
<td>(-53)</td>
<td>moral hazard function parameters calibrated to match (\bar{c} = 0.04) in absence of capital</td>
</tr>
<tr>
<td>(\kappa)</td>
<td>2809</td>
<td>requirements (Sironi, 2001)</td>
</tr>
</tbody>
</table>

2.4.1 Capital, risk and regulatory tightness

We begin with the effects of regulatory tightening. In the upper panel of Figure 2.2 we show responses of various capital concepts to varying \(\alpha\) (from 0.99 to 0.999), the confidence level used to calculate the minimum capital requirement. Of course, economic capital is not affected by changes in \(\alpha\) at all: It is a flat line at 0.5%, which is also the minimum value of common equity allowed in our grid.\(^9\)

\(^9\) Economic capital is chosen at a higher level once the unconditional portfolio default risk, \(\bar{p}\), representing the level of risk in the economy, increases. For example, for \(\bar{p} = 0.04\) the economic capital is set at 0.8%. However, we obtain rather low values of economic capital in general. This happens as subordinate debt, in the absence of any direct default costs, substitutes out common equity. In particular, because of our risk neutrality assumption, the spreads between subordinate debt return rates and the risk-free rate are an exact one-to-one mapping from the bank’s portfolio unconditional default probabilities. However, it is widely recognized in the literature that default risk alone cannot explain the empirically observed interest rate spreads (Huang and Huang, 2003), which are much higher than theoretical models on corporate defaultable bonds would suggest. As a result of the neutrality assumption, our subordinate debt interest rates are thus relatively modest, which explains the strict preference of bank shareholders towards subordinate debt over common equity in the model with no capital regulations.
Naturally, regulatory capital is affected: The solid line indicates that as $\alpha$ increases, the regulatory capital requirement goes up from 2.5% to almost double that level (4.4%). Finally, when there is no penalty for the capital requirement violation actual (i.e. constrained optimal) capital stays right at the regulatory minimum, since $k^{\text{reg}}$ is above the economic capital ratio over the entire range of $\alpha$ considered. This is in line
2.4. Results

with the standard view expressed in the literature: Capital is either at its economic level, or at the required ratio, whichever of the two is higher.

This is not the case anymore when a penalty for ex post requirement violation is introduced. Simply being forced to recapitalize up until a new higher level of $k^{\text{reg}}$ (penalty defined in equation (2.13)) already introduces a wedge between actual capital and required capital, which however is very small and hence almost invisible in the upper panel of Figure 2.2. The introduction of the stronger “recapitalization plus market reputation” penalty (equation (2.14)) leads to a substantial wedge. This brings the model substantially closer to the empirically observed behavior of bank capital, and has strong policy implications. In particular, the model implies that even when banks’ actual capital is already above the ratio required by the regulator, raising the requirement further will still have a significant impact on banks’ capital holdings. This is clearly of crucial importance for the analysis of macroeconomic consequences of tightening capital standards.

The bottom panel of Figure 2.2 shows that for higher unconditional portfolio default rates (here for $\bar{p} = 4\%$) the actual capital ratio is visibly higher than the regulatory requirement also under the less severe recapitalization penalty. The economic capital ratio is no longer chosen at the minimum level allowed by the grid, but it increases with $\bar{p}$.

Consider next the impact of changes in the default rate $\bar{p}$ (Figure 2.3), keeping $\alpha$ fixed. Higher $\bar{p}$ implies also an increase in risk: In the range of values considered here the variance $\bar{p}(1-\bar{p})$ is a rising function of $\bar{p}$. As expected, the economic capital ratio is very low for the lowest levels of risk (upper panel of Figure 2.3), but it rises more than eightfold as the default probability $\bar{p}$ goes up from 1% to 10%, with a commensurate rise in the variance $\bar{p}(1-\bar{p})$. As a result, regulatory capital again exceeds its economic counterpart for all levels of the unconditional default probability. Again, the model without ex post violation penalties sets actual capital at the regulatory requirement for all values of $\bar{p}$ considered.

Introducing ex post violation penalties changes the picture entirely. For very low levels of the default risk the actual capital ratio is constrained by the regulatory requirement, but for $\bar{p}$ above 2% banks choose capital ratios higher than required, even if there is no market penalty involved. For the penalty that includes a proxy for market reputation losses actual capital is chosen substantially above $k^{\text{reg}}$ for all values of the default probability considered, and increasingly so as $\bar{p}$ rises (bottom panel of Figure 2.3).
Most importantly, for both penalty specifications actual capital grows more than regulatory capital with the riskiness of the portfolio. In other words, excess capital held by banks is positively correlated with the level of the risk. This happens as the probability of violating the minimum capital requirement increases in $\bar{p}$: While $k^{\text{exg}}$ rises with $\bar{p}$, the expected bank returns do not increase. Naturally, a higher share
2.4. Results

of common equity in bank’s liabilities reduces return payments to bank’s creditors, and hence protects it from a potential requirement violation. Nevertheless, numerical results show that banks have to increase their actual capital by more than the rise in $k_{\text{reg}}$ to counteract the higher probability of violating the new, higher requirement.

This has an important implication: With ex post violation penalties risk-based capital regulations are even more pro-cyclical (in the sense of exacerbating business cycle fluctuations) than it would result from the changes in the level of $k_{\text{reg}}$ along the business cycle only.\textsuperscript{10} Macroeconomic implications of capital buffers moving countercyclically (up when the cycle goes down) are straightforward to see: An increase in banks’ excess capital levels is normally associated with shrinking lending to the private sector, which has further contractionary effects on the economy.\textsuperscript{11} Empirically, Ayuso, Perez, and Saurina (2004) show that capital buffers held by Spanish banks in years 1986-2000 were negatively correlated with the GDP growth rate. Stolz and Wedow (2005) confirm the result of countercyclical capital buffers for German banks over the period 1993-2003.

2.4.2 Responses to changes in other parameters

To assess the robustness of our results, we also check model responses to changes in other parameters. Changes in different capital concepts when varying the recoverable fraction of invested capita $\lambda$, the cost of equity $r^k$, and the return on bank assets, are presented in Figures 2.5-2.7 in the Appendix. The results of sensitivity checks are intuitive. For example, a higher recovery rate $\lambda$ lowers the value at risk, leading to a commensurate fall in expected losses. As a result all concepts of capital decline, as does the gap between them. The capital buffer held in the case with reputational penalty falls by almost a half compared to the $\lambda = 0$ case. A higher return on bank assets (measured by the intermediation margin - $\delta$ in Figure 2.6 - over the riskless rate) acts as a safety buffer, and leads to smaller excess capital choices. Finally, increasing the cost of common equity shifts bank preferences towards subordinate debt and deposits.

\textsuperscript{10} We reasonably assume that the level of risk and the default probability are negatively correlated with GDP over the cycle: See e.g. Altman, Brady, and Resti (2005).

\textsuperscript{11} Furfine (2001) shows that the introduction of Basel I regulations, while raising actual capital levels held by banks, played a significant role in the dramatic fall in commercial credit in the early 1990s.
CHAPTER 2. CAPITAL REQUIREMENTS AND BANK CAPITAL

2.5 Ex post penalties and Basel III reform

In this Section we extend the model and calibrate it to match Basel III regulations. We investigate the impact of proposed changes in capital requirements on actual bank capital ratios.

2.5.1 Basel III: What will change?

Under Basel III the amount of regulatory capital as a share of risk-weighted assets (RWA) will increase significantly. The structure of the regulatory capital will change too, as the required proportion of Tier 1 capital will go up significantly. First, banks will be obliged to hold a compulsory conservation buffer of 2.5% of RWA, that can be built up from Tier-1-type capital only. This implies that the total capital requirement will increase to 10.5% of RWA, and the Tier 1 capital requirement - to approximately 8.4% (after including additional increase in the share of Tier 1 capital in the base 8% requirement to 6 percentage points).

Basel III also introduces a counter-cyclical capital buffer of up to 2.5% of RWA. It is expected to be implemented by mandating increases in the equity-to-assets ratio (of Tier 1 capital only) during periods of excessive credit growth, and allowing drawing it down during periods of economic slack. In this way, the total capital requirement will reach 13% during expansions, but will fall gradually to 10.5% of RWA during recessions.

2.5.2 Model extension with business cycle

In order to assess the cyclicality of capital requirements, we need to introduce business cycle to the model from Section 2.3. We let the unconditional default probability $\bar{p}$ take on two values, corresponding to expansion and recession times. Formally, we allow for two possible states of the economy: $y_t \in \{0, 1\}$. $y_t = 0$ corresponds to a recession and $y_t = 1$ to an expansion period. The variable $y_t$ is assumed to follow a first-order Markov process, with the following transition probabilities matrix, based on estimates from a regime-switching model for US quarterly data (for period 1959Q1-2011Q2):

$$
\begin{bmatrix}
q_{00} & q_{01} \\
q_{10} & q_{11}
\end{bmatrix} = 
\begin{bmatrix}
0.38 & 0.62 \\
0.03 & 0.97
\end{bmatrix},
$$

12 Tier 1 consists of common equity, retained earnings and preferred stock, while Core Tier 1 consists of common equity and retained earnings only. Tier 2 includes “hybrid” debt/equity capital instruments, subordinated debt, undisclosed reserves, revaluation and general loan-loss reserves.
with \( q_{ij} \) denoting the probability of moving from state \( i \) to state \( j \) during one quarter. In our numerical exercise we set \( \bar{p}(0) = 0.03 \times 0.25 = 0.0075 \) and \( \bar{p}(1) = 0.01 \times 0.25 = 0.0025 \). We take those values from the “Commercial Banks in 1999” Special Report by the Federal Reserve Bank of Philadelphia.\(^{13}\) It follows that the minimum requirement \( k^{\text{reg}}_0 \) will now be different in the two states of the economy: We use \( k^{\text{reg}}_0 \) to denote the regulatory capital ratio corresponding to recessions, and \( k^{\text{reg}}_1 \) to denote the minimum requirement for expansion times. We calibrate the regulatory capital ratio according to the two versions of Basel Accords. First we apply the Vasicek (2002) model and calculate Basel II provisions as corresponding to the confidence level of \( \alpha = 0.999 \). We get \( k^{B2}_0 = 5.5\% \), and \( k^{B2}_1 = 2.7\% \), where the upper-script ”\( B2 \)” stands for Basel II. We then model the increase in the overall capital requirement under Basel III (the conservation buffer) as corresponding to a new, higher confidence level, \( \alpha^{\text{new}} = 0.9997 \).\(^{14}\) Under this specification we obtain \( k^{CB}_0 = 10.65\% \), and \( k^{CB}_1 = 5.5\% \), where the upper-script ”\( CB \)” stands for the conservation buffer. Finally, accounting for the conservation buffer and for the countercyclical buffer gives us \( k^{B3}_0 = 10.65\% \), and \( k^{B3}_1 = 5.5\% + 2.5\% = 8\% \), where the upper-script ”\( B3 \)” stands for Basel III.

Under the new specification the representative bank solves one of two Bellman equations, depending on the state of the economy at the beginning of the period \( (y_{t-1}) \). During the period the new state \( y_t \) is realized, with the transition probabilities conditional on \( y_{t-1} \). In this setting the interest rate expected on the bank’s portfolio \( r^b_t \) is calculated as the average of interest rates corresponding to two different states of the economy, weighted by their conditional probabilities. Finally, we assume that the minimum requirement binding for the bank in a given period is the one corresponding to the state of the economy at the beginning of the period. The exact derivations of the relevant Bellman equations are presented in the Appendix.

2.5.3 Results

Table 2.2 presents results for three alternative specifications of capital requirements: (A) Basel II regulations, (B) Basel III with the conservation buffer only, and (C) Basel III with the conservation and the counter-cyclical buffer. Case C represents Basel III completely as far is its impact on overall capital requirements is concerned. When

\(^{13}\) We again use the rule of thumb to derive quarterly default probabilities based on annual values taken from the data. Moreover, the values of annual unconditional default probabilities are in line with Repullo and Suarez (2013), who conduct a similar analysis of pro-cyclicality of the excess capital held by banks in a simple overlapping generation model. However, they do not consider the impact of regulatory penalties. See the Appendix for calibration details.

\(^{14}\) We derive \( \alpha^{\text{new}} \) as corresponding to a new higher minimum requirement of 8.4% under Vasicek (2002) model and assuming \( \bar{p} = 0.02 \).
modelling the violation penalty, we use equation (2.14), i.e. we include reputational aspects of requirements violation.

Table 2.2 reports the average value of end-of-period bank capital \( k'_t \), and the number of capital requirement violations based on 1 million draws of \( p_t \). For each draw, given the regulatory minimum requirement and the corresponding actual capital choice obtained numerically, the end-of-period common equity \( (k'_t) \) was calculated. Each of simulated observations was treated as independent, i.e. a single period of bank’s life was simulated one million times.

**Conservation buffer.** Consider first changes in actual capital fluctuations resulting from the introduction of the conservation buffer under Basel III (moving from case (A) to case (B) in Table 2.2). The variation of *actual* capital along the cycle decreases only slightly after the introduction of the conservation buffer, which means it has little effect on reducing pro-cyclicality of the system. Most importantly, the size of the decrease is considerably smaller once ex post violation penalties are accounted for. In the model with no penalty the capital variability falls by 10% (from 103.7% to 93.4%), compared to a fall of 3.5% (from 90.2% to 87%) in the model with a penalty.\(^{15}\) This happens as excess capital in the presence of the ex post violation penalty does not decrease when increasing \( \alpha \), while the marginal increase in the minimum capital requirement is always falling with \( \alpha \).

**Counter-cyclical buffer.** On the contrary, introduction of the countercyclical buffer significantly reduces bank capital fluctuations for both model specifications. The relative change in actual capital between expansion and recession falls from 87% to 37.2% when incorporating the violation penalty (and from 93.4% to 33.1% in the absence of violation penalties). While the fall is smaller in the presence of ex post penalties than in their absence, it is still considerable. Clearly, the counter-cyclical buffer is not high enough to eliminate actual capital fluctuations entirely, but it is smooths them significantly. This is one of the key results of our analysis, as - to our knowledge - so far no one has attempted to evaluate the impact of the counter-cyclical buffer on actual capital fluctuations. Our calculations show that a buffer as small as 2.5% of RWA reduces pro-cyclicality considerably.\(^{16}\)

\(^{15}\)Results for the model without the ex post violation penalty are given in Table 2.4 in the Appendix.

\(^{16}\)A separate issue is the feasibility of the countercyclical buffer in the presence of “reputational” costs of minimum requirement violation, see e.g. World Savings Banks Institute (2010).
2.5. *Ex post penalties and Basel III reform*

Table 2.2: Regulatory penalties and the counter-cyclical buffer

This table presents responses of actual bank capital, subordinate debt and deposit holdings, and number of minimum requirement violations under three regulatory regimes: Case (A) Basel II regulations, Case (B) Basel III with the conservation buffer only, and Case (C) Basel III with the conservation and the counter-cyclical buffer. Values of common equity, subordinate debt, deposits and retained earnings reported as % of assets.

<table>
<thead>
<tr>
<th></th>
<th>Case (A)</th>
<th>Case (B)</th>
<th>Case (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(k_0^{\text{reg}}/k_1^{\text{reg}})</td>
<td>5.5/2.7</td>
<td>10.65/5.5</td>
<td>10.65/8</td>
</tr>
<tr>
<td>Actual capital (k_0^{\text{act}}/k_1^{\text{act}})</td>
<td>7.8/4.1</td>
<td>12.9/6.9</td>
<td>12.9/9.4</td>
</tr>
<tr>
<td>Capital buffer ((k_0^{\text{act}} − k_0^{\text{reg}}))</td>
<td>2.3/1.4</td>
<td>2.25/1.4</td>
<td>2.25/1.4</td>
</tr>
<tr>
<td>(k_0^{\text{act}}) change between states</td>
<td>90.2%</td>
<td>87%</td>
<td>37.2%</td>
</tr>
<tr>
<td>Subordinate debt</td>
<td>3/3.96</td>
<td>3/3</td>
<td>3/3</td>
</tr>
<tr>
<td>Deposits</td>
<td>89.2/91.9</td>
<td>84.1/90.1</td>
<td>84.1/87.6</td>
</tr>
<tr>
<td>Violations per 1000 obs.</td>
<td>2.18</td>
<td>2.16</td>
<td>2.16</td>
</tr>
<tr>
<td>Mean end-of-period capital</td>
<td>4.53</td>
<td>7.44</td>
<td>9.84</td>
</tr>
<tr>
<td>Economic capital level</td>
<td>0.5/0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economic sub. debt level</td>
<td>4.03/4.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economic deposits level</td>
<td>95.5/95.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Finally, when ex post penalties are not incorporated, the representative bank does not comply with the regulatory requirement every 7 out of 100 quarters, but once they are in place, banks are out of compliance only in 2 out of 1000 quarters, a decline by a factor 35, bringing this measure more in line with observed frequencies.

2.5.4 Tier 2 capital and the “bail-in” proposal

Basel III provisions also lower the fraction of the regulatory minimum capital requirement that can be held in the form of Tier 2 capital. This is due to rising concerns over the macroprudential role of hybrid instruments like subordinate loans (see Section 2.2). Meanwhile, the European Commission’s “bail-in” procedure, where a failing institution would be forced to write down or convert to equity some of its liabilities before asking for public help, requires sufficient amount of bank liabilities not backed by assets or collateral, such as subordinate debt and senior liabilities. In particular, to assure that banks hold a sufficient amount of liabilities subject to a possible write-down, “bail-in” proposals require banks to hold at least 10% of total liabilities in these types of debt.
This boils down to introducing a new (and a much higher) Tier 2 capital requirement.\footnote{\textsuperscript{17}It also shows that regulators still have problems with unambiguous evaluation of the macroprudential properties of subordinate debt and similar hybrid instruments.}

We contribute to the discussion over the role of Tier 2 capital by investigating the “bail-in” proposal within our theoretical model, where the subordinate debt can be interpreted as Tier 2 capital. Subordinate debt plays a double role in our framework: it increases the moral hazard friction, but at the same time it is a potential market-disciplining tool via the interest rate $r_t$, which increases in the default risk. In this setting raising the minimum capital requirement - by increasing the actual capital ratio - should lower the uncertainty over payoffs to subordinate debt owners and hence lower the interest rate they demand for a given level of subordinate debt. In the analysis that follows we want to verify by how much the risk-sensitivity of the subordinate-debt interest rate would decrease after the introduction of the European Commission’s plans.

We start by plotting the subordinate debt interest rate $r_t$ corresponding to different levels of portfolio risk $\tilde{p}$, when subordinate debt is at $\tilde{d} = 4\%$, the level recommended by Basel II (Figure 2.4, upper panel). The interest rate responds the most to increasing portfolio risk when no ex post violation penalties are present. Introducing regulatory penalties significantly reduces - because of increased actual capital ratios - the responsiveness of $r_t$ to the level of risk. In fact, the line representing $r_t$ is almost entirely flat when “reputational” costs of non-compliance are also accounted for. We conclude that the higher level of common equity, the smaller the market disciplining role of subordinate debt. Thus, higher capital requirements under Basel III and the EU “bail-in” proposal seem to work at cross purposes, at least to some extent. In other words, if the suggested changes in Tier 1 capital requirements under Basel III would lead - as our analysis shows - to significant increases in actual capital ratios, this would also mean a significantly reduced market disciplining role of Tier 2 capital.

In the second part of our exercise we model the increase of the subordinate debt ratio to a new higher level, compatible with the European Commission’s proposal for “bail-in” debt, i.e. $\tilde{d}^{\text{new}} \simeq 10\%$. We present actual capital ratios before and after this change in Table 2.3.
2.5. Ex post penalties and Basel III reform

Figure 2.4: Subordinate debt interest rate $r_e$ for changing $\bar{p} \alpha = 0.999$

When the ratio $\bar{e}$ is increased, subordinate debt substitutes out common equity in the absence of capital regulations: The economic capital ratio is now at the lowest possible level (allowed by the grid) for all considered values of $\bar{p}$. On the contrary, introducing the minimum capital requirement motivates banks to hold actual capital ratios well above the economic capital ratio, just like in the case of the old, lower level of $\bar{e}$. This justifies higher capital requirements as a tool to prevent deterioration of the
quality of capital once the strong “bail-in” requirements are introduced. It also shows that in the presence of capital requirements banks’ use of subordinate debt following the “bail-in” proposal will be increased at the expense of deposit funding. In the presence of ex post violation penalties banks will be unwilling to reduce their capital buffers (held in excess of the regulatory minimum) to compensate for the increased subordinate debt level, which explains the drop in bank deposits.

**Table 2.3: Increasing steady state subordinate debt level: Impact on actual capital**

This table reports steady state actual capital levels corresponding to two equilibrium levels of subordinate debt: $\bar{e} \simeq 4\%$ and $\bar{e} \simeq 10\%$. Actual capital values are reported as % of assets.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>$\bar{p} = 0.01$</th>
<th>$\bar{p} = 0.02$</th>
<th>$\bar{p} = 0.04$</th>
<th>$\bar{p} = 0.1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{e} \simeq 4$</td>
<td>economic capital</td>
<td>0.5</td>
<td>0.5</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>actual capital: no penalty</td>
<td>2.71</td>
<td>4.28</td>
<td>6.61</td>
</tr>
<tr>
<td></td>
<td>actual capital: penalty</td>
<td>3.98</td>
<td>6.43</td>
<td>10.07</td>
</tr>
<tr>
<td>$\bar{e} \simeq 10$</td>
<td>economic capital</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>actual capital: no penalty</td>
<td>2.71</td>
<td>4.28</td>
<td>6.61</td>
</tr>
<tr>
<td></td>
<td>actual capital: penalty</td>
<td>3.98</td>
<td>6.43</td>
<td>10.07</td>
</tr>
</tbody>
</table>

Finally, under the higher subordinate debt level the interest rate $r_t^e$ almost does not respond to increasing portfolio risk anymore: The line representing subordinate debt interest rate for different levels of $\bar{p}$ is almost entirely flat. As a higher amount of subordinate debt implies a lower level of deposits (with actual capital falling only slightly and hence remaining on a relatively high level), the probability of a bank’s default decreases further, lowering the premium demanded by subordinate debt holders. Of course, increasing the share of subordinate debt in banks’ liabilities lowers the probability of a default and hence the need for government’s interventions (as now losses will be borne to a higher extent by capital owners). However, the above exercise shows that a too high level of subordinate debt reduces its market disciplining role further.

### 2.6 Conclusions and possible extensions

It is standard in the economic literature to assume that minimum capital requirements affect banks’ actual capital choices only when they bind. In this case banks always choose to hold actual capital equal to the minimum required, which implies zero capital buffers. However, it is a strong stylized fact that banks hold own capital in excess of the
regulatory minimum. In this study we explain the above-mentioned empirical evidence by pointing at the existence and implications of ex post regulatory and “market” penalties for not meeting capital requirements. In the presence of such anticipated penalties, banks choose actual capital higher than the regulatory requirement for all levels of the portfolio risk considered. Importantly, we show that capital buffers should be taken into account when evaluating alternative regulatory frameworks, as the same policies can lead to different outcomes (in terms of achieved actual capital ratios, the pro-cyclicality of the regulations) once such behavioral responses of banks are correctly accounted for. Key conclusions of our analysis can be outlined as follows:

**Positive excess capital.** Introducing regulatory penalties for not meeting capital requirements results in actual capital choices above the regulatory minima. Actual capital goes up more than the regulatory capital as the riskiness of the portfolio increases under all specifications of the non-compliance penalty. In other words, excess capital is positively correlated with the level of risk in the economy. Therefore, single-risk-curve capital regulation, such as Basel II, is even more pro-cyclical than one would expect from the pro-cyclicality of the requirement only.

**Significant impact of the counter-cyclical buffer.** Because of the positive correlation between excess capital and the level of risk in the economy in the presence of ex post violation penalties, raising the overall level of capital requirements does not reduce the pro-cyclical character of capital requirements. On the contrary, a counter-cyclical buffer, aimed at resembling a two-risk-curve capital requirements schedule and provisioned under Basel III, is highly desirable because it significantly reduces pro-cyclical fluctuations in actual capital. Our results suggest that even the limited 2.5% buffer will have considerable impact.

**Market-disciplining role of Tier-2 capital negatively affected by the level of common equity.** The Tier-2-types of capital, such as subordinate debt, are supposed to serve as a market disciplining tool, limiting risk taken by banks. However, in the presence of capital requirements and ex post violation penalties actual capital levels are much higher and the interest rate on subordinate debt is much less sensitive to changes in the level of risk than in the absence of such regulations. Thus, capital minima, together with ex post regulatory and “market” penalties for not meeting them, can actually negatively affect the adequacy of Tier 2 capital for macroprudential goals.

Our model is admittedly a very simplified description of regulatory practices and capital choices that banks make. A desirable extension of our model would be to endogenize the portfolio risk decision, and to distinguish between different channels through which banks adjust to capital requirement shifts, such as portfolio size reduction with a simultaneous increase in the portfolio risk, versus increasing the capital base and
reducing risk exposure. Similarly, it would be interesting to study different regulatory policies in case of requirements violation, and investigate their macroeconomic implications.
2.7 Appendix

2.7 A Single Risk Factor Model

The cumulative distribution function is given by

\[ F(p_t) = \Phi\left(\sqrt{1 - \rho}\Phi^{-1}(p_t) - \Phi^{-1}(\bar{p})\right), \]

and the corresponding density function is

\[ f(p_t) = \sqrt{\frac{1 - \rho}{\rho}}\exp\left\{-\frac{1}{2\rho}\left(\sqrt{1 - \rho}\Phi^{-1}(p_t) - \Phi^{-1}(\bar{p})\right)^2 + \frac{1}{2} \left(\Phi^{-1}(p_t)\right)^2\right\}, \]

where, according to Basel II provisions for corporate, sovereign and bank exposures, the correlation coefficient \( \rho \) is a function of \( \bar{p} \), and equal

\[ \rho(\bar{p}) = 0.24 - 0.12\frac{1 - e^{50\bar{p}}}{1 - e^{50}}. \]

The above formulas follow from Vasicek (2002) as the limit solution for a portfolio loss rate distribution with the size of portfolio: \( N \to \infty \). \( \Phi \) denotes the cumulative standard normal distribution. We deviate from the Vasicek model by assuming that the correlation coefficient, \( \rho \), is independent of \( \bar{p} \) and fixed.

2.7 B Value Function Iteration Algorithm

**Analytical expressions.** The Bellman equation (2.9) can be simplified to

\[ V_t = \max_{k_t, e_t \in [0, 1]} -k_t + \frac{1}{r_t} \left( (r - r^d d_t - r^r e_t)F(\hat{p}_t) - (r - \lambda) \int_{\hat{p}_t}^{\tilde{p}_t} p_t f(p_t) dp_t + F(\tilde{p}_t)V_{t+1} \right), \]

where \( \hat{p}_t = \frac{r - r^d d_t - r^r e_t}{r - \lambda} \) and \( \tilde{p}_t = \frac{r - r^d d_t}{r - \lambda} \). The subordinate debt interest rate equation (2.6) simplifies to

\[ r^d e_t = r^r e_t F(\hat{p}_t) + \left( (r - r^d d_t)(F(\tilde{p}_t) - F(\hat{p}_t)) - (r - \lambda) \int_{\hat{p}_t}^{\tilde{p}_t} p_t f(p_t) dp_t. \]

**Case with the violation penalty: Forced recapitalization.** If the additional penalty for not meeting capital requirements is introduced to the model, the Bellman
equation (2.12) extends to

\[ V_t = \max_{k_t, e_t \in [0, 1]} -k_t + \frac{1}{r^k} \left[ (r - r^d d_t - r^e_i e_t - F(\hat{p}_t)) - (r - \lambda) \sum_{j=0,1} q_{ij} \int_{0}^{\hat{p}_t} p_t f_j(p_t) dp_t + F(\hat{p}_t)V_{t+1} \right. \]

\[ \left. - \frac{r^k - r^d}{r^k} \left( k^{reg} - (r - r^d d_t - r^e_i e_t) \right) \left( \hat{F}_i(\hat{p}_t) - \hat{F}_i(p_t^*) + (r - \lambda) \sum_{j=0,1} q_{ij} \int_{p_t^*}^{\hat{p}_t} p_t f_j(p_t) dp_t \right) \right], \]

subject to the incentive constraint (2.7), the balance sheet clearing condition, the capital constraint (2.10), and where \( p_t^* = \frac{r - r^d d_t - r^e_i e_t - k^{reg}}{r - \lambda} \). The Bellman equation for the alternative penalty specification (2.14) can be derived in an analogous way.

**Two-state economy case.** After distinguishing between recession and expansion times, the Bellman equation (2.12) for state \( y_i, i \in \{0, 1\} \) changes to

\[ V_t = \max_{k_t, e_t \in [0, 1]} -k_t + \frac{1}{r^k} \left[ (r - r^d d_t - r^e_i e_t - e_t) \hat{F}_i(\hat{p}_t) - (r - \lambda) \sum_{j=0,1} q_{ij} \int_{0}^{\hat{p}_t} p_t f_j(p_t) dp_t + \hat{F}_i(\hat{p}_t)V_{t+1} \right. \]

\[ \left. - \frac{r^k - r^d}{r^k} \left( k^{reg} - (r - r^d d_t - r^e_i e_t - e_t) \right) \left( \hat{F}_i(\hat{p}_t) - \hat{F}_i(p_t^*) + (r - \lambda) \sum_{j=0,1} q_{ij} \int_{p_t^*}^{\hat{p}_t} p_t f_j(p_t) dp_t \right) \right], \]

where \( \hat{F}_i(p_t) = \sum_{j=0,1} q_{ij} F(\hat{p}_j) \), and

\[ f_j(p_t) = \sqrt{1 - \rho} \exp \left\{ -\frac{1}{2\rho} \left( \sqrt{1 - \rho} \Phi^{-1}(p_t) - \Phi^{-1}(\hat{p}_j) \right)^2 + \frac{1}{2} \left( \Phi^{-1}(p_t) \right)^2 \right\}, \]

and where the interest rate \( r^e_i \) was solved for from the equation

\[ r^d e_t = r^e_i e_t \hat{F}(\hat{p}_t) + (r - r^d d_t) \left( \hat{F}(\hat{p}_t) - \hat{F}(\hat{p}_t) \right) - (r - \lambda) \sum_{j=0,1} q_{ij} \int_{\hat{p}_t}^{\hat{p}_t} p_t f_j(p_t) dp_t. \]

Thresholds \( p_t^*, \hat{p}_t \) and \( \hat{p}_t \) were set using the subordinate interest rates solved for from the above equation.

**Grid.** The VFI algorithm was performed on a discrete grid of capital \( G_k = \{ k_1, k_2, ... k_N \} \) and subordinate debt \( G_e = \{ e_1, e_2, ... e_M \} \) pairs with \( N = 1000 \) and \( M = 100 \), i.e. for each \( k_i \) 100 alternative values of \( e_{ij} \) spread across the interval \([0.03, 0.15]\) were available. The imposed range for capital was the interval \([0.005, 0.2]\). As policy and value functions were expected to be highly non-linear for low values of capital, non equidistant grid for capital with higher density of points in the lower range of capital values was used to increase the accuracy of the fit. The grid was constructed according to the rule \( k_i = k_1 + \delta (i - 1)^2, i = 1, 2, ... N \) with
\[ \delta = \frac{(k_N - k_1)}{(N - 1)^2} \]. The same algorithm was used for construction of the subordinate debt grid.

Given the grid pair \( \{k_s, e_s\} \), the corresponding interest rates \( r_s^e \) were numerically approximated. In particular, the Gauss-Chebyshev quadrature on 100 Chebyshev nodes was used to approximate the integral \( \int_{\tilde{p}}^{\hat{p}} p_i f(p_i) dp_i \) in the equation for the subordinate interest rate (2.6).

**Iterative algorithm.** The Value Function Iteration algorithm was performed on the grid of total size \( I = N \times M = 100000 \). In each iteration step, \( m \), the following procedure was implemented (for the baseline Bellman equation (2.9) subject to the incentive constraint (2.7), the balance sheet clearing condition, and the capital requirement (2.10)):

1. For each grid point \( i = 1, \ldots, I \) compute
   \[ V^m_i = -k_i + \frac{1}{r^k} E \left[ \max \left\{ r^b_t - r^d d_i - \min\{r^b_t - r^d d_i, r^e_t e_i\}, 0 \right\} + Pr(r^b_t > r^d d_i)V^{m-1} \right] . \]
2. Find the index \( i^* \) such that \( V^m_i \geq V^m_i \) among \( i \)'s for which \( V^m_i \geq \theta(e_i) \) and \( k_i \geq k_{reg} \) for all \( i = 1, \ldots I \).
3. Set \( V^m = V^m_i^*, k^*_m = k^*_i \).
4. Compare the \( V^m \) with \( V^{m-1} \): continue the iteration until the absolute difference is lower than a given termination condition.

The stationary point function value was used as the initial value (for \( m = 0 \)) of \( V^0_i \) for each grid point \( i \) and the termination condition was set to \( 1E - 25 \).

**2.7 C Calibration choices**

The annual intermediation margin is set to 0.01 in the baseline model. This value in line with e.g. Elizalde and Repullo (2007) or Repullo and Suarez (2013), which we want to compare our model with. The later work uses the net interest margin of 3.42% (the difference between the total interest income and the total interest expense) for US commercial banks in years 2004-2007 (FDIC Statistics on Banking\(^{18}\)) extended by the service charges on deposit accounts rate of 0.55%, which yields the estimate of the intermediation margin of around 4%. However, at the same time the reported total non-interest expenses among US commercial banks achieve a similar level, leaving the effective loan spread above the risk-free deposit interest rate of zero percent. Setting \( \delta = 0.01 \) seems a reasonable consensus between the estimates of the intermediation margin and the non-interest costs of banks’ activity.

We set the recovery rate, \( \lambda = 0.55 \), to match the Loss Given Default (LGD) rate under Basel II for unsecured corporate exposures. While we are aware of the probable positive

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\(^{18}\) Source: fdic.gov.
correlation between LGDs and the portfolio default rates (Altman, Brady, and Resti, 2005), for simplicity of exposition we keep $\lambda$ constant and in particular independent from the level of risk in the economy, as measured by $\bar{p}$. When calculating the minimum capital requirements we slightly depart from the Vasicek (2002) single risk factor model underlying Basel regulatory provisions by assuming that the correlation coefficient, $\rho$, is independent of the unconditional default probability, $\bar{p}$. Under Basel II framework the correlation of defaults is a decreasing function of $\bar{p}$ in order to reflect the fact that smaller companies (in the bank’s portfolio) are perceived as more risky but at the same time subject more to idiosyncratic shocks (and hence the common risk factors are less important for this group of firms) than their larger counterparts. As we restrain from the choice of portfolio risk and keep the unconditional default probability equal for all firms in the bank’s portfolio, we decide to set $\rho$ fixed at 0.164. It is the value corresponding to the reference level of the unconditional portfolio default rate under Basel II, i.e. $\bar{p} = 0.02$.

### 2.7 D Tables and Figures

Figure 2.5: Changes in actual, economic and regulatory capital with respect to $\lambda$, when $\alpha = 0.999$, and $\bar{p} = 0.02$
2.7. Appendix

Figure 2.6: Changes in actual, economic and regulatory capital with respect to $r^k$, when $\alpha = 0.999$, and $\bar{p} = 0.02$

Figure 2.7: Changes in actual, economic and regulatory capital with respect to the intermediation margin $\delta$, when $\alpha = 0.999$, and $\bar{p} = 0.02$
## Table 2.4: Regulatory penalties and countercyclical buffer: With and without ex post penalties

This table presents responses of actual bank capital, subordinate debt and deposit holdings, and number of minimum requirement violations in two model set-ups: in the absence of ex post violation penalty, and in the presence of ex post violation penalty. In each set-up three regulatory regimes are considered: Case (A) Basel II regulations, Case (B) Basel III with the conservation buffer only, and Case (C) Basel III with the conservation and the counter-cyclical buffer. Values of common equity, subordinate debt, deposits and retained earnings reported as % of assets.

<table>
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<th>No penalty</th>
<th>Penalty</th>
<th>No penalty</th>
<th>Penalty</th>
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<td>0.2 0.2</td>
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<tr>
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<td>1.9/1.4</td>
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</tr>
<tr>
<td>% change between states</td>
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<td>33.1%</td>
<td>87%</td>
<td>103.7%</td>
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<tr>
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<tr>
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<td>93.3/93.2</td>
<td>91.9/91.8</td>
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<tr>
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<td>Violations per 1000 obs.</td>
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<tr>
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Note: The table presents responses of actual bank capital, subordinate debt and deposit holdings, and number of minimum requirement violations in two model set-ups: in the absence of ex post violation penalty, and in the presence of ex post violation penalty. In each set-up three regulatory regimes are considered: Case (A) Basel II regulations, Case (B) Basel III with the conservation buffer only, and Case (C) Basel III with the conservation and the counter-cyclical buffer. Values of common equity, subordinate debt, deposits and retained earnings reported as % of assets.
Chapter 3

Shadow banking and traditional bank lending

3.1 Introduction

Prior to the recent financial crisis many regulated financial intermediaries were actively involved in shadow banking activities. For example, in the asset-backed commercial paper market 75% of the total $1.2 trillion paper outstanding as of January 2007 was sponsored directly or indirectly by commercial banks (Arteta, Carrey, Correa, and Kotter, 2013).

The way commercial banks organized their shadow activities - via off-balance entities - suggests that regulatory arbitrage was an important motive for shadow banking: By setting off-balance special purpose vehicles (SPVs), commercial banks could carry out financial intermediation without having to comply with costly capital and other regulatory requirements (Gorton and Metrick, 2012).

SPVs enjoyed various forms of sponsor guarantees that provided recourse to banks’ balance sheets if conduits’ loan portfolios performed poorly. Although often non-contractible, the guarantees were realized in the vast majority of cases when the crisis hit,¹ most likely contributing to financial problems for sponsors themselves: Citigroup and Bank of America in the US, Sachsen LB and Deutsche Industriebank in Germany defaulted within one year after rescuing their SPVs. Importantly, all these institutions were later bailed out by regulators, suggesting that some costs of sponsor guarantees to SPVs were effectively passed to governments and thus to taxpayers.

Motivated by the above evidence, this chapter investigates channels through which

¹ Only 2.5% of ABCP outstanding as of July 2007 entered default in the period from July 2007 to December 2008 (Acharya, Schnabl, and Suarez, 2013), while at the same time a large share of the structurized products had their ratings downgraded (Coval, Jurek, and Stafford, 2009).
guarantees from commercial banks to shadow banks can affect lending and risk-taking by financial intermediaries. It provides nontrivial policy recommendations and shows that guarantees to shadow banks can work as an amplification mechanism for some stylized properties of the pre-crisis shadow banking activities: (I) Positive relationship between off-balance lending and bank lending capacity (Jiangli and Pritsker (2008), Altunbas, Gambacorta, and Marques-Ibanez (2009)), (II) Dominance of large financial institutions.

In order to achieve above goals, this chapter develops a model of bank holding companies (BHCs) granting guarantees to shadow banks. In the model, a BHC consists of two entities: a regulated bank entity investing in risky projects, and an unregulated off-balance SPV selling projects to investors. The BHC can increase the fee income from its SPV by guaranteeing sold loans with the bank entity’s balance sheet.

The main contributions are twofold. First, the model allows to study economy-wide consequences of guarantees from regulated intermediaries to shadow banks. This is done by endogenizing the size of intermediaries’ investments and their risk-taking decisions. For high enough demand for financial assets the value of SPV guarantees depends on the investment by the sponsor’s bank entity: Larger bank investment implies higher expected bank proceeds and higher guarantee repayments to SPV investors. This boosts investors’ demand for risky projects and increases the off-balance fee income for the BHC. As a result, the BHC has incentives to extend its bank investment beyond the level optimal in the absence of guarantees. The total amount of credit in the economy is higher than when no guarantees to the shadow banking sector are granted. This increases costs of providing government support to the traditional banking sector not only in the states when guarantees are executed (via contagion from SPVs), but also when banks default independently of their off-balance entities (as traditional banks are now larger too).

Secondly, the model offers important policy implications. Lowering the capital requirement for regulated banks relative to the level optimal in the absence of guarantees is welfare improving when costs of regulatory interventions are high. This happens as the capital requirement effectively restricts the optimal bank investment in comparison to the size of the shadow banking sector. For a high capital requirement and for high demand for financial assets, guarantee claims of the shadow banking sector are very high relative to the size of the traditional banking sector, and only partial guarantee repayments are possible. The relationship between the bank size and investors’ demand for off-balance intermediation emerges, possibly distorting bank investment decisions and raising costs of public support to the financial sector. In this case lowering the minimum requirement can actually increase the repayment capacity of the traditional
banking sector and reduce costs of regulatory interventions.

This chapter is organized as follows. Section 3.2 provides an overview of the existing literature on shadow banking and guarantees to shadow banks. Section 3.3 presents the problem of a BHC in the absence of implicit guarantees, which are introduced in Section 3.4. Section 3.5 studies optimal capital requirements in the presence of regulatory arbitrage. BHC's monitoring decisions are endogenized in Section 3.6. Section 4.7 concludes. Appendix 3.8 A discusses evidence on the execution of implicit guarantees during the recent financial crisis. All proofs are presented in Appendix 3.8 B. An extended, two-period model with fee bargaining is presented in the online Appendix, available upon request.

3.2 Related literature

My analysis in this chapter contributes to the growing literature on shadow banking and its links to commercial banks. Private and public backstops provided to off-balance entities are recognized as the key ingredient of shadow banking activity (Claessens, Pozsar, Ratnovski, and Singh, 2012).

My model is closest in spirit to the shadow banking models of Gorton and Souleles (2007) and Luck and Schempp (2014). In Gorton and Souleles (2007) banks grant implicit guarantees to overcome the adverse selection problem arising from the asset sale between the sponsoring bank and the SPV. Executing implicit guarantees can be the equilibrium strategy in a multi-period game between the sponsor and the SPV clients, but - contrary to my model - it never results in the sponsor's default. Luck and Schempp (2014) consider the impact of off-balance activities on the financial system’s stability. Similarly to my model, a crisis in the shadow banking sector transmits to the traditional banking sector through guarantees to shadow banks. However, in their set-up guarantees are exogenously given and assumed to be always executed. They do not consider the impact of guarantees on investment decisions and on the size of traditional banks neither. Finally, regulatory arbitrage takes a form of a fixed compliance cost for traditional banks, while in my model the minimum capital requirement maximizes the regulatory objective function.

In my model it is the foregone income that incentivizes sponsors to execute guarantees ex post. Other studies, similarly to Gorton and Souleles (2007), consider guarantees as a tool to solve information asymmetries between the sponsor and investors. Segura (2013) shows that execution of guarantees can provide a positive signal regarding the sponsor’s asset quality to investors deciding on rolling over the existing debt.
In Ordonez (2013) the signalling benefit from executing support is higher when the sponsor faces good investment opportunities. However, none of these papers considers the impact of SPV guarantees on sponsor’s lending and monitoring decisions.

In my set-up shadow banking arises as a result of regulatory arbitrage. Other studies following the regulatory arbitrage hypothesis include Harris, Opp, and Opp (2014) and Plantin (2014). Similarly to the model presented in this chapter, minimum capital requirements restrict bank lending in Harris, Opp, and Opp (2014). In their set-up limited bank activity encourages competition from non-bank intermediaries and distorts risk-taking incentives of banks. In Plantin (2014) the capital requirement optimal in the presence of shadow banking is also lower than in its absence. However, he does not model guarantees from traditional banks to shadow banks: High capital requirement is suboptimal as it makes banks shift to off-balance intermediation, where adverse selection problems are more severe.

Two alternative views on shadow banking focus on the risk diversification through securitization and on liquidity transformation. Gorton and Pennacchi (1990), and DeMarzo (2005) investigate the securitization process per se. They find that pooling and tranching loans can alleviate information asymmetries and increase efficiency of financial intermediation. Gennaioli, Shleifer, and Vishny (2013) show that this is the case only if agents involving in securitization have rational expectations, i.e. there is no neglected aggregate risk.

Moreira and Savov (2014) pursue the liquidity transformation view. In their model shadow banks provide money-like, information-insensitive securities. In normal times additional liquidity encourages saving by households, promotes investment, and increases growth. Shadow banking securities become illiquid following negative uncertainty shocks, which leads to rapid deleveraging, collateral runs, and produces slow recoveries.

Empirically, Arteta, Carrey, Correa, and Kotter (2013) find that manager agency problems and state support to financial intermediaries were crucial in motivating banks to sponsor off-balance vehicles prior to the global financial crisis. Acharya and Schnabl (2010) find evidence supporting the regulatory arbitrage hypothesis. Using data on asset backed commercial paper (ABCP) prior to the recent financial crisis they show that in Spain and Portugal - two European countries where capital charges for off-balance exposures were the same as for on-balance items - the ABCP conduits were practically non-existent. Acharya, Schnabl, and Suarez (2013) argue that most of the credit risk from securitized assets stayed with sponsoring banks, which used off-balance vehicles to reduce their capital requirements.

Finally, while my model captures some important aspects of shadow banking, it is
necessarily silent about many others. Greenbaum and Thakor (1987) and Benveniste and Berger (1987) analyse the safe-harbour character of off-balance vehicles. They show that the use of bankruptcy-remote entities can improve risk allocation among bank liability holders and alleviate moral hazard problems created by deposit insurance.

Problems related to maturity transformation in off-balance financing have been emphasized by Gorton and Metrick (2010), and Gorton and Metrick (2012). They stress that the short-term character of off-balance conduits makes them particularly sensitive to liquidity problems and the risk of runs. Brunnermeier and Oehmke (2013) show that borrowers might shorten the maturity of individual creditors’ debt contracts because this dilutes other creditors. The borrowers then involve in a “maturity rat race” resulting in an inefficiently short maturity debt structure.

Lastly, implicit guarantees are only one of many forms of sponsor support to shadow banks. Gorton and Souleles (2007) and Pozsar, Adrian, Ashcraft, and Boesky (2010) discuss alternative enhancement tools, such as purchases of lowest-grade loan tranches, or reserve accounts.

### 3.3 One-period model

In defining the equilibrium I closely follow Acharya (2003). I modify his infinite horizon model with repeated one-period investments by introducing the shadow banking sector, and by simplifying the investment return structure.

#### 3.3.1 Model primitives

**Agents in the economy.** There are two types of infinitely-lived agents in the economy: a unit mass of risk-neutral bank holding companies (BHCs) and a unit mass of risk-averse investors. Each BHC consists of a bank entity, and it can set up an off-balance special purpose vehicle (SPV). BHCs invest in risky projects each period. Investors are characterized by mean-variance preferences and are endowed with wealth $W$ each period, which they can invest in a safe storage technology, yielding zero net return, or lend to BHCs. It is assumed that $W$ is sufficiently high not to be a binding constraint from the BHC’s funding perspective.\(^2\)

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\(^2\)Investors' demand for financial assets $W$ can be thought of as analogous to the information-insensitive financial debt of Gorton, Lewellen, and Metrick (2012). They find that while the total amount of financial assets in the US has increased exponentially, the share of assets perceived as safe in the total assets has remained remarkably stable (at around 33%) over the last 60 years. They define as “safe” financial assets that are insensitive to information on the issuer (thus, immune to adverse-selection problems), and relate their finding to the stable need for financial assets that can be used as money, i.e. in an information-insensitive manner.
Investment opportunities. The return per unit of investment in a risky project \( \hat{R} \in \{r, R\} \) is realized at the end of the period. Whenever kept on the bank’s balance sheet, the risky project yields a high return \( R \) with probability \( p \): \( \mathbb{P}(R) = p \), with \( pR > 1 \), and \( pr < 1 \). If sold through the SPV, the project loses quality: the probability of the high return \( R \) falls to \( p_2 \), with \( \frac{1}{2} < p < p_2 \), and \( pR > 1 \). Moreover, \( r \) realized on the on-balance project implies \( r \) realized on the sold project too, but not the other way round. All project returns and state probabilities are fully observable.

Empirical evidence on asset transfers prior to the recent financial crisis supports the view that loans sold off-balance had worse quality than loans kept on banks’ balance sheets (Mian and Sufi (2009), Dell’Ariccia, Deniz, and Laeven (2012)). Nevertheless, I assume a lower success probability of sold projects to obtain a positive value of implicit guarantees in the simplest possible way. All results extend to the case with the same quality of bank and SPV projects but with imperfectly correlated returns.

Banks. The difference in risk preferences between investors and BHC shareholders creates demand for bank intermediation and debt funding. The bank entity finances its investment in the risky project \( X_B \) with deposits \( D \), and common equity \( K \). For purposes of this model deposits are fully insured by a regulator, and thus bank debt is safe, with a rate of return \( R_D \geq 1 \). The deposit insurance in the model can be interpreted more generally also as government support to the banking sector, such as during the 2007-2009 financial crisis.\(^3\)

As BHC shareholders are protected by limited liability, the regulator sets a minimum capital requirement \( k \) (such that \( K \geq kX_B \)) on bank equity in order to limit costs of providing deposit insurance. Moreover, BHC shareholders require an expected return on equity of \( \delta \), with \( \delta > R_D \): In this simple way I capture the well-documented preference of financial intermediaries for external funding. As a result, the minimum requirement is always binding.

Finally, similarly to Acharya (2003), maintaining projects and complying with regulatory supervision involves nonpecuniary costs for the bank, given by the quadratic function \( cX^2 \), with \( c > 0 \). When the project is sold and removed from the balance sheet there are no maintenance costs for the bank.

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\(^3\)In a richer model deposit insurance could be motivated by preventing socially costly bank runs or by willingness of the welfare-maximizing regulator to increase utility of risk-averse investors. Government bailouts of both depositors and uninsured bank creditors can be justified by the risk of spillovers from bank defaults to other financial intermediaries, e.g. via correlated asset holdings or through bilateral interbank exposures.
3.3. One-period model

**Special purpose vehicles.** The minimum capital requirement and maintenance costs limit the optimal size of bank investment, and the supply of bank deposits. While the available amount of bank deposits is restricted, there is still unsatisfied demand for risky projects by investors, given their mean-variance preferences. This justifies emergence of SPVs, which in the absence of any guarantees from BHCs can be thought of as investment funds.

In the model a SPV is a pass-through entity through which the BHC intermediates the risky project to investors. For each unit of the intermediated project the SPV charges an upfront fee $s$, while there are no costs of setting up the SPV. There is no minimum capital requirement for the SPV neither, as it is investors who bear the entire project risk.

Each investor buys a share in one risky project: if the project fails, all investors of the same SPV suffer losses. While the investor may use services of one SPV only, each SPV attracts many clients. As a result, the total SPV investment is treated by the representative investor as given.

**Guarantees to the SPV.** In Section 3.4 each BHC can guarantee SPV projects with the bank entity’s proceeds: The guarantee is a promise to pay the full return $R$ to the investor when the SPV project performs poorly but the bank project is successful. Guarantees increase profitability of off-balance investments for investors and boosts the intermediation fee income for the BHC. Guarantees are non-contractible, as otherwise the SPV would be subject to the capital requirement too.

**Bank default.** A bank defaults whenever it is not able to repay deposits in full. It is then allowed by the regulator to operate in the next period with probability $q$. With complementary probability $1 - q$ the bank is shut down and stops operating forever. A BHC stops operating whenever its bank entity shuts down, as the bank is also necessary for intermediation of off-balance projects.

I introduce the positive “bailout” probability to make sure that implicit guarantee promises are executable in the baseline model. With a zero continuation probability BHCs would never realize guarantees if that would lead to a default. In the online Appendix I show that executing guarantees can be an equilibrium strategy in a model with two-stage project returns when $q = 0$. While the assumption of exogenous continuation probability is made mainly for simplicity of exposition, the experiences from the recent financial crisis - with some banks bailed out and some allowed to be liquidated - can justify it as a rough approximation of the reality.
Model outline. Figure 3.1 summarizes the model graphically.

![Model outline diagram]

3.3.2 Benchmark case: no guarantees to the SPV

In this section I solve the model assuming that the fee \( s \) for SPV project intermediation is exogenous. All key results carry out to the extended version of the model presented in online Appendix, where \( s \) is the outcome of bargaining between the BHC and investors. For simplicity I set the project payoff in the low state of the economy to zero: \( r = 0 \).

BHC’s optimization problem. Similarly to Acharya (2003) all payoffs generated by the BHC within the period are consumed by shareholders by the start of the next period. As shareholders cannot commit to any dynamic investment strategy, the BHC’s problem can be expressed as a stationary dynamic program with the objective

\[
(3.1) \quad V_t = \max_{X_B} \left\{ \mathbb{E} \Pi(X_B) \; \right\} + sX_{SPV} + \beta \left( p + (1 - p)q \right) V_{t+1}.
\]

Term \( \mathbb{E} \Pi(X_B) \) represents expected payoffs from the bank entity at the end of the period, and \( X_B \) stands for the size of the risky project funded by the bank. The fee income from intermediating the risky project via the SPV is equal to \( sX_{SPV} \). The bank entity defaults with probability \( 1 - p \), in which case it continues operating with probability \( q \). Thus, the BHC’s continuation probability is equal to \( p + (1 - p)q \). The continuation value \( V_{t+1} \) is discounted with a factor \( \beta \in (0, 1) \). Due to the lack of commitment on the side of shareholders, \( V_{t+1} \) is treated by the BHC as a constant and the BHC chooses the same values of decision variables each period.

As the BHC does not have any impact on the investors’ demand for the risky project, the bank investment is chosen to maximize the expected payoff from the bank
3.3. One-period model

entity, given by

\[ \mathbb{E}\Pi(X_B) = p (RX_B - R_D D) - cX_B^2 - \delta K, \]  

subject to

\[ X_B = D + K, \]  
\[ K \geq kX_B. \]  

The objective (3.2) consists of payoffs realized in the good state \( RX_B - R_D D \) multiplied by the probability of a positive return \( p \), minus maintenance costs \( cX_B^2 \), and minus costs of raising shareholder capital \( \delta K \). It is maximized for \( X_B \) equal

\[ X_{B}^{nr} = \frac{p(R - (1 - k)R_D) - \delta k}{2c}, \]

where the upper-script “nr” stands for the no recourse case, and where I used that \( D = (1 - k)X_B \), and \( K = kX_B \). Given the optimal bank investment, the BHC’s continuation value is an infinite geometric series’ sum with the common ratio \( \beta(p + (1 - p)q) \), and equal

\[ V_{t+1} = V = \frac{[\mathbb{E}\Pi(X_B) + sX_{SPV}]}{1 - \beta(p + (1 - p)q)}. \]

**Investors’ problem.** The risk-averse investor with funds \( W \) chooses his wealth allocation between bank deposits, the risky project available via the SPV, and the safe storage technology, to maximize

\[ EU_W = (\mathbb{E}[\bar{R}_W] - 1)W - \lambda \text{var}[\bar{R}_W]W^2, \]

where \( \lambda \) is a measure of investor’s risk-aversion, and \( \bar{R}_W \) stands for the total return from his investment portfolio. Taking into account that the supply of bank deposits is limited (by bank’s maintenance costs and the minimum capital requirement), it can be easily shown that as long as he is not wealth-constrained, the representative investor invests:

1. the maximum possible amount \((1 - k)X_B\) in bank deposits,
2. \( X_{I}^{nr} \) in the risky project through the SPV, where

\[ X_{I}^{nr} = \frac{pR - 1 - s}{2\lambda p(1 - p)R^2}; \]
CHAPTER 3. SHADOW BANKING AND TRADITIONAL BANK LENDING

3. the remaining amount $W - D - X_I$ in the safe storage technology (cash),

where $E[\tilde{R}_{SPV}] = pR$, and $\text{var}[\tilde{R}_{SPV}] = p(1 - p)R^2$. The amount invested through the SPV maximizes investor’s expected utility from the risky project only: 

$EU_{X_I} = (E[\tilde{R}_{SPV}] - 1 - s)X_I - \lambda \text{var}[\tilde{R}_{SPV}]X_I^2$.

**Equilibrium.** By symmetry, all BHCs choose the same bank investment level $X_B$, and all investors demand the same amount of SPV projects $X_I$. The equilibrium is defined as an allocation $(X_B, X_{SPV}, D, X_I)$ and a price system $(s, R_D)$ where:

1. the representative investor’s demand for the SPV project $X_I$ maximizes the expected utility from the SPV investment for a given $s$,
2. bank lending $X_B$ maximizes the BHC shareholders’ objective (3.2) given $R_D$ and subject to the minimum capital requirement $k$,
3. the deposit rate satisfies $R_D \geq 1$,
4. there are no short sales: $X_B, X_I \geq 0$.

Sufficient conditions for the existence of the equilibrium are that it is profitable to take on risk, i.e. $pR > 1$ and that the maintenance cost function $cX^2$ is steep enough, so that bank activities are not extended infinitely. In the equilibrium $X_B = X_B^{nr}$ given by (3.5), $D = (1 - k)X_B^{nr}$, and $X_{SPV} = X_I = X_I^{nr}$ given by (3.7).

### 3.4 Model with implicit guarantees to SPVs

#### 3.4.1 Design of guarantees

The only way the BHC can increase its fee income from the SPV is by increasing investors’ demand for the risky project: By raising expected returns, or reducing the variance of SPV returns. Of course, there are many ways to do it: With risk-neutral investors increasing the project’s return in successful states sufficiently high would have the same effect as subsidizing the SPV in the states with poor project performance. However, when investors are risk-averse, the latter policy is preferred as it both increases expected returns and decreases the variance of returns. Definition 1 specifies SPV guarantees in the current model.
Definition 1. The **implicit guarantee** is a non-contractible promise by the BHC to pay $R$ to the investor when the SPV’s project return is zero but the bank’s project is successful.  

The guarantee can be realized only if the bank entity has a positive return on its own investment. By assumption, bank and SPV project returns are correlated in a way that the SPV project defaults whenever the bank project defaults, but not the other way round. Thus, the state when the transfer takes place is $(R,0)$, realized with probability $p - p$. All possible payoff states are listed below.

<table>
<thead>
<tr>
<th>Probability</th>
<th>Bank return</th>
<th>SPV return</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p$</td>
<td>$R$</td>
<td>$R$</td>
</tr>
<tr>
<td>$p - p$</td>
<td>$R$</td>
<td>$0$</td>
</tr>
<tr>
<td>$1 - p$</td>
<td>$0$</td>
<td>$0$</td>
</tr>
<tr>
<td>$0$</td>
<td>$0$</td>
<td>$R$</td>
</tr>
</tbody>
</table>

Because guarantees are implicit (any formal contract would make the SPV subject to the minimum capital requirement), there will always be a risk for the investor that the BHC will not realize the guarantee ex post. As a result, for the guarantee to be granted in equilibrium, an ex post execution condition will need to be satisfied. For now I assume that the guarantee, if granted, is always executed. I consider the execution condition in Section 3.4.3.

**SPV project demand with implicit guarantees.** For the investor the repayment from the guarantee is equal to $R \times \min\{X_1, \frac{X_B}{X_{SPV}}X_1\}$. In particular, when demand for the SPV project is high, the BHC is not be able to realize all guarantees in full. The return payment is then equal to bank entity’s total proceeds, $RX_B$, divided among all clients of the SPV, with the single investor receiving back a fraction $\frac{X_B}{X_{SPV}}$ of the

---

4 The way I model implicit guarantees (and shadow banking more in general) is closest to the design of pass-through SPVs in the ABCP market prior to the crisis. The securitization chain was relatively simple in the case of ABCP SPVs, and their main purpose was regulatory arbitrage. Moreover, in the vast majority of cases the sponsor and the guarantor to SPVs were the same institutions. More recently, large state-owned banks have been intermediating securities sales by shadow-banking firms in China. Officially banks only facilitate sales of securitized products and do not hold any responsibility for the quality of underlying assets. Nevertheless, there is anecdotal evidence that governmental support to shadow products has been often channelled through the intermediating banks (see e.g. *The Economist*, 10th May 2014).

5 More in general, each BHC could chose a repayment fraction $0 \leq \alpha \leq 1$ maximizing the expected payoffs from the guarantee. Here BHCs can only set $\alpha \in \{0, 1\}$: it simplifies the exposition, while leaving main results unaffected.
promised amount. In other words, once the size of the shadow investment exceeds the bank investment, only a partial guarantee repayment is feasible, and the value of the guarantee is a function of the bank entity’s size. Finally, as he is only one of many SPV clients, the representative investor treats $X_{\text{SPV}}$ as given.

When the guarantee is granted, the investor’s demand for the risky project increases to

$$X_{\text{rec}}^r = \frac{pR + (p - p)R \min\{1, \frac{X_B}{X_{\text{SPV}}}\} - s}{2\lambda \text{var}[\tilde{R}_{\text{SPV}}]} \geq X_{i}^{nr},$$

where the middle term $(p - p)R \min\{1, \frac{X_B}{X_{\text{SPV}}}\}$ represents the positive effect of the guarantee on the return expected from the investment in SPV. The guarantee also decreases the variance of returns, with $\text{var}[\tilde{R}_{\text{SPV}}] < p(1 - p)R^2$. The upper-script “rec” stands for the recourse case.

Lemma 1 summarizes the relationship between investor’s demand for the risky project and the bank entity’s investment in the risky project.

Lemma 1. The representative investor’s demand for the risky project is non-decreasing in the size of the bank investment for $\delta < 2pR_D$,

$$\frac{\partial X_{\text{rec}}^r}{\partial X_B} \geq 0.$$

Implicit guarantees and bank investment. For the BHC the benefit of granting guarantees is equal to the increase in the fee income from its SPV, $s(X_{\text{rec}}^r - X_{\text{nr}}^r_{\text{SPV}})$, minus the expected cost of guarantee repayments in the state $(R, 0)$, $(p - p)R \min\{X_{\text{SPV}}, X_B\}$.

Implicit guarantees change the BHC’s objective function. When both bank depositors and guarantees to SPV investors can be repaid in full from bank proceeds, the BHC’s continuation probability is not affected, but guarantee repayments reduce the profitability of bank activities. The new objective is

$$\max_{X_B} \left\{ sX_{\text{SPV}} \right\}_{\text{SPV fee income}} + \left\{ p(R - (1 - k)R_D)X_B \right\}_{\text{bank payoff when SPV successful}} + (p - p) \left\{ [(R - (1 - k)R_D)X_B - RX_{\text{SPV}}^r] \right\}_{\text{bank payoff when guarantees repaid}} - c(X_B)^2 - \delta kX_B + \beta (p + (1 - p)q) V_{\text{rec}}^{\text{discounted continuation value}}.$$

---

\[6\] Exact formulas for the variances under guarantees are provided in the Appendix.
In this case it is shareholders who bear all costs related to SPV guarantees. Thus, guarantees provide recourse to bank capital only.

Whenever guarantee commitments exceed bank project proceeds accruing to BHC shareholders ($RX_{SPV} > (R - (1 - k)R_D)X_B$), and if the BHC decides to honour guarantees, the bank defaults on deposits. The BHC is then allowed to continue operating with probability $q$. The BHC continuation probability falls to $p + (1 - p)q$, and it depends on the success probability of the SPV project. The BHC’s objective is

$$\max_{X_B} \left[ \text{SPV fee income} + \text{bank payoff when SPV successful} - \text{discounted continuation value} \right].$$

It is important to note that, independently of the BHC continuing or not, costs of realizing guarantees are partially passed to the regulator, who always repays bank depositors in full: In this scenario guarantees provide recourse to deposit insurance. In other words, when execution of sponsor support leads to the BHC’s default, implicit guarantees offered to investors are de facto implicit government guarantees, as they take advantage of the regulatory safety net to traditional banks. In the model this is captured via the deposit insurance, but one should think also about too-big-to-fail implicit guarantees to large banks running off-balance vehicles, or central bank liquidity programs for regulated intermediaries, such as the Fed’s term securities lending facility opened in March 2008.

**Definition 2. Implicit guarantees to SPVs:**

1. provide **recourse to bank capital** whenever it is the BHC shareholders only who bear the costs of realizing guarantees, $RX_{SPV} \leq (R - (1 - k)R_D)X_B$,

2. provide **recourse to deposit insurance** whenever the sponsoring BHC defaults following guarantee repayments, $RX_{SPV} > (R - (1 - k)R_D)X_B$.

### 3.4.2 Equilibrium with implicit guarantees

The type of recourse provided by guarantees can be expressed as a function of the minimum capital requirement $k$. Intuitively, a high equity-to-assets ratio - by increasing the relative amount of bank capital in the financial sector - should increase the BHCs’ capacity to realize repayments to investors without defaulting on deposits. However, increasing $k$ also lowers the preferred size of bank investments in the risky project ($\frac{dX}{dk} < 0$), as bank capital is expensive to invest ($\delta > R_D$). Thus, raising the minimum
requirement might reduce the *absolute* amount of bank capital in the traditional banking sector and thus reduce BHCs’ capacity to absorb guarantee costs (as the banking sector’s size falls relative to the shadow sector’s size). Lemma 2 gives the condition under which the second effect prevails.

**Lemma 2.** Whenever $k > k^*$, raising the minimum capital requirement lowers bank’s proceeds that accrue to BHC shareholders $(R - (1 - k)R_D)X_B$ in the state when the risky project is successful. The threshold level $k^*$ is equal

$$k^* = \frac{(R - R_D)(2pR_D - \delta)}{2R_D(\delta - pR_D)}.$$  

When $k > k^*$ raising the minimum requirement - by reducing the size of the investment in the risky project - lowers bank proceeds that can be used to repay SPV guarantees without defaulting on bank deposits. From now on I will consider the case when the minimum requirement set by the regulator is larger than $k^*$. In Section 3.5, where $k$ will be endogenous, I will show that the minimum requirement maximizing regulatory objective is indeed high for sufficiently large deposit insurance costs.

Proposition 1 defines conditions under which guarantees to the SPV provide recourse to deposit insurance (and thus to government guarantees) in the model. Other scenarios are considered in the Proof in the Appendix.

**Proposition 1.** Suppose $k > k^*$. Implicit guarantees from the BHC to SPV investors provide recourse to deposit insurance with:

- full guarantee repayments, for $k \in (\bar{k}_1, \bar{k}_2]$, as long as $\bar{k}_2 > \bar{k}_1$. Relative to the case with no guarantees, the representative investor’s demand for the risky project increases to

$$X_{rec}^I = \frac{pR - 1 - s}{2\lambda p(1 - p)R^2} > X_{nr}^I,$$

and the bank’s investment in the risky project falls to

$$X_{rec}^B = \frac{p(R - (1 - k)R_D) - \delta k}{2c} < X_{nr}^B.$$

- partial guarantee repayments for $k > \bar{k}_2$. The representative investor’s risky project demand is increasing in the bank’s investment in the risky project, and
3.4. Model with implicit guarantees to SPVs

equal to

\[ X_I^{\text{rec}} = \frac{pR + (p - \lambda)\frac{RX_{SPV}^{\text{rec}}}{RX_{SPV}} - 1 - s}{2\lambda \text{var}[\tilde{R}_{SPV}^{\text{rec}}]} > X_i^{nr}, \]

and the representative BHC’s bank investment \( X_B^{\text{rec}} \) solves

\[ \max_{X_B} \left[ sX_{SPV}^{\text{rec}}(X_B) + \tilde{v}(R - (1 - k)R_D)X_B - c(X_B)^2 - \delta kX_B + \beta (\tilde{p} + (1 - \tilde{p})q) V^{\text{rec}} \right]. \]

In equilibrium \( X_I^{\text{rec}} = X_{SPV}^{\text{rec}} \).

SPV project demand is always higher when guarantees to the shadow banking sector are granted. The demand for SPV projects depends solely on the new (higher) expected project returns and variance as long as implicit guarantees are fully repaid (equation (3.12)). However, once only partial repayments are feasible, the demand for the off-balance project is a function of the bank size too (term \( X_B^{\text{rec}} \) in equation (3.14)). A higher bank investment raises expected bank proceeds and thus the guarantee repayment each SPV investor can expect. This increases the value of guarantees to SPV investors, who extend their demand for the risky project.

Looking at the BHC’s problem, the bank’s investment in the risky project changes once guarantees provide recourse to deposit insurance. First, the BHC would like to reduce its own investment to account for lost bank payoffs from guarantee repayments (\( X_B^{\text{rec}} < X_B^{nr} \) in equation (3.13)). On the other hand, when only partial guarantee repayments are feasible, a higher bank investment increases the demand for the SPV project (equation (3.14)). In this case the BHC has incentives to invest more ex ante in order to boost the fee income from SPV intermediation (\( X_{SPV}^{\text{rec}}(X_B) \) in equation (3.15)).

Lemma 3 presents the condition under which the latter effect prevails and the total volume of credit in the economy exceeds the “no recourse” level.

**Lemma 3.** When guarantees provide recourse to deposit insurance and only partial guarantee repayments are feasible, multiple solutions to the system of equations (3.14) and (3.15) are possible. As long as \( \lambda < \hat{\lambda} \) and \( R - (1 - k)R_D < 1 \), the bank’s risky project investment always exceeds the “no recourse” level \( X_B^{nr} \), and the total risky project investment \( X_B^{\text{rec}} + X_{SPV}^{\text{rec}} \) is higher than in the absence of implicit guarantees.

Under partial guarantee repayments, decisions of investors are interdependent. By increasing his investment in the SPV individual investor increases the value of the expected guarantee repayment (via a higher share of bank proceeds). At the same time, higher demand by other investors reduces the share of bank proceeds received
by the investor when the guarantee can be claimed, giving him additional incentives to raise own exposure. In general, the system of equations (3.14) and (3.15) can have more than one solution, and the equilibrium risky project demand $X_{\text{SPV}}^{\text{rec}}$ is a nonlinear function of the bank investment. Nevertheless, Lemma 3 states that as long as $\lambda$ is sufficiently small, any solution is characterized by a bank investment in the risky project $X_{B}^{\text{rec}}$ higher than in the absence of implicit SPV guarantees.

A low value of $\lambda$ corresponds to high investors’ demand for the risky project also when guarantees are absent, and to a strong response to an implicit guarantee offer $\left(\frac{dX_{I}}{d\lambda} < 0\right)$. Intuitively, for the guarantees to have a large effect on the SPV project demand, investors cannot be too risk-averse: For highly risk-averse investors the remaining riskiness of the SPV project is more important than the reduction of the default probability offered by guarantees. In the opposite case - for relatively low values of $\lambda$ - the drop in the default probability has a big impact on investors’ demand. This incentivizes the BHC to significantly raise its own bank investment. For $\lambda < \hat{\lambda}$ both the SPV and the bank investment increase beyond the “no recourse” levels. This implies more frequent bank defaults, and higher costs of providing deposit insurance for the regulator. Importantly, the larger size of bank entities makes deposit insurance costs increase also in the states when guarantees cannot be claimed (both bank and SPV projects fail).

Finally, it also holds that $\frac{d\hat{\lambda}}{dk} > 0$: Higher minimum capital requirement increases the risk-aversion threshold for which the BHC is incentivized to increase its own investment to boost the SPV project demand, thus making this scenario more likely to happen.

**Guarantees with recourse to deposit insurance and capital requirements.** Results from Proposition 1 and Lemma 3 are summarized graphically in terms of the minimum capital requirement $k$ and the risk-aversion parameter $\lambda$ in Figure 3.2. As the Figure shows, setting the capital requirement at a very high level might be inefficient in achieving the regulatory goal of controlling deposit insurance costs when guarantees are granted to SPVs. For a high $k$ only partial guarantee repayments are possible, and the perverse incentives of BHCs to increase own investments to boost the value of SPV guarantees emerge. At the same time, Figure 3.2 suggests that, given demand for risky projects ($\lambda$), it is possible to change the type of recourse provided by guarantees by adjusting $k$: The question of the minimum capital requirement optimal in the presence of guarantees to shadow banks is addressed in Section 3.5.
3.4. Model with implicit guarantees to SPVs

This figure shows the three types of implicit guarantees (with recourse to bank capital, with recourse to deposit insurance and with full repayment, with recourse to deposit insurance and with partial repayment) as a function of the minimum capital requirement \( k \), and the risk-aversion parameter \( \lambda \).

**Figure 3.2: Types of recourse as a function of \( k \) and \( \lambda \)**

SPV guarantees and stylized facts about the shadow banking  It is a well-documented fact that banks which involved in shadow activities prior to the 2007-2009 financial crisis tended to increase their lending and leverage by more than banks that did not involve in such operations (Jiangli and Pritsker (2008), Altunbas, Gambacorta, and Marques-Ibanez (2009)). The model proposed in this chapter shows that implicit guarantees from commercial banks to their shadow banks could be one of the channels: In the model banks increase own investment in order to increase the attractiveness of guarantees and investments in off-balance entities.

Another observation is that mostly large banks involved in shadow activities. A potential explanation can be the difference in the value of guarantees offered by large and small sponsors of off-balance vehicles. In terms of the current model, as BHCs with large bank entities would be expected to generate higher end-of-period proceeds than BHCs with small banks, this would directly translate to a higher value of guarantees given to their SPVs.

3.4.3 Execution of guarantees ex post

As guarantees are non-contractible, the representative BHC might refuse to realize them ex post. However, if the BHC fails to repay investors, they might not believe
in a similar promise in the future. As a result, for the guarantees to be granted in
equilibrium, an ex post execution condition will need to hold.

To avoid analyzing alternative punishment strategies in a multiperiod game setting,
I simply assume that if the BHC refuses to repay investors, their demand for the risky
project will fall to the “no recourse” level in all future periods. In other words, investors
will never respond to a guarantee promise again.

\textbf{Proposition 2.} For the guarantees to be granted to SPVs in equilibrium the ex post
execution condition needs to hold. When guarantees provide recourse to deposit insur-
ance, the condition is given by

\begin{equation}
X_{B}^{\text{rec}}(R - (1 - k)R_D) \leq \beta (qV_{\text{rec}} - V_{\text{nr}}) \, .
\end{equation}

When the ex post execution condition is not satisfied, no guarantees are granted to
SPVs in equilibrium: The bank investment is equal to $X_{B}^{\text{nr}}$, and SPV project demand
is given by $X_{I}^{\text{nr}}$.

In the case of recourse to deposit insurance execution of guarantees always leads to
the bank’s default. Therefore, granting and executing SPV guarantees is an equilibrium
strategy if the continuation value corrected for the decreased probability of BHC’s
continuation ($\beta qV_{\text{rec}}$) is higher than the sum of savings from not realizing guarantees
and the continuation value under no recourse policy ($X_{B}^{\text{rec}}(R - (1 - k)R_D) + \beta V_{\text{nr}}$).

\textbf{Lemma 4.} When they provide recourse to deposit insurance, SPV guarantees are re-
alized for sufficiently low $\lambda$, or when the intermediation fee $s$ is high enough. For
sufficiently low $\lambda$, the ex post execution condition (3.16) is increasing in the BHC
continuation probability $q$.

Incentives to realize guarantees depend on the parameter $\lambda$. This happens as costs
of realizing guarantees are effectively restricted by the size of the bank entity under
recourse to deposit insurance. Thus, granting guarantees boosts the intermediation fee
income by more for low values of $\lambda$, while execution costs remain constrained. Moreover,
whenever profitability of guarantees is sufficiently high, i.e. when they substantially
increase the fee income, the ex post execution condition is more likely to be satisfied
for high BHC continuation probability.

Importantly, if $q = 0$ and the BHC always stops operating after a default, guarantees
are never executed, and thus never granted in equilibrium. This is, however, a feature
particular for the baseline set-up with one-period investment returns. In the extended
version of the model in the online Appendix implicit guarantees can provide recourse
to deposit insurance also in the absence of bank bailouts.
3.5 Endogenous capital requirement

In this Section the minimum capital requirement is chosen to maximize the objective function of the regulator who cares about the overall welfare in the economy.

3.5.1 Regulatory objective

The regulator chooses $k$ to maximize a utilitarian welfare function, while for simplicity it is assumed that a defaulting BHC is always allowed to continue to operate: $q = 1$.\footnote{Dewatripont and Freixas (2011) argue that bank bankruptcies have higher social costs - in terms of real economic activity - than bankruptcies of other firms and that therefore it is important to keep bank operations going during the entire resolution process.}

The only costs of regulatory bailouts come from providing deposit insurance, which - similarly to Acharya and Yorulmazer (2008) - is socially costly: Repayment of one unit of funds to depositors requires collecting $F > 1$ of funds via distortive taxes. In the absence of implicit guarantees to SPVs the objective function of the regulator is

$$\text{Welfare} = \underbrace{\mathbb{E} \Pi_B}_\text{bank sector payoffs} + \underbrace{\mathbb{E} U_I}_{\text{investors' utility}} - (1 - p) \underbrace{FRD(1-k)X_{B}^n}_{\text{cost of deposit insurance}} =$$

$$pRX_B^n - \delta k X_B^n - c(X_B^n)^2 + pRX_{SPV}^n - \lambda p(1-p)R^2(X_{SPV}^n)^2 - X_{SPV}^n - (1-k)X_B^n - (F-1)(1-p)RD(1-k)X_B^n.$$

**Lemma 5.** When implicit guarantee agreements are not available, the optimal capital requirement $k^\text{nr}$ is increasing in the cost of regulatory interventions $F$.

The regulatory minimum requirement is increasing in $F$. Thus, the case considered in Section 3.4, where $k > k^*$ corresponds to the situation with a relatively high social cost of regulatory interventions.

3.5.2 Capital requirement in the presence of SPV guarantees

Implicit guarantees to SPVs affect the regulatory objective in two ways. On the positive side, they allow for a transfer of risk from risk-averse investors to risk-neutral BHCs, thus increasing welfare. On the negative side, guarantees incentivize over-investment in less productive off-balance projects, affect bank investment choices, and (under recourse to deposit insurance) increase social costs of providing deposit insurance. Lemma 6 summarizes the net welfare effect of implicit guarantees - relative to the “no recourse” case - for a fixed minimum capital requirement $k$. 
**Lemma 6.** For an unchanged minimum capital requirement \( k \), implicit guarantees with recourse to bank capital are always welfare-improving relative to the “no recourse” case. The net welfare effect of guarantees with recourse to deposit insurance depends on the minimum capital requirement \( k \) in a non-linear way.

When guarantees provide recourse to bank capital only, there are no additional fiscal costs from deposit insurance, while risk-shifting between investors and BHCs improves welfare. On the contrary, granting recourse to deposit insurance increases deposit insurance costs. Depending on the actual level of the minimum capital requirement, the net welfare effect of SPV guarantees in this case can be either positive or negative.

**Capital requirement and the type of guarantees.** As shown in Figure 3.2 in Section 3.4, for high and medium values of \( \lambda \), the regulator can affect the type of recourse provided by implicit guarantees by altering the minimum requirement. For example, when \( k > k^* \) lowering the minimum requirement can move the economy from recourse to deposit insurance to recourse to bank capital, and from partial guarantee repayments to full guarantee repayments. Proposition 3 summarizes the welfare effects of adjusting \( k \) in the presence of SPV guarantees.

**Proposition 3.** The capital requirement optimal in the presence of recourse to bank capital is the same as the minimum requirement optimal in the absence of guarantees, \( k_{nr} \). When guarantees are introduced and provide recourse to deposit insurance, a reduction of the minimum capital requirement from \( k_{nr} \) to a \( k_{new} \) is welfare-improving when:

1. the social cost of regulatory interventions \( F \) is high, and when there is a shift from partial guarantee repayments to full guarantee repayments,

2. when there is a shift from recourse to deposit insurance with full repayments to recourse to bank capital and when \( \lambda < \bar{\lambda} \). When \( \lambda > \bar{\lambda} \), the shift is still welfare-improving for a low social cost \( F \).

The new capital requirement \( k_{new} \) is equal to \( \bar{k}_1 \) or \( \bar{k}_2 \) defined in Proposition 1.

Consider a financial system where initially there are no implicit guarantees to SPVs, and where the minimum capital requirement is equal to \( k_{nr} \). Suppose then that implicit guarantee contracts are invented and introduced into this financial system. By Proposition 3, the optimal minimum capital requirement does not change as long as SPV guarantees provide recourse to bank capital. Such guarantees only redistribute funds
from bank shareholders to risk-averse investors, while not altering BHCs’ investment decisions and not leading to additional bank defaults.

However, by Proposition 1, when \( k^{nr} > \bar{k}_1 \) guarantees to SPVs do not provide recourse to bank capital, but recourse to deposit insurance. In this case, when \( F \) is high, it is optimal to actually decrease \( k \) in order to eliminate partial repayments of guarantees. By eliminating partial repayments, the regulator can prevent the positive link between SPV project demand and BHCs’ investment decisions, which increases investments by traditional banks and inflates costs of regulatory interventions. Since the regulator’s objective both under recourse to bank capital, and under recourse to deposit insurance with full repayments is analogous to equation (3.17), and is a quadratic function of \( k \), the new minimum requirement is equal to one of the threshold values: \( \bar{k}_1 \) or \( \bar{k}_2 \).

Welfare comparisons between guarantees with recourse to bank capital and with recourse to deposit insurance with full repayments are more complicated. First, as the size of bank investment is lower in the latter case, it might happen that costs of providing deposit insurance are actually lower under recourse to deposit insurance. This is when \( \lambda > \lambda_{1} \): the demand for SPV projects does not respond sufficiently high to guarantee offers, and thus costs of more frequent bank defaults under recourse to deposit insurance are out-weighted by the reduction of deposit insurance costs due to the smaller size of banks. In the opposite case, \( \lambda < \lambda_{1} \), fiscal costs are actually higher under recourse to deposit insurance than under recourse to bank capital and a shift to recourse to bank capital is always welfare-improving.

**High capital requirements: Good or bad?** The above analysis incorporates only some channels through which capital requirements affect financial intermediaries. For example, in the model the bank portfolio choice is treated as given, while it is plausible that increased capital requirements prevent excessive risk-taking ex ante, thus making the financial system more stable. The capital requirement in the model is always binding, and fixed along the business cycle, which eliminates potential positive welfare effects of a counter-cyclical \( k \). Nevertheless, key qualitative results of the analysis still hold in a more general setting, as long as the potential for implicit guarantees from traditional banks to shadow banks is not eliminated.

Secondly, while I focus on capital requirements, there are other policy tools that can restrict guarantees to the shadow banking sector. For example, policies reducing attractiveness of executing guarantees ex post - such as taxing fee income, or imposing deposit insurance contributions that depend on the profile of BHCs’ off-balance activities - might be preferred to changes in \( k \).
From an ex ante perspective, close monitoring of the shadow banking sector’s size will be crucial in order to properly evaluate the risks resulting from potential links between commercial banks and shadow banks. In practice this will imply introducing more strict reporting standards for sponsors of off-balance vehicles.

Finally, while - by definition - implicit guarantee promises can never be ruled out, eliminating legal loopholes that enable regulatory arbitrage (such as favourable treatment of liquidity guarantees for off-balance vehicles, which ended with the introduction of Basel III) is another way to reduce the attractiveness of shadow activities for both sponsoring institutions and investors.

3.6 Loan monitoring with implicit guarantees

While implicit guarantees have received a considerable attention in both theoretical and empirical literature, their impact on the sponsor’s risk-taking incentives has not yet been analyzed in a structured way. In this Section I consider the issue by allowing BHCs to exert costly monitoring of both the on-balance and the off-balance project.

3.6.1 Monitoring decisions in the absence of guarantees

The BHC has to make two decisions: whether to monitor the bank project to increase the success probability from \( p_L \) to \( p_H \), and whether to monitor the project sold through the SPV to increase the success probability from \( p_L \) to \( p_H \). For simplicity I assume that \( p_H < p_L \): The SPV project is always dominated by the bank project. The monitoring cost is fixed and equal \( C \) per unit of the monitored project. The decision to monitor is nonobservable and noncontractible.

**Lemma 7.** *In the absence of implicit guarantees to SPVs the representative BHC:*

1. *never monitors the project sold to investors through the SPV,*

2. *monitors the bank project if and only if* \( C \leq C^{nr} \), where

\[
C^{nr} = \frac{\mathbb{E}\Pi_B(p_H) - \mathbb{E}\Pi_B(p_L) + (p_H - p_L)(1 - q)\beta V^{nr}}{X^{nr}_B(p_H)}.
\]

\( \mathbb{E}\Pi_B(p) \) and \( X^{nr}_B(p) \) are respectively the expected payoff, and the risky project investment of the bank. As the monitoring effort is neither observable nor contractible, the BHC has no incentives to monitor the sold project. Investors internalize the inability of the BHC to commit to monitoring and base their risky project demand on
the low success probability $p_L$. The bank project is monitored only if the monitoring cost is sufficiently low.

### 3.6.2 Implicit guarantees and monitoring

When SPV guarantees are granted, the decision to monitor the bank project affects the profitability of the off-balance intermediation too (equation (3.8)). At the same time, when guarantees provide recourse to deposit insurance, bank’s preferred investment is affected by the success probability of the SPV project (equation (3.14)). Thus, the two monitoring decisions are now interdependent.

Consider SPV guarantees with recourse to bank capital first. In this case guarantees are realized in full, the demand for the SPV project depends on the bank project success only (equation (3.12)), and the decision to monitor the SPV project solely reduces the expected costs of repaying guarantees ($(p - p)RX_{SPV}^{rec}(p)$). Lemma 8 summarizes monitoring decisions of the BHC that grants implicit guarantees with recourse to bank capital.

**Lemma 8.** When SPV guarantees provide recourse to bank capital, the BHC monitors the SPV project if

$C^{bc}_{SPV} = R(p_H - p_L)$.

If the SPV project is monitored, the incentives to monitor bank project are either higher or lower than in the absence of guarantees, with the monitoring cost threshold $C^{bc}_{1}$ equal

$$C^{bc}_{1} = \frac{\Delta \Pi_B + (s + p_H R)\Delta X^{rec}_{SPV} - R(p_H X^{rec}_{SPV}(p_H) - p_L X^{rec}_{SPV}(p_L)) + (p_H - p_L)(1 - q)\beta V^{nr}}{\Delta X^{rec}_{SPV} + X^{nr}_B(p_H)}.$$

If the SPV project is not monitored, the incentives to monitor bank project increase, with the monitoring cost threshold $C^{bc}_{2}$ higher than in the absence of guarantees, and equal

$$C^{bc}_{2} = \frac{\Delta \Pi_B + (s + p_L R)\Delta X^{rec}_{SPV} - R(p_H X^{rec}_{SPV}(p_H) - p_L X^{rec}_{SPV}(p_L)) + (p_H - p_L)(1 - q)\beta V^{nr}}{X^{nr}_B(p_H)},$$

where $\Delta \Pi_B = \Pi_B(p_H) - \Pi_B(p_L)$ and $\Delta X^{rec}_{SPV} = X^{rec}_{SPV}(p_H) - X^{rec}_{SPV}(p_L)$.

Introduction of implicit guarantees increases incentives of the BHC to monitor the off-balance project: $C^{bc}_{SPV}$ is now positive. This happens as implicit guarantees create a direct link between the BHC’s payoffs and the success probability of the SPV project: Monitoring of the SPV project reduces the probability of guarantee repayments.

Guarantees always increase incentives to monitor the bank project if the SPV project is not monitored ($C^{bc}_{2} > C^{nr}$). This is not necessarily the case when it is
optimal to monitor the SPV project. On the one hand, monitoring of the bank project increases the SPV project demand. On the other hand, bank proceeds are sometimes used to repay guarantees, which decreases the profitability of the bank project itself.

In the case of recourse to deposit insurance, the interdependence between the two monitoring decisions increases further. While SPV project demand is still a function of the bank success probability, the profitability and thus the size of the bank project (equation (3.13)) depends on the success likelihood of the off-balance project only. Similarly the BHC’s continuation depends now on the success of the sold project. Naturally, this reduces returns from monitoring of the bank project.

Lemma 9 summarizes monitoring decisions of a BHC that grants implicit guarantees with recourse to deposit insurance and with full repayments. Under SPV guarantees with partial repayments monitoring conditions are highly non-linear, while bank and SPV investment choices do not have a closed-form solution.

**Lemma 9.** When guarantees provide recourse to deposit insurance and full guarantee repayments are feasible, decisions to monitor the on-balance and the off-balance project are interdependent: In the case of the bank project, the BHC:

- exerts monitoring effort if the SPV project is monitored and if $C < \bar{C}^{DI}_{B}$, with
  \[
  \bar{C}^{DI}_{B} = \frac{s [X_{SPV}^{rec}(p_H) - X_{SPV}^{rec}(p_L)]}{X_{B}^{rec}(p_H) + X_{SPV}^{rec}(p_H) - X_{SPV}^{rec}(p_L)},
  \]
  - exerts monitoring effort if the SPV project is not monitored and if $C < \bar{C}^{DI}_{B}$, with
  \[
  \bar{C}^{DI}_{B} = \frac{s [X_{SPV}^{rec}(p_H) - X_{SPV}^{rec}(p_L)]}{X_{B}^{rec}(p_L)} > C^{DI}_{B}.
  \]

In the case of the SPV project, the BHC:

- monitors the off-balance project if the bank project is monitored and if $C < \bar{C}^{DI}_{SPV}$, with
  \[
  \bar{C}^{DI}_{SPV} = \frac{\mathbb{E}\Pi_{B}(p_H) - \mathbb{E}\Pi_{B}(p_L) + (p_H - p_L)(1-q)\beta V^{nr}}{X_{SPV}^{rec}(p_H) + X_{B}^{rec}(p_H) - X_{SPV}^{rec}(p_L)},
  \]
  - monitors the off-balance project if the bank project is not monitored and if $C < \bar{C}^{DI}_{SPV}$, with
  \[
  \bar{C}^{DI}_{SPV} = \frac{\mathbb{E}\Pi_{B}(p_H) - \mathbb{E}\Pi_{B}(p_L) + (p_H - p_L)(1-q)\beta V^{nr}}{X_{SPV}^{rec}(p_L)} > C^{DI}_{SPV}.
  \]
Interestingly, the overall impact of implicit guarantees on incentives to monitor the bank project depends on the relative profitability of the shadow banking business: both monitoring cost thresholds $C_{DI}$ and $\bar{C}_{DI}$ depend on the fee level $s$, and the response of the SPV project demand to implicit guarantees ($X_{SPV}(p_H) - X_{SPV}(p_L)$). The introduction of guarantees creates perverse monitoring incentives in the traditional banking sector, where the decision to monitor depends on the profitability of the off-balance project.

Monitoring thresholds and monitoring decisions from Lemma 9 are depicted graphically below.

**Figure 3.3: BHC’s monitoring decisions under recourse to deposit insurance with full repayments**

This figure shows the monitoring cost thresholds and monitoring decisions for the bank’s on-balance project and the off-balance SPV project.

Monitoring cost thresholds for the bank project and for the SPV project are displayed on two separate axes in Figure 3.3 for convenience. In reality they are ordered on one cost line, as the monitoring cost is the same for both investment projects.

As Figure 3.3 shows, bank and SPV projects are monitored simultaneously for the monitoring cost sufficiently low (upper left corner), and none of the projects is monitored for $C$ very high (bottom right corner). For moderate values of $C$ only one of the projects is monitored in most cases. That is, when $C_{DI} < C < \bar{C}_{DI}$ only the SPV project is monitored. On the other hand, when $C_{DI} < C < \bar{C}_{DI}$, it is the bank project that is screened.

However, in the region where $C \in (C_{DI}, \bar{C}_{DI})$ and also $C \in (C_{SPV}, \bar{C}_{SPV})$, there
are two possible strategies. First, if the bank project is monitored, the cost threshold applicable for the SPV project is $C_{SPV}^{\text{DI}}$ and the SPV project is not monitored. This in turn is consistent with the monitoring cost threshold of $C_{B}^{\text{DI}}$ for the bank project. Similarly, monitoring of the SPV project ($C < C_{SPV}^{\text{DI}}$) is consistent with the bank project not being monitored ($C > C_{B}^{\text{DI}}$). A natural interpretation of the middle region in Figure 3.3 is thus a cost range for which the two monitoring decisions are strategic substitutes: monitoring of one project eliminates the necessity to exert effort to screen the second project.

The last question is whether incentives to monitor the bank project are actually higher or lower in the presence of implicit guarantees than in the “no recourse” case. A comparison between the monitoring threshold $C^{\text{nr}}$ and thresholds under implicit guarantees: $C_{1}^{\text{bc}}$, $C_{\text{DIB}}^{\text{DI}}$, $C_{\text{DIB}}^{\text{DI}}$ does not give a clear-cut answer. As expected, in numerical examples the monitoring threshold is either higher or lower than in the absence of guarantees, depending on the relative profitability of bank and SPV activities, and the type of recourse provided by guarantees.

### 3.7 Concluding remarks

This chapter attempts to explain the incentives of financial intermediaries to set up off-balance vehicles, and to provide them with implicit recourse guarantees. In the model, SPVs are created to satisfy excess demand for risky projects in the presence of costly capital requirements, while implicit guarantees are a tool to increase the fee income from off-balance project intermediation. In the presence of implicit guarantees, and for high demand for information-insensitive financial assets, the size of off-balance intermediation depends on bank investment decisions. In equilibrium banks supporting SPVs invest more themselves, internalizing the positive effect of their decision on SPV project demand and thus on their fee income. This potentially increases the total amount of credit in the economy.

The model captures two important properties of the guarantees from commercial banks to their shadow banks. First, as execution of guarantees can lead to sponsoring banks’ defaults on their own obligations, guarantees to shadow banks effectively provide recourse to government guarantees. In the model this is captured by deposit insurance, which should be interpreted more broadly as any type of government support to the traditional banking sector, for example in the case of a crisis.

Second, as guarantees create a link between commercial banks’ and shadow banks’ lending decisions, they might have unwanted consequences for regulatory policies aimed
at commercial banks only. In the model this is reflected in the negative feedback from higher capital requirements: Attempts to regulate traditional banks more strictly increase attractiveness of shadow activities, that are not subject to regulatory rules.

Importantly, model’s policy recommendations are in line with most of the regulatory efforts that have followed the 2007-2009 financial crisis. The Dodd-Frank Act, and the ring-fencing proposal in the UK are aimed at eliminating any links between the banks’ core lending businesses and their other activities. Basel III rules terminate favourable treatment of liquidity lines provided by sponsoring banks to their off-balance vehicles when calculating capital charges. At the same time, however, the model speaks for caution when setting very high minimum capital requirements for commercial banks.
3.8 Appendix

3.8 A SPVs and implicit guarantees prior to and during the great financial crisis.

Higgins and Mason (2003) investigate 17 implicit recourse events that happened in the credit card securitization market in the period 1987-2001. In two cases the associated sponsors, Republic Bank and Southeast Bank, entered a default, having repaid SPV investors full principal in the early amortization process prior to the default event. Further, they distinguish between alternative recourse schemes. Through the early amortization the sponsor agrees to make principal payments to conduit investors earlier than planned whenever the underlying pool of conduit assets worsens performance and the portfolio yield falls. In early amortization, the sponsor effectively takes the previously securitized assets back on its balance sheet. Alternatively, the sponsor can provide investors with what is called “implicit recourse”, in which case there is a transfer of funds from the sponsor to the off-balance vehicle without any asset transfer.

Acharya, Schnabl, and Suarez (2013) study special purpose vehicles in the asset-backed commercial paper market (ABCP) prior and during the 2007-2009 financial crisis. They write: “... regulatory arbitrage was the main motive behind setting up conduits: the guarantees were structured so as to reduce regulatory capital requirements, more so by banks with less capital, and while still providing recourse to bank balance sheets for outside investors. Consistent with such recourse, we find that conduits provided little risk transfer during the “run”: losses from conduits remained with banks rather than outside investors and banks with more exposure to conduits had lower stock returns.”

They show that despite significant losses experienced by the ABCP conduits, all investors in conduits with strong credit guarantees were repaid in full, while investors in conduits with weak credit guarantees suffered only small losses. In total, only 2.5% of asset-backed commercial paper outstanding as of July 2007 entered default (i.e. stopped repaying investors) in the period from July 2007 to December 2008. As Coval, Jurek, and Stafford (2009) report, only in 2007 Moody’s downgraded 31 percent of all tranches for asset-backed collaterized debt obligations it had rated and 14 percent of those initially AAA-rated.

In many cases SPV rescues led to serious problems of the sponsoring institutions. In summer 2007 German banks Sachsen LB and Deutsche Industriebank were bailed out by authorities and then sold after they suffered mass losses in the ABCP vehicles they sponsored. In the U.S., the world largest ABCP sponsor Citigroup was bailed
out in November 2008, followed by the bailout of Bank of America - another large
ABCP conduit sponsor in early 2009. Citigroup decided to bring $ 49 billion of its
SPVs’ assets and liabilities onto its own balance sheet in December 2007. In general,
the execution of SPV support by sponsors was backed by the U.S. authorities fearing
potential runs and fire-sales if sponsors decided to halt repaying SPV investors.

Apart from providing non-contractible - and thus implicit - guarantees, sponsoring
institutions also used legal loopholes to provide protection to their SPVs at the lowest
capital cost. The existence of such loopholes was recognized in the accounting and
legal literature prior to the crisis, see e.g. Klee and Butler (2002). For example,
the liquidity guarantees widely used by sponsoring banks prior to the crisis were so
popular as - contrary to direct credit guarantees - under liquidity guarantee moving a
portfolio of loans off the balance was still recognized as a “true sale” of assets, which
additionally reduced the amount of required minimum capital for the sponsoring bank
(Gilliam (2005)). In particular, under Basel II only a 20% or a 50% capital weight
applied to liquidity lines provided by sponsors, in comparison to a full 100% charge
for credit guarantees. Yet, as Acharya, Schnabl, and Suarez (2013) argue, liquidity
guarantees provided the short-term wholesale investors with the same protection as
the credit guarantees would.

The currently implemented changes to the regulatory framework - known as Basel
III - eliminate the favourable treatment of liquidity lines. Basel III also requires all
entities enjoying the early amortization support to be recognized on the supporting
institution’s balance sheet (BIS (2012)).
3.8 B Proofs

Lemma 1

Proof. Whenever \( X_B > X_{SPV}^{rec} \), the investor’s SPV project demand \( X_I^{rec} \) in (3.8) does not depend on \( X_B \). For the opposite case, \( X_B \leq X_{SPV}^{rec} \), we have

\[
\frac{dX_I^{rec}}{dX_B} = \frac{2\lambda \text{var}[\hat{R}_{SPV}^{rec}](p - p) R_{X_{SPV}^{rec}} - \frac{d\text{var}[\hat{R}_{SPV}^{rec}]}{dX_B} (pR + (p - p) R_{X_{SPV}^{rec}} - 1 - s)}{4\lambda^2 \text{var}^2[\hat{R}_{SPV}^{rec}]}.
\]

The variance \( \text{var}[\hat{R}^{rec}] \) and its derivative with respect to \( X_B \) are equal

\[
\text{var}[\hat{R}_{SPV}^{rec}] = R^2_p (1 - p) + \left( \frac{R_X}{X_{SPV}^{rec}} \right)^2 (p - p) (1 - p + p) - 2R \left( \frac{R_X}{X_{SPV}^{rec}} \right) p(p - p),
\]

\[
\frac{d\text{var}[\hat{R}_{SPV}^{rec}]}{dX_B} = (p - p)(1 - p + p) \frac{2R^2 X_B}{(X_{SPV}^{rec})^2} - \frac{p(p - p)}{2R^2 X_{SPV}^{rec}}.
\]

Substituting \( \frac{d\text{var}[\hat{R}_{SPV}^{rec}]}{dX_B} \) in (3.18) and simplifying yields

\[
\frac{dX_I^{rec}}{dX_B} = \frac{(p - p) R^2_p}{2\lambda \text{var}^2[\hat{R}_{SPV}^{rec}]} \left[ p(1 - p) R - (p - p)(1 - p + p) R \left( \frac{X_B}{X_{SPV}^{rec}} \right)^2 - 2(pR - 1 - s)(1 - p + p) \frac{X_B}{X_{SPV}^{rec}} + 2p(pR - 1 - s) \right].
\]

The derivative is always positive if the term in squared parentheses on the RHS of (3.21) is positive. The term in parentheses has the lowest value for \( X_B = X_{SPV}^{rec} \), in which case it is equal to

\[
p(1 - p) R - (p - p)(1 - p + p) R - 2(pR - 1 - s)(1 - p + p) + 2p(pR - 1 - s) = \left[ p(1 - p) R - (p - p) R (1 - p) - 2(pR - 1 - s)(1 - p) \right] = (1 - p) [2(1 + s) - pR],
\]

which is positive as long as \( pR \leq 2 \) for a positive \( s \).

Lemma 2

Proof. Banks’ proceeds that accrue to BHC shareholders when the bank project is
successful decrease in $k$ if

$$\frac{d(R - (1 - k)R_D)X_{B}^{nr}}{dk} < 0 \iff (R - R_D)(2pR_D - \delta) + 2kR_D(pR_D - \delta) < 0 \iff k > \frac{(R - R_D)(2pR_D - \delta)}{2R_D(\delta - pR_D)} = k^*.$$ 

### Proposition 1

**Proof.**  
**Case 1: Guarantees with recourse to bank capital.** When guarantees are always repaid in full, the individual SPV project demand is equal to

$$X_{rec}^{I} = \frac{pR - 1 - s}{2\lambda p(1 - p)R^2}.$$ 

The bank is equal to the “no recourse” value $X_{B}^{nr}$ given by (3.5). The pair $(X_{B}^{nr}, X_{rec}^{I})$ is feasible in equilibrium only if $RX_{SPV}^{rec} < X_{B}^{nr}(R - (1 - k)R_D)$. Using that $X_{SPV}^{rec} = X_{rec}^{I}$ yields

$$RX_{SPV}^{rec} < X_{B}^{nr}(R - (1 - k)R_D) \iff \frac{R(pR - 1 - s)}{2\lambda p(1 - p)R^2} < \left[ \frac{p(R - (1 - k)R_D) - \delta k}{2c} \right] (R - (1 - k)R_D) \iff (3.23)$$

$$R_D(\delta - pR_D)k^2 - (R - R_D)(2pR_D - \delta)k + A < 0,$n

with

$$A = \frac{c(pR - 1 - s)}{\lambda p(1 - p)R} - p(R - R_D)^2.$$ 

Two solutions quadratic equation (3.23) are given by

$$\bar{k}_1, 2 = \frac{(R - R_D)(2pR_D - \delta) \pm \sqrt{\Delta}}{2R_D(\delta - pR_D)},$$

$$\Delta = (R - R_D)^2(2pR_D - \delta)^2 - 4R_D(\delta - pR_D)A.$$ 

As $\bar{k}_1 > k^* > \bar{k}_2$, there is the only one relevant capital requirement threshold as long as $k > k^*$.

**Case 2: Guarantees with recourse to deposit insurance and with full repayments.** The individual demand for the SPV project is again equal to (3.22). The bank investment size is

$$X_{B}^{rec} = \frac{p(R - (1 - k)R_D) - \delta k}{2c} < X_{B}^{nr}.$$
The new pair \((X_B^{rec}, X_I^{rec})\) is feasible in equilibrium if

\[
RX_{SPV}^{rec} < RX_B^{rec} \iff \frac{pR - 1 - s}{2 \lambda p (1 - p) R^2} \leq \frac{p(R - (1 - k)R_D) - \delta k}{2c} \iff k \leq \frac{p(R - R_D)}{\delta - pR_D} = \bar{k}_2.
\]

**Case (3): Guarantees with recourse to deposit insurance and with partial repayments.** The SPV investment size depends on the bank investment \(\frac{dX_B^{rec}}{dX_B} > 0\), and the pair \((X_B^{rec}, X_I^{rec})\) is implicitly given by the system of equations (3.14)-(3.15).

**Lemma 3**

**Proof.** Using that in equilibrium \(X_I^{rec} = X_{SPV}^{rec}\) and substituting formula (3.19) for the variance \(\text{var}[\tilde{R}_{SPV}^{rec}]\), equation (3.14) can be rewritten as a quadratic equation

\[
(3.24) \quad 2\lambda R^2 p (1 - p) (X_I^{rec})^2 - \left[4\lambda R^2 p (1 - p) X_B - (pR - 1 - s)\right] X_I^{rec} + 2\lambda (p - p)(1 - p + p)(RX_B)^2 - (p - p)RX_B = 0,
\]

which has two solutions, given by

\[
X_I^{rec} = \frac{\left[4\lambda R^2 p (p - p) X_B - (pR - 1 - s)\right] \pm \sqrt{\Delta}}{4\lambda R^2 p (1 - p)},
\]

\[
\Delta = \left[4\lambda R^2 p (p - p) X_B - (pR - 1 - s)\right]^2 - 8\lambda R^2 p (1 - p) \left[RX_B (p - p)(2\lambda(1 - p + p)RX_B - 1)\right].
\]

There is only one positive solution to (3.24) if and only if it holds that

\[
2\lambda (1 - p + p)RX_B - 1 < 0 \iff X_B < \frac{1}{2(1 - p + p)\lambda}.
\]

The minimum equilibrium value of \(X_B\) is given by (3.13). Substituting yields

\[
\lambda < \frac{c}{(1 - p + p)R(p(R - (1 - k)R_D) - \delta k)} = \hat{\lambda}.
\]

The equilibrium individual investor’s demand is then given by

\[
(3.25) \quad X_I^{rec} = \frac{\left[4\lambda R^2 p (p - p) X_B - (pR - 1 - s)\right] + \sqrt{\Delta}}{4\lambda R^2 p (1 - p)}.
\]
The bank investment solves
\[ p(R - (1 - k)R_D)) - \delta k + \frac{dX_{B_{rec}}}{dX_B} = 2c X_B, \]
where
\[
\frac{dX_{B_{rec}}}{dX_B} = \frac{p - p}{1 - p} \left( 1 + \left[ 4\lambda R^2 p(p - p)X_B - (pR - 1 - s) + (1 - p)R(1 - 2\lambda(1 - p + p)RX_B) \right] \sqrt{\Delta} \right). 
\]

The term \( D \) and thus the whole derivative are positive as long as \( \lambda < \hat{\lambda} \). The first order condition (3.25) allows for multiple solutions. For a given solution to (3.25) to be higher than \( X_{B_{nr}} \) (the bank investment in absence of implicit guarantees), it needs to hold that
\[
p(R - (1 - k)R_D)) - \delta k + \frac{p - p}{1 - p} (1 + D) > p(R - (1 - k)R_D)) - \delta k \leftrightarrow 
\]
\[
\frac{p - p}{1 - p} (1 + D) > (p - p)(R - (1 - k)R_D)) \leftrightarrow \frac{1 + D}{1 - p} > (R - (1 - k)R_D)), 
\]
which always holds as long as \( D \) is positive and \( R - (1 - k)R_D < 1 \). \( \square \)

**Proposition 2**

*Proof. Case 1: Guarantees with recourse to bank capital.** Under recourse to bank capital, the ex post execution condition is
\[
\beta V_{rec} - RX_{SPV}^{rec} \geq \beta V_{nr} \leftrightarrow 
\]
\[
RX_{SPV}^{rec} \leq \beta(V_{rec}^{rec} - V_{nr}^{rec}) \leftrightarrow 
\]
\[
RX_{SPV}^{rec} \leq \frac{\beta s(X_{SPV}^{rec} - X_{SPV}^{nr})}{1 - \beta(p + (1 - p)q)}. 
\]

**Case 2: Guarantees with recourse to deposit insurance.** Accounting for the reduced continuation probability under guarantees with recourse to deposit insurance gives
\[
q\beta V_{rec} - (R - (1 - k)R_D)X_{B_{rec}} \geq \beta V_{nr} \leftrightarrow (R - (1 - k)R_D)X_{B_{rec}} \leq \beta(qV_{rec}^{rec} - V_{nr}^{rec}). 
\]
\( \square \)
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Lemma 4

Proof. Case 1: Guarantees with recourse to bank capital. The execution condition can be simplified to

$$\beta(V_{rec} - V_{nr}) - RX_{rec}^1 \leq 0 \iff \frac{(pR - 1 - s)p(1 - p)}{(pR - 1 - s)p(1 - p)} - \frac{As}{As - R} \geq 0,$$

where

$$A = \frac{\beta}{1 - \beta(p + (1 - p)q)}.$$

Taking the derivatives of the LHS of the execution condition with respect to $q$, and $s$ respectively yields

$$\frac{dA}{dq}sR > 0,$$

$$\frac{p(1 - p)p(1 - p)}{((pR - 1 - s)(pR - 1 - s))^2} + \frac{AR}{(As - R)^2} > 0.$$

Case 2: Guarantees with recourse to deposit insurance. The execution condition holds if

$$\beta \left[ q \left( \frac{\Pi_{rec}^B + sX_{SPV}^1}{1 - \beta(p + (1 - p)q)} - \frac{\Pi_{nr}^B + sX_{SPV}^1}{1 - \beta(p + (1 - p)q)} \right) \right] - X_{B}^1(R - (1 - k)R_D) \geq 0.$$

Moreover, taking the derivative with respect to $q$ gives

$$\beta \left[ \frac{(\Pi_{rec}^B + sX_{SPV}^1)(1 - \beta(p + (1 - p)q) + q(1 - p))}{(1 - \beta(p + (1 - p)q))^2} - \frac{\Pi_{nr}^B + sX_{SPV}^1}{(1 - \beta(p + (1 - p)q))^2} \beta(1 - p) \right],$$

which is positive for $\Pi_{rec}^B + sX_{SPV}^1$ sufficiently higher than $\Pi_{nr}^B + sX_{SPV}^1$, i.e. when $\lambda$ is sufficiently small. For recourse to deposit insurance with full repayments it holds that

$$\frac{d(\Pi_{rec}^B + sX_{SPV}^1 - \Pi_{nr}^B - sX_{SPV}^1)}{d\lambda} = s \left( \frac{- (pR - 1 - s)}{2\lambda^2p(1 - p)R^2} + \frac{pR - 1 - s}{2\lambda^2p(1 - p)R^2} \right) < 0.$$
For low $\lambda$, $X_{SPV}^{rec}$ has only one positive solution for a given $X_B^{rec}$, that is decreasing in $\lambda$, and thus $\Pi_B^{rec} + sX_{SPV}^{rec}$ is decreasing in $\lambda$ too.

**Lemma 5**

**Proof.** Taking the derivative of (3.17) with respect to $k$ gives

$$k^{nr} = \frac{(\delta + pR - 2pR_D)((1 - p)FR_D - (R_D - 1)) - (\delta - pR_D)p(R - R_D)}{(\delta - pR_D)(\delta + 2(R_D - 1) - pR_D - 2(1 - p)FR_D)}.$$  

Taking the derivative of $k^{nr}$ with respect to $F$ yields

$$\frac{dk^{nr}}{dF} = \frac{(pR - \delta)(1 - p)R_D}{(\delta + 2(R_D - 1) - pR_D - 2(1 - p)FR_D)^2},$$

which is always positive for $pR > \delta$.

**Lemma 6**

**Proof.** Keeping $k$ fixed, the net welfare effect of recourse to bank capital is

$$\text{Welfare}^{bc} - \text{Welfare}^{nr} = (\frac{1}{2} \left( (2pR - pR - 1)X_{SPV}^{full} - (pR - 1)X_{SPV}^{nr} \right) + \frac{1}{2} \left( (2pR - 1)(1 - p - p) + ppR^2(2p - 1) \right) - \lambda R^2 (p(1 - p)(X_{SPV}^{full})^2 - p(1 - p)(X_{SPV}^{nr})^2) =$$

which is always positive as $p + p - 1 < 2p - 1$ and $2pR - 1 < p^2R^2 < ppR^2$. The net welfare effect of recourse to deposit insurance with full repayments is

$$\text{Welfare}^{di,full} - \text{Welfare}^{nr} =$$

Two cases follow:

1. The net welfare effect of recourse to deposit insurance is increasing in $F$, and is
negative for $F < \frac{B - A_1}{(p - p)(R - (1 - k)R_D)(X_B^{nr} + (1 - p)R_D(1 - k) - RX_{SPV})^2} + 1 = \tilde{F}_1$ when

$$(R - (1 - k)R_D)(X_B^{nr} + (1 - p)R_D(1 - k)) - RX_{SPV} > 0 \iff \lambda > c\frac{(pR - 1)}{p(1 - p)R}\left(\frac{1}{R_D}ight)(1 - k)\delta k$$

2. The net welfare effect of recourse to deposit insurance is decreasing in $F$, and is negative for $F > \tilde{F}_1$ when $\lambda < \hat{\lambda}$. Both thresholds $\tilde{F}_1$ and $\hat{\lambda}$ depend on $k$ in a non-linear way.

For $\lambda < \hat{\lambda}$ and thus $X_B^{di,partial} > X_B^{nr}$, the net welfare effect is

$$\text{Welfare}^{di,partial} - \text{Welfare}^{nr} = \underbrace{\Delta \Pi_B + (1 - k)(X_B^{nr} - X_B^{di,partial})}_{A_2 < 0} + \frac{1}{2} \left[ (pR - 1)(X_{SPV}^{partial} - X_{SPV}^{full}) - (p - p)RX_{B}^{di,partial} \right] - \underbrace{(F - 1)(1 - k)R_D}_{B_2 \geq 0} \left[ (1 - p)X_B^{di,partial} - (1 - p)X_B^{nr} \right]_{C > 0}.$$ 

The net welfare effect is negative and decreasing in $F$ if

$$(3.28) \quad F > \frac{A_2 + B_2}{(1 - k)R_D \left[ (1 - p)X_B^{di,partial} - (1 - p)X_B^{nr} \right]} + 1 = \tilde{F}_2,$$

which is again a nonlinear function of $k$.

**Proposition 3**

*Proof.* I begin with the welfare under recourse to bank capital (minimum requirement $k^{nr}$) and under recourse to deposit insurance with partial repayments ($k^{di,p}$). For $k^{nr} > k^\ast$: (1) $k^{nr} < k^{di,p}$, and (2) $(1 - k^{nr})X_B^{nr} < (1 - k^{di,p})X_B^{di,p}$ for $\lambda < \hat{\lambda}$. The comparison yields

$$\text{Welfare}^{di,p} - \text{Welfare}^{bc} = \Delta \Pi_B + (1 - k^{nr})X_B^{nr} - (1 - k^{di,p})X_B^{di,p} + \underbrace{\frac{1}{2} \left[ (pR - 1)(X_{SPV}^{partial} - X_{SPV}^{full}) - (p - p)(RX_B^{di,p} - X_{SPV}^{full}) \right] - (F - 1)\left[ (1 - p)(1 - k^{di,p})R_DX_B^{di,p} - (1 - p)(1 - k^{nr})R_DX_B^{nr} \right]}_{< 0}.$$
The net welfare effect of recourse to deposit insurance is negative for the fiscal cost $F$ sufficiently high.

Comparing welfare under recourse to deposit insurance with full $(k^{di,f})$ and with partial repayments $(k^{di,p})$ for $k^{di,f} > k^*$ yields

$$\text{Welfare}^{di,p} - \text{Welfare}^{di,f} = \Delta \Xi \Pi_B + \frac{1}{2} \left[ (pR - 1)(X_{\text{SPV}}^{\text{part}} - X_{\text{SPV}}^{\text{full}}) - (p - p)(RX_{B}^{\text{di,p}} - X_{\text{SPV}}^{\text{full}}) \right] - (F - 1) \left[ (1 - p)(1 - k^{di,p})R_{D}X_{B}^{\text{di,p}} - (1 - k^{di,f})R_{D}X_{B}^{\text{di,f}} + (p - p)R(X_{B}^{\text{di,f}} - X_{\text{SPV}}^{\text{full}}) \right],$$

which is negative for $F$ high enough.

Comparing welfare under recourse to bank capital $(k^{nr})$ and under recourse to deposit insurance with full repayments $(k^{di,f})$ for $k^{nr} > k^*$ yields

$$\text{Welfare}^{di,full} - \text{Welfare}^{bc} = \Delta \Xi \Pi_B + \frac{1}{2} \left[ (1 - k^{nr})X_{B}^{nr} - (1 - k^{di,f})X_{B}^{di,f} \right] + (F - 1) \left[ (p - p)\left( (R - (1 - k^{di,f})R_{D})X_{B}^{di,f} - RX_{\text{SPV}}^{full} \right) + (1 - p)R_{D}\left( (1 - k^{nr})X_{B}^{nr} - (1 - k^{di})X_{B}^{di} \right) \right].$$

The whole expression is negative if

$$\lambda < \frac{(p - p)(pR - 1)}{p(1 - p)R \left[ (1 - k^{nr})X_{B}^{nr} - (1 - k^{di})X_{B}^{di} \right] + (p - p)(R - (1 - k^{di,f})R_{D})X_{B}^{di,f}} = \lambda_{\Pi}.$$

For $\lambda > \lambda_{\Pi}$, the net welfare effect is decreasing in the fiscal cost $F$.

**Lemma 7**

**Proof.** The condition to monitor bank project is

$$p_{H}(R - (1 - k)R_{D})X_{B}(p_{H}) - c(X_{B}(p_{H}))^{2} - \delta kX_{B}(p_{H}) - CX_{B}(p_{H}) + (p_{H} + (1 - p_{H})q)\beta V^{nr} \geq p_{L}(R - (1 - k)R_{D})X_{B}(p_{L}) - c(X_{B}(p_{L}))^{2} - \delta kX_{B}(p_{L}) + (p_{L} + (1 - p_{L})q)\beta V^{nr} \iff$$

$$C \leq \frac{\Xi \Pi_B(p_{H}) - \Xi \Pi_B(p_{L}) + (p_{H} - p_{L})(1 - q)\beta V^{nr}}{X_{B}^{nr}(p_{H})} = C_{nr}.$$
Lemma 8

Proof. With guarantees providing recourse to bank capital the BHC’s objective is

\[
\mathbb{E}I_B(p) + sX_{SPV}^{bc}(p) - (p - p_H)R_{text}^{bc}(p) - \mathbb{I}_{monitoring}^{bank}C_{X_B}^{rec}(p)
\]

\[
- \mathbb{I}_{monitoring}^{SPV}C_{X_{SPV}}^{rec}(p) + (p + (1 - p)q)\beta V^{nr},
\]

where \( \mathbb{I}_{monitoring} = 1 \) if the project is monitored. Monitoring of the SPV project \( (p = p_H) \) takes place if

\[
(p - p_H)R_{SPV}^{bc}(p) - C_{X_{SPV}}^{rec}(p) \geq (p - p_L)R_{SPV}^{bc}(p) \Leftrightarrow
\]

\[
C < R(p_H - p_L) = C_{bc_{SPV}}.
\]

When \( C \leq C_{bc_{SPV}} \), the condition to monitor the bank project is

\[
\mathbb{E}I_B(p_H) + sX_{SPV}^{bc}(p_H) - (p_H - p_H)R_{SPV}^{bc}(p_H) - C_{X_B}^{rec}(p_H) - C_{X_{SPV}}^{bc}(p_H) \geq
\]

\[
\mathbb{E}I_B(p_L) + sX_{SPV}^{bc}(p_L) - (p_H - p_L)R_{SPV}^{bc}(p_L) - C_{X_B}^{rec}(p_L) - C_{X_{SPV}}^{bc}(p_L) \Leftrightarrow
\]

\[
C \leq \frac{\Delta \mathbb{E}I_B + (s + p_H R)\Delta X_{SPV}^{rec} - R(p_H X_{SPV}^{rec}(p_H) - p_L X_{SPV}^{rec}(p_L)) + (p_H - p_L)(1 - q)\beta V^{nr}}{\Delta X_{SPV}^{rec} + X_{B}^{bc}(p_H)} = C_{1_{bc}}.
\]

When \( C > C_{bc_{SPV}} \), the condition to monitor the bank project is

\[
\mathbb{E}I_B(p_H) + sX_{SPV}^{bc}(p_H) - (p_H - p_H)R_{SPV}^{bc}(p_H) - C_{X_B}^{rec}(p_H) \geq
\]

\[
\mathbb{E}I_B(p_L) + sX_{SPV}^{bc}(p_L) - (p_L - p_L)R_{SPV}^{bc}(p_L) - C_{X_B}^{rec}(p_L) \Leftrightarrow
\]

\[
C \leq \frac{\Delta \mathbb{E}I_B + (s + p_H R)\Delta X_{SPV}^{rec} - R(p_H X_{SPV}^{rec}(p_H) - p_L X_{SPV}^{rec}(p_L)) + (p_H - p_L)(1 - q)\beta V^{nr}}{X_{B}^{bc}(p_H)} = C_{2_{bc}}.
\]

Lemma 9

Proof. With guarantees providing recourse to deposit insurance and can be fully repaid, the BHC’s objective is

\[
\mathbb{E}I_B(p) + sX_{SPV}^{rec}(p) - \mathbb{I}_{monitoring}^{bank}C_{X_B}^{rec}(p) - \mathbb{I}_{monitoring}^{SPV}C_{X_{SPV}}^{rec}(p) + (p + (1 - p)q)\beta V^{nr}.
\]

Monitoring of the bank project takes place if

\[
sX_{SPV}^{rec}(p_H) - \mathbb{I}_{monitoring}^{bank}C_{X_B}^{rec}(p) - \mathbb{I}_{monitoring}^{SPV}C_{X_{SPV}}^{rec}(p_H) \geq sX_{SPV}^{rec}(p_L) - \mathbb{I}_{monitoring}^{SPV}C_{X_{SPV}}^{rec}(p_L).
\]
Depending if the SPV project is monitored or not, this is equivalent to
\[
C \leq \frac{s [X_{SPV}(p_H) - X_{SPV}(p_L)]}{X_{SPV}^r(p_H) + X_{SPV}^r(p_H) - X_{SPV}^r(p_L)} = \overline{C}_{DI}^{SPV},
\]
\[
C \leq \frac{s [X_{SPV}(p_H) - X_{SPV}(p_L)]}{X_{SPV}^r(p_L)} = \overline{C}_{DI}^{SPV},
\]
respectively. Monitoring of the SPV project takes place if
\[
E\Pi_B(p_H) - \tau_{monitoring}^B X_{SPV}^r(p_H) - \tau_{monitoring}^B X_{SPV}^r(p) + (p_H + (1 - p_H)q)\beta V^{nr} \geq E\Pi_B(p_L) - \tau_{monitoring}^B X_{SPV}^r(p_L) + (p_L + (1 - p_L)q)\beta V^{nr}.
\]
Depending if the bank project is monitored or not, this is equivalent to
\[
C \leq \frac{E\Pi_B(p_H) - E\Pi_B(p_L) + (p_H - p_L)(1 - q)\beta V^{nr}}{X_{SPV}^r(p_H) + X_{SPV}^r(p_H) - X_{SPV}^r(p_L)} = \overline{C}_{DI}^{SPV},
\]
\[
C \leq \frac{E\Pi_B(p_H) - E\Pi_B(p_L) + (p_H - p_L)(1 - q)\beta V^{nr}}{X_{SPV}^r(p_L)} = \overline{C}_{DI}^{SPV},
\]
respectively.
Chapter 4

Banking union optimal design under moral hazard

4.1 Introduction

The global financial crisis ignited the debate around a common regulatory framework for European banks. The International Monetary Fund (2013) emphasized the threat of contagion, since bank sectors in Europe are highly interconnected. Figure 4.1 documents asymmetric exposures, with larger Eurozone economies (e.g., Germany, France, and the Netherlands) as net creditors to Greece, Ireland, Italy, Portugal, and Spain (GIIPS). The Dexia and Fortis bailouts unveiled the need for coordinated regulatory response at the supranational level. Is a single regulator also stricter with insolvent systemic institutions? Not necessarily: In January 2012 the European Central Bank (ECB) insisted that the Irish government repay senior debt in the Anglo-Irish bank at face value. At the same time, the Irish national bank was willing to impose haircuts.

The contribution of our analysis is twofold. From a positive perspective, we argue that a single-resolution mechanism (SRM) generates tension between increased regulatory efficiency in responding to bank defaults, on the one hand, and weaker commitment to liquidate failed systemic institutions, on the other hand. The size of the interbank market and the risk taking incentives of banks have a complex effect on this trade-off. The net welfare effect can be negative if banks hold complex assets, for which poor risk management standards have a large impact on asset returns.

This chapter is based on joint work with Marius A. Zoican.
Figure 4.1: Dynamics of Eurozone interbank foreign exposures (upper Figure), and share of claims against GIIPS countries and total positions (bottom Figure)

This figure describes interbank exposures across Eurozone banks. Panel A shows the exposure of Eurozone banks in 11 countries (GIIPS countries, Austria, Germany, Finland, France, the Netherlands, and Portugal) to the European banking sector, in both absolute terms and as a fraction of total foreign exposure. Panel B presents the net and total international balances of banks from selected countries against GIIPS countries between 2008:Q1 and 2013:Q1. The size of the marker is proportional to the total position. Source: Bank for International Settlements.
4.1. Introduction

From a normative perspective, we study the optimal mandate of a banking union, particularly the single-resolution mechanism. Restricting the banking union’s mandate can restore incentives and improve welfare. The best way to allocate bank default interventions between national and supranational regulators depends on bank risk-taking incentives and expected asset returns. Furthermore, we discuss the effect of moral hazard on the resolution fund shares for the members of the banking union.

In the model, the banking union is defined as an ex post resolution mechanism. Given the default of a financial intermediary in any of the participating countries, the banking union must decide between two possible policies: either a costly bailout financed by the taxpayers or an inefficient liquidation of the bank’s assets. The costs of both these policies are shared between union members according to an ex ante contract. The cross-border links between banks create the scope for default contagion, as noted by Freixas, Parigi, and Rochet (2000) and Allen and Gale (2000). Banks endogenously choose the risk of their portfolios as a function of the regulatory environment.

The banking union eliminates costly regulatory interventions for banks failing due to international contagion, despite profitable domestic activity. It thus eliminates cross-border spillover effects, improving the efficiency of liquidity provision. The fiscal burden for taxpayers is reduced. The enhanced efficiency, however, comes at a price. Liquidation or bail-in threats under a banking union become less credible: Systemically important banks are bailed out more often to avoid domino defaults. Their incentives to monitor risks are reduced; consequently, systemic banks become more fragile. For a more asymmetric deposit base across countries and for moderate intensities of the moral hazard problem, the incentive effect dominates and the banking union reduces welfare. Without the banking union, larger international liabilities strengthen the national regulator’s commitment not to bail out a defaulting bank. In other words, the cross-border interbank market acts as a disciplining force.

For very low short-term asset returns, however, the relative leniency of a banking union improves risk-taking incentives. In this situation, debtor banks strategically reduce their foreign borrowing under national regulation to induce bailouts upon default. A banking union is more lenient and debtor banks can increase their borrowing without triggering liquidation in the insolvency state. Thus, the banking union stimulates cross-border trading while the bailout policy is unchanged. The additional interbank return for the debtor bank helps to reduce risk-taking incentives.

The normative part of the chapter focuses on optimal institutional design. If the banking union distorts incentives, a limited mandate is preferred: The joint regulator resolves only a limited subset of banks defaults, the rest falling under national jurisdiction. The optimal limited mandate depends on the intensity of the moral hazard
problem, as well as on the expected returns on bank projects. There is a trade-off between restoring incentives by reducing the scope of the banking union and limiting its benefits. For relatively low moral hazard, the less restrictive mandate is chosen; as moral hazard increases, the mandate of the banking union should be further limited.

Net creditor countries on the international banking market contribute more than proportionally to joint resolution costs, since they are the main beneficiaries of eliminating the default spillover. If the banking union increases risk taking incentives, the maximum resolution fund share for creditor countries diminishes. Most importantly, in the presence of distorted incentives, the set of feasible resolution fund contracts shrinks dramatically. The reason is twofold. First, defaults become more likely: Although cost sharing reduces the fiscal cost of a given bank default, creditor countries intervene more often. Second, under national regulation, debtor countries have a credible commitment device to liquidate defaulting banks since they do not internalize cross-border spillovers. The commitment is lost under the banking union and the welfare surplus is reduced for debtor countries.

The rest of the chapter is organized as follows. Section 4.2 reviews the relevant literature. Section 4.3 presents the model. Section 4.4 discusses optimal resolution policies and welfare implications. Section 4.5 focuses on the banking union design, namely the optimal mandate and resolution fund structure. Section 4.6 extends the baseline model to analyze the impact of a banking union on interbank markets. Section 4.7 concludes the study.

4.2 Related literature

Our study contributes to the expanding literature on financial institution design and banking regulation in the following ways. First, it integrates moral hazard into a cross-border banking model with endogenous regulatory architecture. Second, it offers policy proposals on the optimal design of a joint resolution mechanism, evaluating both the mandate of a banking union and the structure of the resolution fund. Third, it offers insights into the effects of the banking union on the interbank market.

The model shares the same interbank contagion mechanism as Beck, Todorov, and Wagner (2011) and Colliard (2013). However, their models abstract from ex ante banks risk taking incentives, as well as optimal design analysis. For Colliard (2013), moral hazard is due to local supervisors’ monitoring decisions rather than bank risk taking. In the same spirit, Philippon (2010) argues that coordinated bank bailouts can improve overall system efficiency, whereas individual countries might not have the incentives to
bail out their own financial system. Foarta (2014) looks at the banking union from a political economy perspective and argues that, with imperfect electoral accountability, a banking union can encourage rent-seeking behavior for politicians in debtor countries and reduce welfare.

Our analysis relates to the literature on bank default contagion and moral hazard. Acharya and Yorulmazer (2007), Farhi and Tirole (2012), and Eisert and Eufinger (2013) argue that banks coordinate on risk and network choices to benefit from larger government guarantees, generating a “too many to fail” problem. Despite the existence of contagion risk, Brusco and Castiglionesi (2007) and Allen, Carletti, and Gale (2009) argue in favour of financial integration: Markets improve welfare through coinsurance benefits. Additionally, Rochet and Tirole (1996) point out the certification role played by the interbank market. The role of regulatory cooperation in preventing systemic crises, close in spirit to the banking union, is discussed by Freixas, Parigi, and Rochet (2000) and Kara (2012).

A number of papers study the weak commitment of regulators to liquidating defaulting banks: Mailath and Mester (1994), Freixas (1999), Perotti and Suarez (2002) for an analysis of the role of charter values, Cordella and Yeyati (2003) for the relation with leverage, and Acharya and Yorulmazer (2008), who distinguish between various intervention rules. Allen, Carletti, Goldstein, and Leonello (2013) show that authorities with deeper pockets face a more severe commitment problem, even if governments can fail to provide full deposit insurance (giving rise to “fundamental panics”). Our model extends the analysis to discuss weak commitment problems for a supranational regulator.

A number of relevant policy papers analyze the European banking union from an empirical and institutional point of view: Schoenmaker and Gros (2012), Carmassi, Di Noia, and Micossi (2012), and Ferry and Wolff (2012) for fiscal alternatives and Schoenmaker and Siegmann (2013) for an analysis of cross-border externalities. Schoenmaker and Wagner (2013) propose a methodology to compare the benefits and costs of financial integration. Our model complements the policy discussion by providing a mechanism design perspective on the European banking union.

4.3 Model

4.3.1 Primitives

The model primitives follow Acharya and Yorulmazer (2008) and Beck, Todorov, and Wagner (2011). We consider an economy with four dates, $t \in \{-1, 0, 1, 2\}$, and two
countries, labeled A and B. In each country are four types of agents: a bank (BK_A and BK_B), a local regulator (RG_A and RG_B), depositors, and “deep-pockets” outside investors. On date \( t = -1 \), local regulators decide whether to merge into a supranational banking union \( RG_{BU} \).

**Depositors.** Depositors receive heterogeneous endowments on date \( t = 0 \): Depositors receive \( 1 + \gamma \) units in the country A (the “rich” country) and \( 1 - \gamma \) units in country B (the “poor” country), where \( \gamma \in (0, 1] \). They can invest their endowment in the domestic bank for a return \( r > 1 \) on the final date. On the intermediate date, as for Diamond and Dybvig (1983), a fraction \( \phi \) of depositors randomly receive a liquidity shock. Consequently, they withdraw their deposits at zero interest. Depositors are fully insured by the regulator. Hence, there is no bank run equilibrium.

The heterogeneity in deposits ensures that interbank cash flows do not net out in equilibrium for any given bank. Exposure spillover from debtors to creditors is analyzed in a parsimonious framework, without introducing a complex network structure. Such an assumption is not unrealistic: Banks in emerging countries, for example, usually have investment opportunities that exceed their deposit base and draw funds from banks in developed countries.

**Long-term assets.** Both banks have access to a productive technology with constant returns to scale that requires an investment of \( I \in [0, 1] \) on date \( t = 0 \) and generates returns at both \( t = 1 \) and \( t = 2 \). The investment yields a country-specific stochastic return at \( t = 1 \) of \( \tilde{R}_1 = \{0, R_{1A}^B\} \) per unit for BK_A and \( \tilde{R}_1 = \{0, R_{1B}^B\} \) for BK_B. The second period’s return per unit of investment is deterministic and equal to \( R_2 > 1 \) for both banks. In addition, banks have access to a zero-return cash storage technology.

**Assumption 1.** The following conditions on \( R_{1A}^A \) and \( R_{1B}^B \) hold:

1. The maximum project proceeds at \( t = 1 \) cover all liquidity shocks. There is no default if both projects are successful: \( R_{1A}^A + R_{1B}^B \geq 2\phi \).

2. Bank BK_A cannot cover the liquidity shock without investing on the interbank market: \( R_{1A}^A + \gamma \leq (1 + \gamma)\phi, \forall \gamma \in (0, 1] \). The assumption is relaxed in Section 4.6.

Only domestic banks can directly invest in their country specific opportunities, whereas foreign banks have to use them as an intermediary. One can think of this assumption as a form of local expertise.
4.3. Model

**Monitoring.** There is moral hazard as for Holmstrom and Tirole (1997). Banks can choose whether to monitor their portfolios. The probability of success at \( t = 1 \) is dependent on the banks’ monitoring decisions.

If a bank monitors its loans, \( \mathbb{P}(\tilde{R}_1 = R_1) = p_H \) but the bank manager pays a monitoring cost \( C \). If it chooses not to monitor, then the probability of a positive return at \( t = 1 \) is reduced to \( p_L < p_H \). The difference \( p_H - p_L \) is denoted \( \Delta p \). Bank effort is not observable or verifiable by the national regulator or the banking union.

**Interbank market.** At \( t = 0 \), \( BK_A \) can lend any excess funds (not invested in long-term assets) on the interbank market to \( BK_B \). The interbank loans are short term (they mature at \( t = 1 \)) and yield a gross return of \( r^I \). The interbank market size \( \gamma^I \) and the interest rate \( r^I \) are set in two steps:

1. Bank \( BK_B \) communicates to \( BK_A \) the interest rate \( r^I \) at which it is willing to borrow funds.

2. Given \( r^I \), \( BK_A \) chooses the size of the loan \( \gamma^I \) that maximizes its expected profit.

The bank \( BK_B \) has full market power on the interbank market; thus, \( BK_A \) is a competitive creditor. The assumption guarantees that \( BK_A \) cannot strategically restrict lending to influence the foreign regulator’s decision. Alternatively, a representative competitive \( BK_A \) is equivalent to a continuum of banks in the rich country competing for limited investment opportunities abroad.

**Regulator.** We model the regulator’s decision according to Acharya and Yorulmazer (2008). A regulator can either bail out defaulting banks at \( t = 1 \), by providing them with additional liquidity, or liquidate them, selling their assets to outside investors.\(^1\) In the case of a bailout, the bank owners continue to operate the loan portfolio at \( t = 2 \). In the case of a liquidation, outside investors can only obtain \( (1 - L) R_2 \) at \( t = 2 \) per unit of investment, where \( L \in (0, 1) \).

The regulator incurs a linear fiscal cost for the cash it injects into the banking sector. For each monetary unit invested in a regulatory intervention, \( F \) units have to be raised in taxes, where \( F \in (1, \frac{1}{1-L}) \). A marginal fiscal cost of intervention larger than one reflects the distortionary character of taxes. The regulator’s objective function is to maximize total welfare in its own country at \( t = 2 \). The welfare measure is defined as the sum of payoffs for all agents in the economy.

\(^1\)The model outcomes are the same if the liquidated assets are managed by the regulator.
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The condition $F < \frac{1}{1-L}$ is imposed to ensure that there are no “profitable liquidations.” The fiscal proceeds from liquidated assets are always lower than the actual face value of the debt.

**Assumption 2.** The proceeds from bank liquidation are not sufficient to pay domestic depositors in full:

$$\frac{1}{1-L} R_2 \leq \phi (1 - \gamma) + (1 - \phi)(1 - \gamma) r.$$  

Hence, foreign creditors lose their whole investment.

The banking union is a special type of regulator that can choose whether to bail out a particular defaulting bank. The banking union can have a partial mandate, acting as a resolution authority only in some states of the world. The contribution to the resolution fund for each union member is set at $t = -1$ as a fraction of the intervention cost. The banking union’s objective function is to maximize joint welfare — the sum of payoffs for all agents in both countries — as opposed to welfare in a single country.

The regulatory architecture, that is, national regulation, a full or a partial mandate banking union, is contracted upon at $t = -1$ and is not renegotiable. Regulators cannot, however, commit to a particular type of intervention given a bank default.

**Timeline.** The timeline is illustrated in Figure 4.2.
4.3. Model

\( t=-1 \)  
\( R_G^A \) and \( R_G^B \) decide whether to form a banking union (\( R_G^{BU} \))

\( t=0 \)

1. \( B_K^A \) and \( B_K^B \) collect deposits.
2. \( B_K^A \) and \( B_K^B \) determine the interbank rate.
3. Funds are exchanged on the interbank market, maturing at \( t=1 \).
4. Banks give loans to local firms and decide to monitor them (\( M \)) or not (\( N M \)).

\( t=1 \)

For each bank, \( \tilde{R}_1 \) is realized

\[ \tilde{R}_1 = R_1 \]

1. Banks pay demand deposits.
2. Interbank loans mature and creditors are paid.

\( \tilde{R}_1 = 0 \)

RG (\( R_G^{BU} \)) resolution

- Liquidation
  1. Bank assets sold for \( (1 - L) R_2 \)
  2. Domestic claims net of \( (1 - L) \) raised at marginal cost \( F > 1 \)
  3. Only domestic depositors paid out.

- Bailout
  1. Short term claims paid by \( R_G \) at marginal cost \( F > 1 \)

\( t=2 \)

Loans payoff: \( (1 - L) R_2 \).

Loans payoff: \( R_2 \).

Loans payoff: \( R_2 \).

Figure 4.2: Model timing
4.3.2 A closed economy example

To build intuition, this section provides a simplified analysis of the disciplining role of bailouts. To this end, consider a closed economy: a single bank with one unit of deposits and one regulator deciding on bank resolution at $t = 1$.

There is no international banking market and the regulator decides to bail out a failing bank if the fiscal cost of providing liquidity is lower than the efficiency loss from transferring $BK_A$’s assets to outside investors. Liquidation threats are credible to the extent that bailouts are fiscally (and politically) costly, as also argued by Acharya and Yorulmazer (2008).

Bank monitoring choice. If the bank monitors, it earns $R_1 - \phi$ in the first period with probability $p_H$ and continues to the second period without the need for government intervention. With probability $(1 - p_H)$, it fails to produce a positive return in the first period. Then it earns profit at $t = 2$ profit if and only if the regulator decides to bail it out. The expected profit of $BK_A$ is a function of the monitoring decision ($\pi_{BK}$), given by

$$\pi_{BK} (\text{Monitor}) = p_H (R_1 + R_2 - (\phi + (1 - \phi) r)) + (1 - p_H) (R_2 - (1 - \phi) r) I_{\text{Bailout}} - C,$$

$$\pi_{BK} (\text{Not Monitor}) = p_L (R_1 + R_2 - (\phi + (1 - \phi) r)) + (1 - p_L) (R_2 - (1 - \phi) r) I_{\text{Bailout}}.$$

where the indicator variable $I_{\text{Bailout}}$ takes the value one if the regulator decides to bail out the bank (and zero otherwise). The incentive compatibility constraint can be written as

$$\pi_{BK} (\text{Monitor}) \geq \pi_{BK} (\text{Not Monitor}).$$

Simplifying, this leads to

$$\frac{C}{\Delta p} \leq R_1 - \phi + (R_2 - (1 - \phi) r) (1 - I_{\text{Bailout}}).$$

The incentive compatibility constraint is loosened when $I_{\text{Bailout}} = 0$. When the regulator does not bail out the bank, the bank chooses to monitor even for larger costs $C$ and smaller $\Delta p$, since otherwise it forgoes the second-period profits at $t = 2$.

Resolution choice. The regulator decides to bail out the bank if the fiscal cost incurred at time $t = 1$ to provide $\phi$ (such that the bank pays all demand deposits) is lower than the efficiency loss from selling $BK_A$’s assets to outside investors.
4.4. The impact of a full mandate banking union

Welfare includes the final wealth of the banker, depositors, and outside investors, minus the costs of the fiscal intervention. The cost of the fiscal intervention is equal to the regulator’s payment to depositors minus any bank liquidation proceeds, multiplied by the marginal fiscal cost $F$. By assumption, the cost of the fiscal intervention is always positive (liquidation proceeds are never sufficient to pay depositors). The policy-dependent expressions for welfare are

\[
\text{Welfare}_{\text{Bailout}} = R_2 - \left( F - 1 \right) \phi ,
\]

\[
\text{Welfare}_{\text{Liquidation}} = R_2 - 2 L R_2 + R_2 (1 - L) (F - 1) - \left( \phi + (1 - \phi) r \right) (F - 1) .
\]

The bailout condition is given by $\text{Welfare}_{\text{Bailout}} - \text{Welfare}_{\text{Liquidation}} \geq 0$, or

\[
R_2 \left( 1 - F (1 - L) \right) \geq (1 - F) (1 - \phi) r .
\]

For $F \in \left( 1, \frac{1}{1-L} \right)$ the left-hand side of equation (4.5) is larger than zero, and the right-hand side is smaller than zero. Hence, the bank is always bailed out and the regulator cannot commit to a liquidation resolution policy that will lead to better incentives for the bank.

4.4 The impact of a full mandate banking union

In this section, equilibrium monitoring and resolution strategies, as well as total welfare, are determined for both a banking union with full mandate and national resolution systems. Banks are allowed to operate on international markets, the status quo in the European Union (EU).

A full mandate banking union is defined as a resolution authority with the power to decide between the bailout and liquidation of any defaulting bank, in all possible states of the world. Its objective function is to maximize the joint welfare of participating countries. By contrast, national regulators focus only on domestic welfare, ignoring cross-border externalities generated by bank default.
4.4.1 Cross-border spillover mechanism under national bank resolution

Conditional on $BK_B$’s default, $RG_B$ decides between bailout and liquidation, with different consequences for uninsured foreign debt holders. If the regulator opts for a bailout, it has to provide sufficient funds to satisfy the claims of both the domestic as well as foreign creditors of the defaulting bank. In the case of liquidation, the proceeds are only used to cover insured domestic depositors in country B. The bank in country A does not receive any of its claims (see Assumption 2). Consequently, $RG_A$ must also intervene and provide costly liquidity to a distressed $BK_A$.

For a bailout, $RG_B$ provides a liquidity injection of $\phi (1 - \gamma) + r^I \gamma$. In a liquidation, $RG_B$ covers only the domestic depositors’ claims, $\phi + (1 - \phi) r$, partly from liquidation proceeds. The ex post welfare in the case of a bailout (Welfare$^B_{\text{Bailout}}$) and in the case of a liquidation (Welfare$^B_{\text{Liquidation}}$) is, respectively,

\begin{align*}
\text{Welfare}^B_{\text{Bailout}} &= R_2 + \phi (1 - \gamma) - F \left[ \phi (1 - \gamma) + r^I \gamma \right], \\
\text{Welfare}^B_{\text{Liquidation}} &= R_2 - L \times R_2 + R_2 (1 - L) (F - 1) - \left[ (\phi + (1 - \phi) r) (1 - \gamma) \right] (F - 1).
\end{align*}

Welfare conditional on liquidation is computed as the cash receipts of insured depositors minus the regulator’s net costs. Hence, $BK_B$ is bailed out by regulator $RG_B$ if the welfare after a bailout exceeds the welfare after a liquidation, conditionally equivalent to:

\begin{equation}
R_2 (1 - F (1 - L)) \geq (1 - F) (1 - \phi) (1 - \gamma) r + Fr^I \gamma.
\end{equation}

The outcome for $BK_A$ is a function of the resolution policy in country B, since the proceeds from the interbank loan are wiped out in the case of a liquidation. First, if equation (4.7) holds and $BK_B$ is bailed out, $BK_A$ is able to pay all liquidity demands and continues operating to $t = 2$ without any regulatory intervention. Otherwise, if $BK_B$ is liquidated, then $BK_A$ defaults too, prompting regulatory intervention. Regulator $RG_A$ steps in and bails out $BK_A$ if the domestic welfare after a bailout is at least equal to the welfare after a bank liquidation:

\begin{equation}
\text{Welfare}^A_{\text{Bailout}} = R_2 + \phi (1 + \gamma) - F [\phi (1 + \gamma)],
\end{equation}
The impact of a full mandate banking union

Welfare_{Liquidation}^{A} = R_{2} \times R_{2} + R_{2} (1 - L) (F - 1) - (\phi + (1 - \phi) r) (1 + \gamma) (F - 1).

The bailout condition is given by

\begin{equation}
R_{2} (1 - F (1 - L)) \geq (1 - F) (1 - \phi) (1 + \gamma) r.
\end{equation}

In addition to the spillover scenario described above ($BKB$ defaulting and $BKA$ being successful at $t = 1$), there are other three possible states of the world, depending on the realization of $R_{1}^{i}$, which are similar to the one country setting in Section 4.3.2.

4.4.2 National resolution equilibrium

Proposition 4 describes the optimal resolution policies for national regulators, as well as the monitoring choices of banks under national regulation.

Proposition 4. Under national bank regulation, the following holds:

1. **Resolution policy.** Regulator $RGA$ always bails out local bank $BKA$. Regulator $RG_{B}$ bails out local bank $BKB$ if $\gamma \leq \gamma^{*}$, where the threshold interbank market size is

\begin{equation}
\gamma^{*} = \frac{R_{2} (1 - F (1 - L)) + (F - 1) (1 - \phi) r + F (R_{1}^{A} - \phi)}{F\phi + (F - 1) (1 - \phi) r}.
\end{equation}

2. **Monitoring decisions.** Bank $BKA$ never monitors. For $\gamma < \gamma^{*}$, monitoring is optimal for $BKB$ only if the moral hazard problem is low enough: $\frac{C}{\Sigma p} \leq c_{1}$. If $\gamma \geq \gamma^{*}$, monitoring is optimal if $\frac{C}{\Sigma p} \leq c_{2}$, where $c_{2} > c_{1}$. The moral hazard thresholds are given by $c_{1} = R_{1}^{A} + R_{1}^{B} - 2\phi$ and $c_{2} = c_{1} + R_{2} - (1 - \phi) (1 - \gamma) r$ respectively.

3. **Interbank market.** The interbank market clears at a rate $r_{I} = \frac{\phi (1 + \gamma) - R_{1}^{A}}{\gamma}$.

The spillover mechanism and equilibrium resolution policies are further detailed in Figure 4.3.
This figure shows the mechanism through which shocks are transmitted across borders in the model. For \( \gamma < \gamma^* \), there is no spillover effect; if \( BK_B \) defaults, it is bailed out and can pay its short-term debt to \( BK_A \). Conversely, if \( \gamma \geq \gamma^* \), the national regulator liquidates \( BK_B \) and none of the proceeds reach \( BK_A \). An (inefficient) intervention of the national regulator in country A is now necessary.

The first part of Proposition 4 states that for large enough interbank markets, \( BK_B \) will never be bailed out. In the case of default, \( RG_B \) has to repay the short-term international debt if it wants to avoid liquidating \( BK_B \). However, it does not internalize the welfare transfer abroad. Since a larger \( \gamma \) implies a larger international transfer, the domestic gains from the bailout of \( BK_B \) decrease with \( \gamma \). Over a certain interbank market size threshold (\( \gamma^* \), as defined in equation (4.11)), the liquidation loss is relatively smaller and \( BK_B \) is liquidated.

The intuition behind \( BK_A \) always being bailed out relies on the fact that the regulator internalizes the welfare of depositors. Unlike in the case of \( BK_B \), no funds leave the country. Furthermore, if \( BK_A \) succeeds at \( t = 1 \) or is bailed out, international inflows alleviate \( BK_A \)’s liquidity needs. Since bailouts are cheaper than liquidation, \( RG_A \) has no ex post mechanism to impose a higher level of discipline ex ante by offering monitoring incentives.

Bank \( BK_A \) never monitors its loans: Its profit on the intermediate date is zero due to \( BK_B \) having full bargaining power; the full profit at \( t = 2 \) is guaranteed by
the equilibrium bailout strategy. The interbank market plays a twofold disciplining role for $BK_B$, through both improved regulatory commitment and leverage effects. First, liquidation threats become a credible instrument for $\gamma > \gamma^*$. As bailouts become suboptimal, failure would lead to foregoing the profit not only at $t = 1$, but also at $t = 2$. Bank $BK_B$’s incentives to monitor jump at $\gamma = \gamma^*$ and then increase linearly with $\gamma$ due to the leverage effect on profits at $t = 2$.

![Figure 4.4: Equilibrium monitoring decisions of $BK_B$ under national regulation](image)

This figure shows the monitoring indifference curve of $BK_B$ with a national resolution policy. For a given interbank market size and monitoring cost, $BK_B$ monitors in the shaded region (below the indifference curve). Note that the liquidation threat becomes credible for $\gamma \geq \gamma^*$ and the bank has better incentives to monitor its loans.

### 4.4.3 Banking union equilibrium

The two national regulators are replaced by a single supranational regulator $RG_{BU}$ operating a common bank resolution mechanism. The regulator’s objective is to maximize the joint welfare in the two member countries, where

$$
(4.12) \quad [\text{Welfare}^A + \text{Welfare}^B]_{\text{Bailout}} \geq [\text{Welfare}^A + \text{Welfare}^B]_{\text{Liquidation}}.
$$

Given the new bailout rule (4.12), the decisions of the joint regulator differ from those in the national resolution case. Proposition 5 summarizes the equilibrium under the common resolution mechanism.

**Proposition 5.** Under the banking union, the following holds:
1. **Resolution policy.** Regulator RG$_{BU}$ always bails out a defaulting bank.

2. **Monitoring decisions.** Monitoring is never optimal for BK$_A$. Bank BK$_B$ monitors if and only if the moral hazard problem is lower than the threshold $\frac{C}{\Delta p} \leq c_1$, with $c_1$ defined in Proposition 4. The monitoring strategies of BK$_B$ and BK$_A$ are mutually independent.

3. **Interbank market.** The interbank market clears at a rate $r_I = \frac{\phi(1+\gamma) - R\Delta}{\gamma}$.

As opposed to the national regulation benchmark case, the common regulator always bails out BK$_B$, independent of the size of the interbank market, $\gamma$. Intuitively, this happens because the supranational regulator internalizes the negative effect the liquidation of BK$_B$, through interbank exposure, will have on BK$_A$. To avoid further welfare losses, regulator RG$_{BU}$ always bails out BK$_B$.

The bank in country B also monitors less under a banking union. Since the joint regulator cannot credibly commit to liquidation for any $\gamma$, the payoff at $t = 2$ is guaranteed for BK$_B$; the only incentive to monitor is generated by the expected profits at $t = 1$. For $\gamma > \gamma^*$, this is equivalent to a banking union decreasing monitoring incentives for financial intermediaries.

The equilibrium decisions under both national and joint resolution are summarized in Table 4.1.
4.4. The impact of a full mandate banking union

Table 4.1: Resolution and monitoring equilibrium decisions.

This table presents the regulator’s resolution decision on defaulted banks, as well as the monitoring decisions of individual banks. The decisions depend on the size of the interbank market ($\gamma$), the monitoring cost scaled by the shift in the project’s probability of success ($\frac{C \Delta p}{\phi}$), and the regulatory environment, whether national or a banking union. The interbank market threshold is defined as

$$\gamma^* = \frac{R_2 (1 - F (1 - L)) + (F - 1) (1 - \phi) r + F \left( R_1^A - R_2 A \right)}{F \phi + (F - 1) (1 - \phi) r}.$$ 

The monitoring thresholds are defined as $c_1 = 2 (R_1^B - \phi)$ and $c_2^B = c_1 + R_2 - (1 - \phi) (1 - \gamma) r$. The highlighted cells point out differences between the national resolution system and the banking union.

<table>
<thead>
<tr>
<th>$\gamma$ range</th>
<th>$\frac{C \Delta p}{\phi}$ range</th>
<th>Regulator</th>
<th>Resolution upon bank default</th>
<th>Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma &lt; \gamma^*$</td>
<td>$(0, c_1)$</td>
<td>all</td>
<td>bailout</td>
<td>bailout</td>
</tr>
<tr>
<td>$\gamma &gt; \gamma^*$</td>
<td>$(0, c_1)$</td>
<td>national</td>
<td>bailout</td>
<td>liquidation</td>
</tr>
<tr>
<td>$\gamma &gt; \gamma^*$</td>
<td>$(0, c_1)$</td>
<td>banking union</td>
<td>bailout</td>
<td>bailout</td>
</tr>
<tr>
<td>$\gamma &gt; \gamma^*$</td>
<td>$(c_1, c_2)$</td>
<td>national</td>
<td>bailout</td>
<td>liquidation</td>
</tr>
<tr>
<td>$\gamma &gt; \gamma^*$</td>
<td>$(c_1, c_2)$</td>
<td>banking union</td>
<td>bailout</td>
<td>bailout</td>
</tr>
<tr>
<td>$\gamma &gt; \gamma^*$</td>
<td>$(c_2, \infty)$</td>
<td>national</td>
<td>bailout</td>
<td>liquidation</td>
</tr>
<tr>
<td>$\gamma &gt; \gamma^*$</td>
<td>$(c_2, \infty)$</td>
<td>banking union</td>
<td>bailout</td>
<td>bailout</td>
</tr>
</tbody>
</table>

4.4.4 Welfare effect of a full mandate banking union

The impact of a full mandate banking union is evaluated through a welfare comparison with the national regulatory systems. Ex ante, two opposite effects are apparent. First, the banking union eliminates inefficient liquidation outcomes caused by international spillovers. Second, the banking union resorts to bailouts in states of the world where
CHAPTER 4. BANKING UNION OPTIMAL DESIGN UNDER MORAL HAZARD

National regulators would have liquidated a defaulting bank. Systemic banks can take on more risk and benefit from de facto default insurance. The first effect is welfare improving, while the second is welfare reducing. Consequently, the net effect of the banking union on joint welfare is non-trivial.

For small interbank markets, the following result holds:

Lemma 10. The welfare under the banking union coincides with the welfare under national regulators if there are no differences in the ex post bailout strategies between the two systems \((\gamma < \gamma^*)\).

Lemma 10 is intuitive. Since the monitoring decisions of the banks depend on the regulators’ ex post optimal resolution, the welfare only differs when the resolution policies of the joint and national regulators are not the same. This only happens when the interbank market is large enough, that is, \(\gamma > \gamma^*\), such that the bailout of \(BK_B\) under national supervision becomes suboptimal.

Proposition 6 focuses on the case of \(\gamma > \gamma^*\), presenting the conditions under which a banking union is welfare improving.

Proposition 6. Under the banking union, the following holds.

1. Low moral hazard. If \(\frac{C}{\Delta p} \leq c_1\), the banking union always improves welfare.

2. High moral hazard. If \(\frac{C}{\Delta p} \geq c_2\), the banking union also always improves welfare. The welfare surplus decreases relative to the case of low moral hazard by a factor of \(\frac{1-p_H}{1-\gamma} < 1\).

3. Intermediate moral hazard. If \(\frac{C}{\Delta p} \in (c_1, c_2)\), the banking union is only welfare improving if \(\Delta p \leq \Delta p^*\), where \(\Delta p^*\) is given by

\[
\Delta p^* = \frac{(1-p_H)(R_2(1-F(1-L)) + (1-\gamma)(1-\phi)(F-1)r)}{F(2\phi - R_1^A) + (R_1^A + R_1^B - 2\phi)}.
\]

If moral hazard is low, that is, \(\frac{C}{\Delta p} \leq c_1\), \(BK_B\) monitors both under the banking union and under the national regulator. The introduction of the banking union does not decrease the monitoring incentives of \(BK_B\). The banking union only eliminates the exposure spillover, that is, losses for the creditor country due to liquidations in the debtor country. In this case, the banking union is strictly welfare improving.

For high moral hazard intensity, that is, \(\frac{C}{\Delta p} \geq c_2\), \(BK_B\) never monitors either under the banking union or under national supervision. The incentives of \(BK_A\) are not affected by the introduction of the union and the only effect is the elimination of the liquidity
spillover; the banking union is again strictly welfare improving. Since the probability of spillover is larger ($BK_B$ fails more often), the welfare surplus from a joint regulator is larger than for low moral hazard.

The most interesting case is for intermediate moral hazard values, $\frac{C}{\Delta p} \in (c_1, c_2)$. Under national regulation, $BK_B$ monitors its assets, since the liquidation threat is credible. However, under the banking union it is always bailed out. Consequently, it no longer monitors.

The welfare surplus from the banking union eliminating spillovers can be written as the sum of the benefit of avoiding inefficient liquidation and the cost of repaying insured deposits from taxpayer money:

$$
(4.14) \quad \text{Spillover Effect} = R_2 (1 - F (1 - L)) + (F - 1) (1 - \gamma) (1 - \phi) r .
$$

The negative incentive effect of the banking union can be written as the additional bailout cost (banking union bails out both banks instead of only $BK_A$) plus the expected loss from $BK_B$ realizing a positive payoff on the intermediate date with a lower probability:

$$
(4.15) \quad \text{Incentive Effect} = (F - 1) (2 \phi - R_A^1) + R_B^1 .
$$

The total welfare effect of the banking union can be written as a function of either one or both of these components, depending on whether the banking union affects risk taking incentives:

$$
(4.16) \quad \mathbb{E} \Delta \text{Welfare}_{BU} = \begin{cases} 
(1 - p_H) \text{Spillover Effect} & \text{if } \frac{C}{\Delta p} \leq c_1 , \\
(1 - p_L) \text{Spillover Effect} & \text{if } \frac{C}{\Delta p} \geq c_2 , \text{ and} \\
(1 - p_H) \text{Spillover Effect} - \Delta p \times \text{Incentive Effect} & \text{if } \frac{C}{\Delta p} \in (c_1 , c_2) .
\end{cases}
$$

For a large enough $\Delta p$, the negative market discipline effect outweighs the benefits of eliminating international contagion and thus the banking union becomes suboptimal. A large $\Delta p$ corresponds to a significant effect of monitoring on asset returns. It can be interpreted as a measure of asset complexity or opacity: Structured derivative products, for example, require more expertise and effort to monitor. Figure 4.5 plots welfare surplus as a function of moral hazard ($\frac{C}{\Delta p}$).
CHAPTER 4. BANKING UNION OPTIMAL DESIGN UNDER MORAL HAZARD

Figure 4.5: Banking union welfare surplus and moral hazard

This figure shows the welfare surplus from the banking union relative to national regulation systems as a function of moral hazard $\frac{C}{\Delta p}$. For low or high values of $\frac{C}{\Delta p}$, the banking union never distorts incentives and always improves welfare by eliminating spillovers. For intermediate values of $\frac{C}{\Delta p}$, it is possible that the loss of market discipline outweighs the benefits from lower spillovers and the banking union is suboptimal.

The maximum welfare surplus the banking union can generate corresponds with the case when it does not shift incentives: $(1 - p_H) \times \text{Spillover Effect}$. The full mandate banking union is welfare improving for $\Delta p \leq \frac{(1-p_H)\text{Spillover Effect}}{\text{Incentive Effect}}$. Intuitively, the welfare improving region increases in the surplus from eliminating spillovers and decreases in the loss from incentive distortion.

4.5 Optimal design of the banking union

This section focuses on two dimensions of banking union design. First, the optimal resolution mandate is analyzed, that is, the set of states for which the banking union, as opposed to national regulators, intervenes after a bank default. Second, we investigate the range of feasible resolution fund contracts.

4.5.1 Optimal resolution mandate

From an ex post joint welfare perspective, the liquidation of $BK_B$ is always suboptimal. However, liquidation might be necessary to maximize monitoring incentives. Part of
the banking union welfare surplus from spillover effects can be traded off for better risk monitoring.

The second best is achieved by a joint regulator that can commit to ex post inefficient liquidation. It can select the optimal liquidation probability that minimizes the welfare surplus reduction. Ex post inefficient actions are, however, very difficult to implement in practice.

A feasible alternative is a limited mandate (state-contingent) banking union. In some states of the world, the default of $BK_B$ is resolved by the national regulator, which finds liquidation optimal. This institutional framework generates a different outcome from the full mandate banking union of Section 4.4. The optimal mandate design defines the exact scope of joint and national regulator interventions that maximize welfare while offering full monitoring incentives.

Second best resolution policy with random liquidation

The second best case\(^2\) corresponds to a mixed strategy: The banking union randomly liquidates $BK_B$ upon default. The policy implies full ex ante commitment to ex post inefficient policies.

For low and high levels of moral hazard, there is no incentive distortion effect and thus no need to implement a spillover-generating liquidation: The optimal liquidation probability is zero.

For $\frac{C}{\Delta p} \in (c_1, c_2)$, the banking union commits ex ante to a random bailout policy for $BK_B$. Given default, $BK_B$ is bailed out with probability $\alpha$ (and liquidated with probability $1 - \alpha$).

Since lower values of $\alpha$ correspond to a larger probability of liquidation, $BK_B$ has better incentives to monitor its assets to earn positive profits at $t = 2$. As $\alpha$ decreases, the cross-border spillover is allowed more often and the efficiency gains from the banking union drop. The joint regulator’s problem is to choose $\alpha$ to maximize the welfare surplus of the banking union, subject to the incentive compatibility constraint of $BK_B$:

$$\max_{\alpha} \Delta \text{Welfare} (\alpha) = \alpha (1 - p_H) \times \text{Spillover Effect},$$

subject to:

$$\frac{C}{\Delta p} = c_1 + (1 - \alpha) (c_2 - c_1).$$

(4.17)

The optimal probability of a bailout that eliminates the incentive distortion effect is

\(^2\)The first best corresponds to an economy without the moral hazard friction, where effort is observable and contractible.
given by the solution to the monitoring constraint. It is equal to

\begin{equation}
\alpha^* = \frac{c_2 - \frac{C}{\Delta p}}{c_2 - c_1} \in (0, 1).
\end{equation}

The equilibrium probability of a bailout decreases with the intensity of the moral hazard problem (\(\alpha^*\) drops as \(\frac{C}{\Delta p}\) increases). For lower monitoring incentives of \(B K_B\), the banking union has to liquidate it more often upon default to encourage monitoring. At the same time, a higher liquidation probability translates into a higher cross-border spillover probability, which reduces the joint welfare surplus.

The full mandate banking union following a random resolution policy maximizes the welfare surplus in the presence of moral hazard. It eliminates the incentive distortion problem by sacrificing the least possible from the benefits of the banking union. However, in practice, regulators may not be able to commit to ex post inefficient policies and to thus achieve the second best.

The next subsection studies an alternative institutional design that can partially alleviate moral hazard, that is, a banking union with a limited mandate.

**Limited mandate banking union**

From Proposition 5, a full mandate banking union always bails out defaulting banks. This resolution policy is optimal under low and high moral hazard intensities, as stated by Lemma 11. Thus, a restricted mandate does not improve welfare.

**Lemma 11.** A full mandate banking union is weakly optimal for low (\(\frac{C}{\Delta p} \leq c_1\)) and high (\(\frac{C}{\Delta p} \geq c_2\)) levels of moral hazard.

Under intermediate moral hazard problems, \(\frac{C}{\Delta p} \in (c_1, c_2)\), a limited mandate can improve upon the outcome of a full banking union. This is particularly vital when the full mandate banking union reduces welfare. For relatively larger values of moral hazard in \((c_1, c_2)\), a limited mandate banking union can still fail to improve incentives.

The limited mandate is defined as a state-contingent contract: the banking union only intervenes in a subset of defaults, the rest falling under national jurisdiction. We consider two alternative limited banking unions.

**Definition 3.** The limited mandate banking union possible designs are defined as follows:

1. **Independent default mandate.** The banking union intervenes when either \(B K_A\) alone or both banks default on domestic investments: \((0, R^R)\) or \((0, 0)\), respectively.
2. **Contagion mandate.** The banking union intervenes when either BK_A alone or BK_B alone defaults on domestic investments: \((0, R_B^0)\) or \((R_A^1, 0)\), respectively.

Proposition 7 states the conditions under which a limited mandate banking union improves upon the outcome of both the full mandate banking union and national resolution.

**Proposition 7.** For intermediate moral hazard values, \(\frac{c}{\Delta p} \in (c_1, c_2)\), a limited mandate improves welfare if

1. The full mandate union improves welfare (\(\Delta p < \Delta p\)) but the incentive effect is large enough: \(\Delta p > \min\{p_L, 1 - p_L\} \Delta p\).

2. The full mandate union reduces welfare (\(\Delta p \geq \Delta p\)) and moral hazard is below a certain threshold: \(\frac{c}{\Delta p} < c_1 + \max\{p_L, 1 - p_L\} (c_2 - c_1)\).

The optimal limited mandate depends on the value of \(p_L\). Keeping \(p_H\) fixed, a large \(p_L\) translates into a small impact of monitoring on the probability of success, that is, the case of less complex banking products, easy to understand and to monitor. Alternatively, with \(\Delta p\) kept fixed, a larger \(p_L\) can be interpreted as a good economic environment, where investments have a high probability of success. Conversely, a small \(p_L\) is interpreted as an economy with complex banking products, where monitoring has a large impact on success probabilities, as well as poor investment opportunities. Bloom, Floetotto, Jaimovich, Saporta-Eksten, and Terry (2012) find that microeconomic uncertainty is more pronounced in recessions, consistent with both interpretations of lower values for \(p_L\).

If both limited and full mandate banking unions improve welfare but the surplus from the restricted joint regulator is larger, the optimal limited mandate depends only on \(p_L\). For \(p_L\) smaller than one-half, the independent default mandate is optimal; otherwise, the contagion mandate is preferred. The optimal limited mandate is selected to maximize the probability of a joint intervention.

If the full mandate banking union reduces welfare, the moral hazard friction intensity also influences the optimal limited mandate. For low moral hazard, a limited mandate banking union should focus on the most likely distress situations. A small liquidation probability is sufficient to provide monitoring incentives and a lower share of welfare surplus needs to be sacrificed to achieve them. The limited mandate choice changes if moral hazard is greater and a higher liquidation probability is needed to restore incentives. In this case, welfare surplus is further reduced by additionally limiting bailouts.
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Corollary 1. For relatively low moral hazard levels, \( \frac{C}{\Delta p} \in (c_1, c_1 + \min \{p_L, 1 - p_L\} (c_2 - c_1)) \), the limited mandate with the highest welfare surplus is selected, that is, the independent default mandate for \( p_L < \frac{1}{2} \) and the contagion mandate otherwise. For higher moral hazard, \( \frac{C}{\Delta p} \in (c_1 + \min \{p_L, 1 - p_L\} (c_2 - c_1), c_1 + \max \{p_L, 1 - p_L\} (c_2 - c_1)) \), the alternative limited mandate needs to be chosen to restore incentives.

The optimal choice of limited mandates for \( \Delta p \geq \overline{\Delta p} \) is summarized below.

<table>
<thead>
<tr>
<th>( p_L &gt; \frac{1}{2} )</th>
<th>Contagion mandate</th>
<th>Independent default mandate</th>
<th>No mandate</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p_L \leq \frac{1}{2} )</td>
<td>Independent default mandate</td>
<td>Contagion mandate</td>
<td>No mandate</td>
</tr>
</tbody>
</table>

When the monitoring strategy has a large impact on the return distribution, that is, for more complex assets of \( BK_A \)'s, the banking union optimally intervenes after \( BK_B \)'s default only when creditor \( BK_A \) also defaults on its domestic portfolio. In this case, the systemic crisis is not mainly driven by the contagion effect. Otherwise, for a low impact of monitoring on the probability of success, the joint regulator only intervenes after \( BK_B \)'s default when contagion is the main driver of the systemic crisis (\( BK_A \) is successful but \( BK_B \) fails). The welfare surplus of a banking union with a full and with a limited mandate, as well as the second best surplus, are presented in Figure 4.6.

Further implications

If a limited mandate banking union improves the outcome over a full mandate joint regulator, there are two additional implications. First, it also represents an improvement over ex post transfers between countries, even in the absence of a bargaining friction. Second, a limited mandate banking union can be more lenient ex ante than a full mandate banking union.

The case for a limited mandate union over ex post agreements. An alternative to setting up a banking union is relying on an ex post fund transfer from \( RG_A \) to \( RG_B \). However, ex post transfers can be very costly. The international exposure of banks is difficult to measure, especially if complex instruments are involved. Informational asymmetries complicate the bargaining process, potentially increasing liquidation costs and delaying resolution. In principle, a full mandate banking union is equivalent to an ex post transfer from country A to country B. Both arrangements implement the ex post optimal outcome, as follows from the Coase (1960) theorem.
Figure 4.6: Welfare surplus and banking union design: Optimal limited mandate when $p_L > \frac{1}{2}$ (upper Figure), and Optimal limited mandate when $p_L \leq \frac{1}{2}$ (bottom Figure).

This figure plots the welfare surplus of the banking union with different mandates and commitment levels. The full mandate, no commitment banking union is optimal for very low and very high moral hazard. For intermediate moral hazard, a limited mandate can offer a positive welfare surplus. The exact optimal mandate depends on the investment opportunity set (size of $p_L$).
A corollary of the analysis in this section is that if a limited mandate banking union improves welfare relative to a full mandate banking union, it also improves welfare relative to ex post transfers.

Implications for supervision policy. One of the salient policy implications of our model is that bank supervision under a joint resolution mechanism needs to be stronger. Stronger ex ante regulatory requirements can limit the risk taking behavior amplified by a more lenient ex post resolution policy. There are several caveats to stronger supervision. First, Colliard (2013) argues agency frictions exist between local and joint bank supervisors. Second, as we show in Chapter 3, banks respond to tougher capital requirements by moving risky assets off their balance sheets, while using taxpayer money to insure them. A limited mandate banking union improves upon the ex post outcome, thus reducing the need for particularly tough ex ante measures and further distortions.

4.5.2 Resolution fund contributions

In this section, national regulators endogenously decide to join the banking union at \( t = -1 \). The banking union is created if it is individually optimal for both regulators to move away from local resolution policies.

For simplicity, we focus on linear resolution fund contracts: \( RG_A \) supports a share \( \beta \in (0, 1) \) of all intervention costs, whereas \( RG_B \) supports \( 1 - \beta \). Thus, if a bailout requires a liquidity injection \( \ell \), country \( A \) will pay \( \beta F \times \ell \) and country \( B \) will pay \( (1 - \beta) F \times \ell \), where \( F > 1 \) is the marginal fiscal cost of providing funds.

The goal of the analysis is to determine the feasible range for \( \beta \) that offers incentives to both regulators to join the banking union. The following incentive compatibility constraints should hold simultaneously:

\[
\begin{align*}
E[Welfare^{BU}_{A} - Welfare^{A}_{National}] & \geq 0, \\
E[Welfare^{BU}_{B} - Welfare^{B}_{National}] & \geq 0.
\end{align*}
\]

Two cases exist. First, when \( \gamma \geq \gamma^* \), the banking union changes the bailout policy for \( BK_B \) and has a positive effect on welfare, as described in Section 4.4.4. Second, when \( \gamma < \gamma^* \), the banking union does not change bailout policies or affect welfare. The case when the effect on welfare is negative is omitted, since the banking union is never optimal.

The banking union improves joint welfare when \( \gamma > \gamma^* \) and \( \Delta p < \bar{\Delta p} \). Three cases arise. The first two are concerned with the situation when the full mandate banking
union does not shift incentives (low and high moral hazard values). If the full mandate banking union decreases the incentives of $BK_B$, the joint welfare surplus is reduced and the full mandate banking union is no longer necessarily optimal. Proposition 8 describes the feasible contract sets when the full mandate banking union is optimal.

**Proposition 8.** When $\gamma > \gamma^*$ and the full mandate banking union is optimal, the cost sharing contracts $(\beta, 1-\beta)$ depend on moral hazard, as follows.

1. **Low moral hazard.** If $\frac{C}{\Delta p} \leq c_1$, then there exists $1 \geq \beta_M > \beta_D \geq \frac{1}{2}$, such that for any $\beta \in \left(\beta_M, \beta_M\right)$ the full mandate banking union is feasible.

2. **High moral hazard.** If $\frac{C}{\Delta p} \geq c_2$, then there exist $\beta_N$ and $\beta_N$ such that $\beta_M > \beta_N > \frac{1}{2}$ and for any $\beta \in \left(\beta_N, \beta_N\right)$ the full mandate banking union is feasible.

3. **Intermediate moral hazard.** If $\frac{C}{\Delta p} \in (c_1, c_2)$, the welfare surplus is reduced: There exists $\beta_D < \beta_D$ such that $\left(\beta_D, \beta_D\right) \subset \left(\beta_N, \beta_N\right)$ and for any $\beta \in \left(\beta_D, \beta_D\right)$ the full mandate banking union is feasible.

The maximum resolution fund share the creditor country is willing to pay satisfies

$$\beta_M \geq \beta_D \geq \beta_D.$$ 

When the limited banking union mandate is optimal, similar cost sharing contracts are available.

**Lemma 12.** There exist pairs $\beta_I < \beta_I$ and $\beta_C < \beta_C$ such that the independent default mandate banking union is feasible for $\beta \in \left(\beta_I, \beta_I\right)$ and the contagion mandate banking union is feasible for $\beta \in \left(\beta_C, \beta_C\right)$. Moreover, $\beta_C = 1$; that is, the creditor country is willing to pay the full costs under the contagion mandate banking union.

The result that $\beta_C = 1$ is intuitive. Under the limited mandate banking union that focuses on the contagion case, the creditor country reaps all the benefits of the union: Spillovers are partially eliminated while incentives are restored. Furthermore, creditor countries never contribute to cross-border bailouts if their own national bank system also defaults due to domestic reasons.

When $\gamma < \gamma^*$, the policies are identical under national and joint resolution mechanisms. Hence, the banking union has a zero net welfare effect. The following lemma identifies the unique linear contract between the two countries in this case, and Figure
4.7 plots the resolution fund shares \((\beta, 1 - \beta)\) as a function of the interbank market size.

![Figure 4.7: Feasible cost sharing rules for the full mandate banking union](image)

This figure shows the feasible linear sharing rules of the fiscal cost of the form \(\{\text{Country A: }\beta, \text{ Country B: }1 - \beta\}\). For a small interbank market, the banking union does not improve welfare and there is an unique way to split the costs between countries. For situations in which there is a positive welfare surplus from the banking union (large \(\gamma\)), the country that benefits from resolving the externality also internalizes the largest part of the fiscal cost.

**Lemma 13.** When \(\gamma < \gamma^*\), \(\beta\) is unique and given by the following:

(i) If \(BK_B\) monitors its loans, \(\beta = \beta^{ZS}_M\), where \(\beta^{ZS}_M = \frac{(1-p_L)R^A}{2(1-p_H)\phi + \Delta p_R^1} < \beta_M\).

(ii) If \(BK_B\) does not monitor its loans, \(\beta = \beta^{ZS}_N\), where \(\beta^{ZS}_N = \frac{R^A}{2\phi} \in (0, \frac{1}{2})\).

The national regulator in country A is less willing to contribute to the resolution fund if the union worsens the risk taking incentives in country B compared with the case when \(BK_B\) never monitors the loans. By not joining an incentive-shifting banking union, \(RG_A\) intervenes less often, since the spillover frequency is lower. When moral hazard is high, the decision of \(RG_A\) to give up its resolution mechanism does not influence the probability of spillover.

Incentive shifting reduces the space of potential resolution fund contracts. Since \(\overline{\beta}_D - \beta_D < \overline{\beta}_N - \beta_N\), the feasible set for \(\beta\) is reduced. The total welfare surplus from the union drops. As previously discussed, \(RG_A\) demands even more of the declining surplus. Furthermore, \(RG_B\) loses the liquidation commitment device by joining the banking
union. In compensation, it asks for a larger share of the total surplus. Consequently, the feasible contract space shrinks.

For \( \gamma > \gamma^* \), \( RG_A \) pays a larger share of the resolution fund than for \( \gamma < \gamma^* \). Formally, \( \beta_M > \beta^{ZS}_M \) and \( \beta_N > \beta^{ZS}_N \). The result follows from the fact that the banking union solves a spillover externality that affects mostly country A. Since \( \beta_D > \beta_N > \beta^{ZS}_N \), the result is unaffected by incentive distortion effects. At the same time, \( RG_B \) also demands a lower share of the union costs, since its contributions to \( BK_B \) bailouts are also more frequent.

4.6 Banking union effect on the interbank market

This section studies the effect of a banking union on interbank market size and interest rate. The baseline model in Section 4.3 studies the case in which \( BK_A \) needs to lend on the interbank market to repay early depositors. The assumption guarantees an interbank transfer of \( \gamma \) and also fixes the interest rate at \( r_I = \frac{\phi(1+\gamma)-R_A}{1} \). To allow the regulatory framework to impact the interbank market, the baseline model is extended by relaxing Assumption 1. We analyze the situation when \( BK_A \) is able to fulfill all claims at \( t = 1 \) without lending on the interbank market, which is when

\[
R^A_1 + \gamma - \phi(1+\gamma) > 0. 
\]

Let \( \gamma^I \in [0, \gamma] \) denote the equilibrium size of the interbank loan and \( r^I \) denote the equilibrium gross interbank interest rate. In what follows, \( BK_B \) has full bargaining power. At \( t = 0 \), it communicates to \( BK_A \) the interest rate \( r^I \) at which it is willing to borrow funds. Given \( r^I \), \( BK_A \) chooses the size of the loan \( \gamma^I \) that maximizes its expected profit.

Lemmas 14 through 16 provide useful intermediate results to derive the interbank market equilibrium.

**Lemma 14.** For a given interest rate \( r^I \geq 1 \), the probability of success weakly increases with \( \gamma^I \) for both \( BK_A \) and \( BK_B \).

The expected profit for \( BK_B \) increases with the size of the interbank loan due to investment returns to scale. Part of the increase in the expected profit for \( BK_B \) is shared with \( BK_A \) through the interest rate \( r^I \geq 1 \). The larger expected profit offers better incentives to monitor for both banks. The effect on incentives is amplified if \( \gamma^I \) becomes large enough to trigger bank liquidation.
**Lemma 15.** Conditional on the $BK_B$ resolution policy, the expected profit of $BK_A$ weakly increases with interbank market size. If $BK_B$ is bailed out given default, a competitive creditor $BK_A$ accepts any interest rate $r^I \geq 1$. The expected profit of $BK_B$ decreases with $r^I$.

If $BK_B$ is bailed out given default, the interbank loan is always repaid. The expected profit of $BK_A$ increases with the interbank market size for any given $r^I > 1$. For $BK_A$, investing in the interbank market and investing in liquid assets are equivalent. It follows that $BK_A$ accepts an interbank market rate as low as the return on liquidity ($r^I = 1$). If $BK_B$ is liquidated given default, then Lemma 14 implies that a higher interbank market size increases the repayment probability of the interbank loan through better monitoring incentives for $BK_B$. Consequently, the expected profit for $BK_A$ increases.

**Lemma 16.** For $R_2 < \frac{F}{1-F(1-L)}$, an interbank market threshold $\gamma^I_{\text{National}} < \gamma$ exists such that the national regulator $RG_B$ liquidates $BK_B$ for $\gamma^I > \gamma^I_{\text{National}}$. If neither bank obtains a positive payoff at $t = 1$, or if liquidating $BK_B$ triggers the default of $BK_A$, then the banking union bails out both banks. Otherwise, for $R_2 < R_2 < \frac{F}{1-F(1-L)}$, an interbank market threshold $\gamma^I_{\text{Union}} < \gamma$ exists such that the banking union liquidates $BK_B$ for $\gamma^I > \gamma^I_{\text{Union}}$. In addition, $\gamma^I_{\text{Union}} > \gamma^I_{\text{National}}$.

Both the national regulator and the banking union always bailout $BK_A$ given default, as in the baseline case. If the returns at $t = 2$ are not too high, $RG_B$ liquidates the domestic bank for large enough interbank markets.

The banking union liquidates $BK_B$ if three conditions hold simultaneously. First, the liquidation of $BK_B$ does not trigger or increase the costs of an intervention on $BK_A$. The banking union only liquidates $BK_B$ if its default is isolated: Creditor $BK_A$ can fully cover the interbank losses without needing additional liquidity. Second, $R_2$ is lower than a threshold $R_2 < \frac{F}{1-F(1-L)}$. For $R_2 \in \left(\frac{F}{1-F(1-L)}, \frac{F}{1-F(1-L)}\right)$, the national regulator liquidates $BK_B$ for large interbank loans, but a banking union never does. Third, the interbank market $\gamma^I$ is larger than $\gamma^I_{\text{Union}}$. The banking union internalizes the interest losses for $BK_A$ from the liquidation of $BK_B$. As a result, both the return and the interbank market size bailout thresholds are less restrictive for the banking union than for national regulation.

Proposition 9 describes the effect of the banking union on the interbank market as a function of asset returns at $t = 1$ and $t = 2$.

**Proposition 9.** The equilibrium interbank market size and interest rate depend on the long term return $R_2$ and the short term return for $BK_B$, $R_1^B$. The possible equilibria are graphed in Figure 4.8, where $R_1^B (R_2) < R_1^B (R_2)$ are continuous functions of $R_2$. 

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4.6. Banking union effect on the interbank market

For large returns and liquidation costs, that is, \( R_2 > \frac{F}{1-F(1-L)} \), both the national regulator and the banking union always bail out a defaulting bank. It follows that the banking union has no real welfare effect. For \( R_2 < \frac{F}{1-F(1-L)} \), we group the equilibria by their implications on the effects of a banking union.

Banking union decreases incentives (A+B+C). The banking union decreases \( BK_B \) monitoring incentives for \( R_1^B > R_1^B \), corresponding to the regions (A) to (C) in Figure 4.8.

![Figure 4.8: Banking union impact on the interbank market](image)

This figure presents the interbank market equilibria, the size of the interbank loan \( \gamma \), and the interest rate \( r \), for both the national regulation and banking union settings. Five regions are identified as a function of investment returns at \( t = 1 \), \( R_1^B \) and at \( t = 2 \), \( R_2 \). The implicit functions \( R_1^B \) and \( R_2 \) are convex for \( p - (1 - \gamma + \gamma^*) > 0 \) and concave otherwise. This figure only graphs the convex case.

Under national regulation, \( BK_B \) borrows the maximum available amount on the interbank market and pays a positive interest rate \( r^I_{National} > 1 \). If it defaults, it is liquidated by the national regulator. The investment returns \( R_1^B \) and \( R_2 \) are high enough for \( BK_B \) to accept the default risk. Creditor \( BK_A \) is compensated for the default risk through a positive net interest rate. A banking union decreases monitoring
incentives in three ways: through more bailouts, through higher interest rates, and through thinner interbank markets. It always bails out $BK_B$ more often than the national regulator.

In regions (A) and (B), $BK_B$ faces a trade-off between borrowing the full surplus $\gamma$ on the interbank market or $\gamma^{I}_{\text{Union}} < \gamma$. If it borrows $\gamma$, $BK_B$ earns an additional return on the marginal investment $\gamma - \gamma^{I}_{\text{Union}}$. On the other hand, it faces non-zero liquidation risk and has positive interest costs, since $r^{I}_{\text{Union}} > 1$. If $BK_B$ borrows the lower amount $\gamma^{I}_{\text{Union}}$, then it forgoes the additional return but is always bailed out and has zero interest costs.

In region (A), for high $R^{B}_1$, the additional investment return effect dominates. Bank $BK_B$ borrows the full surplus $\gamma$ on the interbank market. The banking union bails out $BK_B$ only when both banks fail independently. The interest rate is higher under a banking union than under the national resolution mechanism: $r^{I}_{\text{Union}} > r^{I}_{\text{National}} > 1$. Intuitively, a banking union bails out $BK_B$ for higher foreign loan values than a national regulator does. It follows that the implicit insurance provided by a bailout is more valuable under a joint resolution mechanism, thus $BK_A$ requires greater compensation to renounce it. Both the bailout and the interest rate effects imply weaker monitoring incentives for $BK_B$ under a joint regulator.

In region (B), for lower $R^{B}_1$, the additional investment return is low enough that $BK_B$ prefers not to borrow the whole amount $\gamma$. Bank $BK_B$ borrows $\gamma^{I}_{\text{Union}} < \gamma$, such that it is always bailed out. The trading surplus and monitoring incentives are reduced relative to the national regulation case.

If $R_2$ is large enough, the banking union always bails out $BK_B$, irrespective of the size of the interbank loan. In region (C), $BK_B$ can borrow up to $\gamma$ without ever being liquidated. The full trading surplus is restored to national regulation levels, but monitoring incentives decrease since a banking union is more lenient.

**Banking union improves incentives (D).** If $R^{B}_1$ is low enough, that is, $R^{B}_1 < R^{B}_1 (R_2)$, the banking union improves the monitoring incentives of $BK_B$ and has an unequivocal positive welfare impact.

For $R^{B}_1 < R^{B}_1 (R_2)$, $BK_B$ has very little incentives to take any default risk. For both national and joint resolution mechanisms, $BK_B$ borrows funds only up to the maximum level that does not trigger liquidation on default. In a banking union this liquidation threshold for $\gamma^{I}$ is higher. It follows that $BK_B$ borrows more on the interbank market under a banking union. The trade surplus increases and consequently the monitoring incentives of $BK_B$ improve as well.
**Summary**  In sum, a banking union intensifies moral hazard for systemically important banks in all cases in which a national regulator can credibly commit to ex post liquidation. Extending the model to allow for an endogenous interbank market reveals an additional benefit of the banking union in the situation where national regulators cannot commit to ex post liquidation: If banks strategically limit their foreign borrowing to increase the probability of being bailed out by a national regulator, then a banking union allows them to borrow more without bearing default risk. A larger interbank market, ceteris paribus, stimulates monitoring and increases the trade surplus, improving welfare.

### 4.7 Concluding remarks

In this chapter we contribute to the recent European debate around the single-resolution mechanism. We study the welfare impact and optimal design of a banking union from both a positive and a normative standpoint. We make policy proposals regarding the mandate of the banking union and the structure of the resolution fund.

**Implications of a banking union.** The banking union provides liquidity more efficiently, reducing the taxpayers’ burden. It eliminates international contagion at the price of increased leniency toward systemically important institutions. The net effect on welfare is negative if poor risk management significantly reduces expected returns. This is particularly the case if banks hold complex and opaque products, such as structured derivatives.

The interbank market amplifies the incentive distortion of a banking union, unless the short-term returns are particularly low. In the latter case, neither the national nor the joint resolution authority can credibly commit to liquidate failed banks in equilibrium. However, a banking union creates incentives for more interbank trading, increasing welfare.

**Empirical implications.** The model allows for a number of empirical predictions. Following the implementation of a single-resolution mechanism, banks with large European cross-border liabilities take on more risk. The effect is stronger for banks with larger European cross-border liabilities and moderate ex ante risk taking incentives. Such behavior could manifest, for example, as a shift in bank portfolios toward high-risk and high-return loans, or toward riskier asset classes (Rajan, 2006). Laeven and Levine (2009) propose several measures for bank risk taking behaviour: the distance
to insolvency, the volatility of equity prices, and the volatility of earnings. In addition, the model implies systemically important banks are bailed out more often by a common regulator. The implication can be tested using deep out-of-the money put options to identify the behaviour of the systemic insurance premium (Kelly, Lustig, and Nieuwerburgh, 2011).

**Policy recommendations.** Incentives can be restored by a more sophisticated institutional design in which the banking union and national resolution systems coexist, with clearly delimited intervention jurisdictions. A limited mandate banking union necessarily allows in equilibrium for a positive probability of contagion, thus falling short of the second-best outcome.

Net creditor countries should contribute most to the resolution default fund, since they are the main beneficiaries from the elimination of contagion effects. However, when the banking union worsens market discipline, all countries seek to contribute lower shares to the joint intervention fund, since the welfare surplus of a single-resolution mechanism is reduced.
4.8 Appendix

4.8 A The road to a banking union in Europe

**Initial response to the global financial crisis.** Initially, the response of European authorities to the destabilizing situation in the financial system was carried out within two funding programs: the European Financial Stability Facility and the European Financial Stabilization Mechanism, established on May 10, 2010. The two programs had the authority to raise up to EUR 500 billion, guaranteed by the European Commission and the EU member states. The mandate of the European Financial Stability Facility and the European Financial Stabilization Mechanism was to “safeguard financial stability in Europe by providing financial assistance” to Eurozone member countries.

Financial help from the two facilities could be obtained only after a request made by a Eurozone member state and was conditional on implementation of a country-specific program negotiated with the European Commission and the IMF.

In September 2012, the two programs were replaced by the European Stability Mechanism. The European Stability Mechanism support, again conditional on acceptance of a structural reform program, was designed also for direct bank recapitalization.

**Path to the banking union.** On June 29, 2012, during the Eurozone summit, European leaders called for a Single supervisory mechanism (SSM) of national financial systems within the ECB. On September 12, 2012, in response to the Eurozone summit debate, the European Commission proposed that the ECB become the direct supervisor of all EU banks (with the right to grant and retract banking licenses). In the first half of 2013, the key elements of the European banking union took shape. Two main pillars were proposed: the SSM (on March, 19) and the Single Resolution Mechanism (on June, 27).

**SSM.** According to the proposals as of January 2014, participation in the SSM will be mandatory for all Eurozone countries, and optional only for other EU member states. Within the SSM, only banks viewed as “systemically important” will be supervised by the ECB directly. Approximately 150 institutions are included that satisfy at least one of five following requirements:

1. Value of assets exceeds EUR 30 billion.

2. Value of assets exceeds EUR 5 billion and 20% of the GDP of the given member state.
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3. The institution is among top three largest banks in the country of the location.

4. The institution is characterized by intense cross-border activities.

5. The institution receives support from the EU bailout programs.

All other banks will remain under the direct supervision of national regulators, with the ECB keeping the overall supervisory role. The supreme body of the SSM will be the Supervisory Board consisting of national regulators — members of the SSM — and representatives of the ECB. The Supervisory Board, although administratively separated, will, however, remain legally subordinate to the governing council of the ECB.

Single resolution mechanism (SRM). The resolution of troubled banks will be entrusted to the Single Resolution Board (SRB), consisting of representatives from the ECB and the European Commission, and relevant national authorities. In case of bank distress, based on the SRB’s recommendation, the decision regarding the future of the defaulting institution will be made by the European Commission.

The resolution tools made available to the SRB include: the sale of business, setting up a bridge institution with the purpose of asset sales in the future, separation of assets with the use of asset management vehicles, and bail-ins, in which the claims of unsecured bank creditors will be converted into equity or written down.

The availability of funding support will be guaranteed through the Single Bank Resolution Fund financed with contributions from financial institutions under the SSM. Use of the Single Bank Resolution Fund will be restricted to 5% of the total liabilities of the distressed institution and will be made conditional on the bail-in of at least 8% of total liabilities.

4.8 B Proofs

Proposition 4

Proof. Resolution policy. From (4.6), welfare following bailout is greater than welfare following liquidation for \( RG_B \) if

\[
\gamma \leq \frac{R_2 (1 - F (1 - L)) + (F - 1) (1 - \phi) r}{FrI + (F - 1) (1 - \phi) r}.
\]
If $BK_B$ has full bargaining power, $r^I = \frac{(1+\gamma)\phi - R_A^B}{\gamma}$. The bailout condition for $RG_B$ is

$$\gamma = \gamma^* \leq \frac{R_2 (1 - F (1 - L)) + (F - 1) (1 - \phi) r + F \left( R_A^1 - \phi \right)}{F \phi + (F - 1)(1 - \phi) r}.$$  

The equivalent bailout condition for $RG_A$ is

$$R_2 (1 - F (1 - L)) \geq (1 - F)(1 + \gamma)(1 - \phi) r.$$  

Since $F < \frac{1}{1-L}$, the left-hand side of the equation is positive, whereas the right-hand side is negative. Therefore, regulator $RG_A$ always bails out $BK_A$.

**Monitoring decisions.** If $\gamma \leq \gamma^*$, $BK_B$ is always bailed out. The expected profit for $BK_B$, conditional on its monitoring decision, is

- $\pi_B(\text{Monitor}) = R_2 - (1 - \gamma)(1 - \phi) r + p_H \left( R_A^1 + (1 - \gamma) \phi - r^I \gamma \right) - C$,
- $\pi_B(\text{Not Monitor}) = R_2 - (1 - \gamma)(1 - \phi) r + p_L \left( R_A^1 - (1 - \gamma) \phi - r^I \gamma \right)$.

Bank $BK_B$ only monitors its portfolio if

$$\frac{C}{\Delta p} \leq R_A^1 - (1 - \gamma) \phi - r^I \gamma = \gamma^B_1.$$  

For $\gamma > \gamma^*$,

- $\pi_B(\text{Monitor}) = p_H \left( R_A^1 + R_2 - (1 - \gamma) \phi - (1 - \gamma)(1 - \phi) r - r^I \gamma \right)$,
- $\pi_B(\text{Not Monitor}) = p_L \left( R_A^1 + R_2 - (1 - \gamma) \phi - (1 - \gamma)(1 - \phi) r - r^I \gamma \right) - C$.

Bank $BK_B$ monitors if

$$\frac{C}{\Delta p} \leq R_A^1 + R_2 - (1 - \gamma) \phi - (1 - \gamma)(1 - \phi) r - r^I \gamma = \gamma^B_2 < \gamma^B_1.$$  

Bank $BK_A$ does not monitor its loans: it is always bailed out and earns zero profit at $t = 0$ (since it has no bargaining power on the interbank market).

**Interbank market.** Bank $BK_A$ always receives $R_2$ at $t = 2$. It is not able to pay demand depositors at $t = 1$ without the interbank market. The lowest interest rate it can accept corresponds to zero profits at $t = 1$, which implies

$$(4.27) \quad \text{InterbankPayoff}_A = p \left( R_A^1 - \phi (1 + \gamma) + \gamma r^I \right) \geq 0 \implies r^I \geq \frac{\phi (1 + \gamma) - R_A^1}{\gamma}.$$  

Let $r_I = \frac{\phi (1 + \gamma) - R_A^1}{\gamma}$ be the minimum interest rate required by $BK_A$ to trade in the
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interbank market.

Bank $BK_B$ gains from borrowing on the interbank market since it can leverage up its return but incurs a loss if it is no longer bailed out given default. The net payoff is

\[ \text{InterbankPayoff}_B = p_H \left[ (R^B_1 + R_2) \gamma - r^I \gamma \right] - (1 - p_H) (1 - \gamma) (R_2 - (1 - \phi) r). \]

Bank $BK_B$ is willing to pay a maximum rate of

\[ r^I = (R^B_1 + R_2) - \frac{(1 - \gamma) (1 - p_H)}{\gamma p_H} (R_2 - (1 - \phi) r). \]

If $\gamma + p_H \geq 1$, then $r^I > r^I_B$. 

**Proposition 5**

**Proof.** Resolution policy. First, consider the case when $BK_A$ receives zero and $BK_B$’s payoff is $R^A_1$ at $t = 1$. The banking union’s welfare after the bailout of $BK_A$ is

\[ [\text{Welfare}^A + \text{Welfare}^B]_{\text{Bailout}} = 2R_2 + R^B_1 + (1 - F) R^A_1. \]

The banking union welfare after liquidation of $BK_A$ is

\[ [\text{Welfare}^A + \text{Welfare}^B]_{\text{Liquidation}} = R_2 + R^B_1 + R^A_1 + (1 + \gamma) (1 - \phi) r (1 - F) - F (R^A_1 - R_2 (1 - L)). \]

The bailout takes place if

\[ R_2 (1 - F (1 - L)) \geq (1 - F) (1 + \gamma) (1 - \phi) r, \]

which is true since $F < \frac{1}{1-L}$.

Consider now the case when $BK_A$ receives $R^A_1$ and $BK_B$ receives zero at $t = 1$. If $BK_B$ is bailed out,

\[ [\text{Welfare}^A + \text{Welfare}^B]_{\text{Bailout}} = 2R_2 + 2\phi - F (2\phi - R^A_1). \]

If $BK_B$ is liquidated, $RG_A$ always bails out $BK_A$ if $F < \frac{1}{1-L}$. Welfare is

\[ [\text{Welfare}^A + \text{Welfare}^B]_{\text{Bailout}} = F \times R^A_1 + R_2 + (2\phi + (1 - \gamma) (1 - \phi) r) (1 - F) + F ((1 - L) R_2). \]

For $1 < F < \frac{1}{1-L}$, the supranational regulator always bails out $BK_B$. The same outcome occurs when both $BK_A$ and $BK_B$ receive zero at $t = 1$.

**Monitoring decisions.** The monitoring condition for $BK_A$ is the same as under national regulation and $BK_A$ never monitors. Bank $BK_B$’s is always bailed out and it
monitors if
\[
\frac{C}{\Delta p} \leq R_1^B - (1 - \gamma) \phi - r^I \gamma = c_1.
\]

**Interbank market.** The interbank market result is identical to that in the previous proof.

**Lemma 10**

*Proof.* The proof is shown through immediate mathematical calculation.

**Proposition 6**

*Proof.* If \(\gamma > \gamma^*\) and \(\frac{C}{\Delta p} \leq c_1\), the total welfare impact of a banking union is
\[
(1 - p_H) \left[ R_2 (1 - F (1 - L)) + (F - 1) (1 - \gamma) (1 - \phi) r \right] \geq 0.
\]
The banking union is welfare-improving. It eliminates contagion and does not distort incentives for \(BK_B\) (\(BK_B\) always monitors).

If \(\gamma > \gamma^*\) and \(\frac{C}{\Delta p} > c_2\), the total welfare impact of a banking union is
\[
(1 - p_L) \left[ R_2 (1 - F (1 - L)) + (F - 1) (1 - \gamma) (1 - \phi) r \right] \geq 0.
\]
The banking union is again welfare improving. It eliminates contagion and does not distort incentives for \(BK_B\) (\(BK_B\) never monitors).

If \(\gamma > \gamma^*\) and \(c_1 < \frac{C}{\Delta p} \leq c_2\), \(BK_B\) only monitors under the national resolution mechanism. The welfare surplus under the banking union decreases, since the probability of default is larger for \(BK_B\). The banking union is only welfare improving if
\[
\Delta p \leq \Delta p^* = \frac{(1 - p_H) (R_2 (1 - F (1 - L)) + (1 - \gamma) (1 - \phi) (F - 1) r)}{F (2\phi - R_1^A) + (R_1^A + R_1^A - 2\phi)}.
\]

**Lemma 11**

*Proof.* Under low (\(\frac{C}{\Delta p} \leq c_1\)) and high (\(\frac{C}{\Delta p} \geq c_2\)) moral hazard, the banking union does not shift monitoring incentives. A limited mandate union simply reduces the spillover surplus without providing any benefits, thus being suboptimal.
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Proposition 7

Proof. Consider the case where the full mandate banking union improves welfare. The full mandate welfare impact is

\[(4.38) \quad \text{Welfare}^{A+B}_{\text{FullMandate}} = (1 - p_H) \text{Spillover Effect} - \Delta p \times \text{Incentive Effect}.\]

The independent default mandate banking union welfare impact is

\[(4.39) \quad \text{Welfare}^{A+B}_{\text{IndDef}} = (1 - p_H)(1 - p_L) \text{Spillover Effect}.\]

The independent default mandate is optimal if

\[(4.40) \quad \Delta p > p_L \frac{(1 - p_H) \text{Spillover Effect}}{\text{Incentive Effect}} = p_L \bar{\Delta p}.\]

The contagion mandate banking union welfare impact is

\[(4.41) \quad \text{Welfare}^{A+B}_{\text{Contagion}} = (1 - p_H) p_L \text{Spillover Effect}.\]

The contagion mandate is optimal if

\[(4.42) \quad \Delta p > (1 - p_L) \frac{(1 - p_H) \text{Spillover Effect}}{\text{Incentive Effect}} = (1 - p_L) \bar{\Delta p}.\]

For \(\Delta p < \min \{p_L, 1 - p_L\} \bar{\Delta p}\), at least one limited mandate improves welfare relative to a full mandate banking union.

Consider the case in which the full mandate banking union reduces welfare. Under the independent default mandate, \(BK_B\) monitors if

\[(4.43) \quad \frac{C}{\Delta p} \leq R_1^A + R_1^B - 2\phi + p_L(R_2 - (1 - \gamma)(1 - \phi)r) = c_1 + p_L(c_2 - c_1) = c^*_2.\]

For \(\frac{C}{\Delta p} \in (c_1, c^*_2]\) \(BK_B\) monitors its loans. The independent mandate is optimal in this case, since

\[(4.44) \quad \text{Welfare}^{A+B}_{\text{IndDef}} - \text{Welfare}^{A+B}_{\text{National}} = (1 - p_H)(1 - p_L) \text{Spillover Effect} > 0.\]

Under the contagion mandate, \(BK_B\) monitors if

\[(4.45) \quad \frac{C}{\Delta p} \leq R_1^A + R_1^B - 2\phi + (1 - p_L)(R_2 - (1 - \gamma)(1 - \phi)r) = c_1 + (1 - p_L)(c_2 - c_1) = c^*_2.\]
The banking union is welfare improving relative to national regulation whenever $BK_B$ monitors the loans, for $\frac{C}{\Delta p} \in (c_1, c_2]$.

\begin{equation}
\text{Welfare}^{A+B}_{\text{Contagion}} - \text{Welfare}^{A+B}_{\text{National}} = (1 - p_H)p_\text{L}\text{Spillover Effect} > 0.
\end{equation}

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Corollary 1

Proof. If $p_\text{L} < \frac{1}{2}$, then $c_2^s > c_2$. If $\frac{C}{\Delta p} \in (c_1, c_2^s]$, $BK_B$ monitors under both limited mandates, but the welfare surplus is greater under the independent default mandate. For $\frac{C}{\Delta p} \in (c_1^s, c_2^s]$, $BK_B$ monitors under the banking union with contagion mandate only. For $\frac{C}{\Delta p} \in (c_2^s, c_2)$, none of the partial mandate banking unions induces monitoring. Thus national regulation is optimal.

If $p_\text{L} > \frac{1}{2}$, then $c_2 < c_2^s$. If $\frac{C}{\Delta p} \in (c_1, c_2^s]$, $BK_B$ monitors under the two alternative banking unions considered but the banking union with a contagion mandate is preferred, since there are fewer liquidations. If $\frac{C}{\Delta p} \in (c_1^s, c_2^s]$ $BK_B$ monitors under the banking union with an independent default mandate. If $\frac{C}{\Delta p} \in (c_2^s, c_2)$, national regulation is optimal.

If $p_\text{L} = \frac{1}{2}$, then $c_2^s = c_2$. Any limited mandate banking union is optimal if $\frac{C}{\Delta p} \in (c_1, c_2^s]$. 

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Proposition 8

Proof. Consider first the case if $\gamma > \gamma^*$ and $\frac{C}{\Delta p} \leq c_1$ or $\frac{C}{\Delta p} > c_2$. Since there are no incentive distortions, the state world probabilities are unaffected by a banking union. The welfare surplus for $RG_A$ is

\begin{equation}
\mathbb{P}(0, R_1^A) (1 - \beta) FR_1^A + \mathbb{P}(R_1^A, 0) (1 - \beta) F(2\phi - R_1^A) + \mathbb{P}(0, 0) (F\phi (1 + \gamma) - 2F\beta\phi) \geq 0,
\end{equation}

which is equivalent to

\begin{equation}
(4.48) \quad \beta \leq \frac{\mathbb{P}(0, R_1^B) FR_1^A + \mathbb{P}(R_1^A, 0) F(2\phi - R_1^A) + \mathbb{P}(0, 0) (F\phi (1 + \gamma))}{\mathbb{P}(0, R_1^B) FR_1^A + \mathbb{P}(R_1^A, 0) F(2\phi - R_1^A) + 2\mathbb{P}(0, 0) F\phi} \in (0, 1).
\end{equation}

Similarly, the condition for $RG_B$ yields an upper bound for $\beta$, given by

\begin{equation}
(4.49) \quad \beta \geq \frac{\mathbb{P}(0, R_1^B) FR_1^A + \mathbb{P}(R_1^A, 0) F(2\phi - R_1^A) + \mathbb{P}(0, 0) (F\phi (1 + \gamma)) - \mathbb{E}\Delta\text{Welfare}_{BU}}{\mathbb{P}(0, R_1^B) FR_1^A + \mathbb{P}(R_1^A, 0) F(2\phi - R_1^A) + 2\mathbb{P}(0, 0) F\phi}.
\end{equation}
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If \( \frac{C}{\Delta p} \leq c_1 \), then the bounds are

\[
\beta \leq \frac{(1 - p_H)(1 - \Delta p + p_H(1 - \gamma) + \gamma(1 + \Delta p)) \phi + \Delta p R_1^A}{2(1 - p_H) \phi + \Delta p R_1^A} = \beta_M < 1,
\]

\[
\beta \geq \beta_M - \frac{E \Delta \text{Welfare}_{BU}^M}{2F(1 - p_H) \phi + F \Delta p R_1^A} = \beta_M'.
\]

If \( \frac{C}{\Delta p} \geq c_1 \), then the bounds are

\[
\beta \leq \frac{1 + p_H(1 - \gamma) + \gamma(1 + \Delta p) - \Delta p}{2} = \beta_N,
\]

\[
\beta \geq \beta_N - \frac{E \Delta W_{BU}^N}{2F(1 - p_L) \phi} = \beta_N'.
\]

If \( \gamma > \gamma^* \) and \( c_1 < \frac{C}{\Delta p} \leq c_2 \), introduction of the banking union reduces the monitoring incentives of \( BK_B \). We focus on the case in which \( \Delta p \leq \Delta p^* \), such that the banking union is still welfare improving. Let \( W_1, W_2, W_3 \) and \( W_4 \) denote the welfare of country \( i \) under national regulation in the four states of the world: \((R_A^1, R_B^1)\), \((0, R_B^1)\), \((R_A^1, 0)\), and \((0, 0)\). In addition, let \( S_i, i \in \{1, 2, 3, 4\} \), denote welfare surplus for country A in all states of the world. The banking union feasibility condition for \( RG_A \) is

\[
p_L^2 S_1 + (1 - p_L) p_L (S_2 + S_3) + (1 - p_L)^2 S_4 + \Delta p [p_L (W_3 - W_1) + (1 - p_L) (W_4 - W_2)] \geq 0.
\]

The upper limit for \( \beta \) is

\[
\beta_D = \beta_N - \frac{\Delta p [(1 + \gamma) \phi - R_1^A]}{2 \phi (1 - p_L) F} = \beta_N - \frac{\Delta p [W_1^A - W_3^A]}{2 \phi (1 - p_L) F}.
\]

A similar computation for \( RG_B \) yields the lower bound

\[
\beta_D' = \beta_N + \frac{\Delta p [W_1^B - W_3^B]}{2 \phi (1 - p_L) F} > \beta_N.
\]

To prove \( \beta_D > \beta_D' \), it is enough to show that

\[
\beta_N - \beta_N - \frac{\Delta p (W_1^A [R_1^A, R_1^B] - W_1^A [R_1^A, 0])}{2F \phi (1 - p_L)} - \frac{\Delta p (W_1^B [R_1^A, R_1^B] - W_1^B [R_1^A, 0])}{2F \phi (1 - p_L)} \geq 0.
\]

From \( \beta_N - \beta_N = \frac{E \Delta W_{BU}^N}{2F \phi (1 - p_L)} \) and the definitions of \( W_i \),

\[
2 \phi F - 2 \phi > F \phi + F \phi \gamma + (F - 1) \phi - (F - 1) \phi \gamma \iff -2 \phi > -2 \phi - 2 \phi \gamma;
\]
which is true, since \( \phi > 0 \) and \( \gamma > 0 \).

**Lemma 12**

*Proof.* The only interesting cases are for positive expected welfare surplus, i.e. when

\[
\Delta \text{Welfare} = (1 - p_H) \max \{p_L, 1 - p_L\} \text{Spillover} > 0.
\]

**Independent default mandate.** There is no welfare surplus if \( BK_A \) succeeds in domestic projects. Otherwise, the following is obtained.

\[
\begin{array}{cccc}
\text{State} & \text{Probability} & \text{Surplus A} & \text{Surplus B} \\
(0, R_B^1) & p_H (1 - p_L) & (1 - \beta) F \times R_A^1 & - (1 - \beta) F \times R_A^1 \\
(0, 0) & (1 - p_H) (1 - p_L F (1 + \gamma) - 2 F \beta \phi) & \Delta \text{Welfare} - F \phi (1 + \gamma) + 2 F \beta \phi
\end{array}
\]

The incentive compatibility constraints for \( RG_A \) are

\[
p_H (1 - p_L) (1 - \beta) F \times R_A^1 + (1 - p_H) (1 - p_L) \left( F \phi (1 + \gamma) - 2 F \beta \phi \right) > 0.
\]

This gives the upper bound for \( \beta \),

\[
\beta \leq \overline{\beta}_I = \frac{p_H \times R_A^1 + (1 - p_H) (1 + \gamma) \phi}{p_H \times R_A^1 + 2 (1 - p_H) \phi} < 1.
\]

The incentive compatibility constraints for \( RG_B \) are

\[
-p_H (1 - p_L) (1 - \beta) F \times R_A^1 + (1 - p_H) (1 - p_L) \left( \Delta \text{Welfare} - F \phi (1 + \gamma) + 2 F \beta \phi \right) > 0.
\]

This gives the lower bound for \( \beta \),

\[
\beta \geq \underline{\beta}_I = \overline{\beta}_I - \frac{(1 - p_H) \text{Spillover Effect}}{F (p_H \times R_A^1 + 2 (1 - p_H) \phi)} < \overline{\beta}_I.
\]

**Contagion mandate.** There is no welfare surplus relative to national regulation if either both banks fail or both banks succeed. Otherwise, the following is obtained.

\[
\begin{array}{cccc}
\text{State} & \text{Probability} & \text{Surplus A} & \text{Surplus B} \\
(0, R_B^1) & p_H (1 - p_L) & (1 - \beta) F \times R_A^1 & - (1 - \beta) F \times R_A^1 \\
(R_A^1, 0) & p_L (1 - p_H) & (1 - \beta) F \times (2 \phi - R_A^1) & \Delta \text{Welfare} - (1 - \beta) F \times (2 \phi - R_A^1)
\end{array}
\]
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The incentive compatibility constraints for $RG_A$ are

$$ p_H (1 - p_L) (1 - \beta) F \times R_1^A + p_L (1 - p_H) (1 - \beta) F \times (2\phi - R_1^A) > 0. $$

The equation holds for any $\beta \leq 1$, so the upper bound for $\beta$ is $\beta_I = 1$.

The incentive compatibility constraints for $RG_B$ are

$$ -p_H (1 - p_L) (1 - \beta) F \times R_1^A + p_L (1 - p_H) (\Delta \text{Welfare} - (1 - \beta) F \times (2\phi - R_1^A)) > 0. $$

This gives the lower bound for $\beta$,

$$ \beta \geq \beta_C = 1 - \frac{p_L \Delta \text{Welfare}}{p_L (1 - p_H) F (2\phi - R_1^A) + F (1 - p_L) p_H \times R_1^A} < \beta_C = 1. $$

Lemma 13

Proof. If the banking union does not affect welfare, it is only feasible if, as a zero-sum game between countries, $\text{Welfare}^A_{BU} - \text{Welfare}^A_{National} = 0$. From Proposition 5, the monitoring strategy of $BK_B$ is unaffected by the banking union. If $BK_B$ never monitors its loans, then the welfare condition is

$$ (1 - p_L) p_L (1 - \beta) F R_1^A - p_L (1 - p_H) \beta F (2\phi - R_1^A) + (1 - p_L)^2 (F R_1^A - 2\beta F \phi) = 0. $$

The equilibrium fiscal cost share of country A is given by

$$ \beta^ZS_N^A = \frac{R_1^A}{2\phi} \in \left(0, \frac{1}{2}\right). $$

If $BK_B$ is monitoring, the welfare condition is

$$ (1 - p_L) p_H (1 - \beta) F R_1^A - p_L (1 - p_H) \beta F (2\phi - R_1^A) + (1 - p_L) (1 - p_H) (F R_1^A - 2\beta F \phi) = 0, $$

and the corresponding equilibrium fiscal cost share of country A is

$$ \beta^ZS_M^A = \frac{(1 - p_L) R_1^A}{2 (1 - p_H) \phi + \Delta p R_1^A} \in (0, 1). $$

\qed
Lemma 14

Proof. If it is bailed out upon default, $BK_B$ monitors its loans if the costs are low enough. The condition is given by

\begin{equation}
\frac{C}{\Delta p} \leq (1 - \gamma + \gamma^I) R_1^B - \phi (1 - \gamma) - \gamma^I r^I.
\end{equation}

If it not bailed out upon default, $BK_B$ monitors its loans if

\begin{equation}
\frac{C}{\Delta p} \leq (1 - \gamma + \gamma^I) (R_1^B + R_2) - \phi (1 - \gamma) - (1 - \phi) (1 - \gamma) r - \gamma^I r^I.
\end{equation}

The monitoring thresholds for $BK_B$ increase with $\gamma^I$.

Bank $BK_A$ monitors if the cost level is low enough and the payoff at $t = 1$ is relatively high,

\begin{equation}
\frac{C}{\Delta p} \leq R_1^A + \gamma - \phi (1 + \gamma) + \gamma^I r^I \text{Prob (interbank loan reimbursed)} - 1.
\end{equation}

Lemma 15

Proof. Let $p_{IB}$ be the interbank loan reimbursement probability:

\begin{equation}
p_{IB} = P(BK_B \text{ succeeds at } t = 1) + P(BK_B \text{ succeeds at } t = 1) \times P(BK_B \text{ is bailed out}).
\end{equation}

Consider first $BK_A$’s payoff at $t = 1$. If $BK_B$ is bailed out, then $p_{IB} = 1$ and the payoff for $BK_A$ is

\begin{equation}
\pi^{t=1}_A = R_1^A + (\gamma - \gamma^I) - \phi (1 + \gamma) + \gamma^I r^I.
\end{equation}

For $BK_A$, investing in this market is equivalent to holding the surplus as liquidity, so it will accept the return on liquidity: $r^I = 1$.

If $BK_B$ is not bailed out, then the payoff for $BK_A$ is

\[
\pi^{t=1}_A = \begin{cases} 
R_1^A + (\gamma - \gamma^I) - \phi (1 + \gamma) + P(BK_B \text{ succeeds}) \gamma^I r^I, & \text{if } R_1^A + (\gamma - \gamma^I) - \phi (1 + \gamma) \geq 0, \\
P(BK_B \text{ succeeds}) (R_1^A + (\gamma - \gamma^I) - \phi (1 + \gamma) + \gamma^I r^I), & \text{if } R_1^A + (\gamma - \gamma^I) - \phi (1 + \gamma) < 0.
\end{cases}
\]
The payoff piecewise increases in $\gamma^I$, since, from Lemma 14 the probability success of $BK_B$ is non-decreasing in $\gamma_I$. Since the payoff function is continuous\(^3\) it increases in $\gamma^I$ on its full domain. Furthermore, the payoff of $BK_B$ decreases with the interest rate paid to $BK_A$.

Lemma 16

Proof. The welfare values for $RG_B$ following bailout or liquidation are given by

\[
\text{Welfare}_{B,\text{Bailout}} = (1 - \gamma + \gamma^I) R_2 + (1 - F) (1 - \gamma) \phi - Fr^I \gamma^I,
\]

\[
\text{Welfare}_{B,\text{Liquidation}} = (1 - \gamma + \gamma^I) R_2 (1 - L) F + (1 - F) [(1 - \gamma) \phi + (1 - \gamma) (1 - \phi) r].
\]

Regulator $RG_B$ bails out $BK_B$ only for $\gamma < \gamma^I_{\text{National}}$, where

\[
\gamma^I_{\text{National}} = \frac{(F - 1) (1 - \phi) (1 - \gamma) r + (1 - \gamma) R_2 (1 - F (1 - L))}{Fr^I - R_2 (1 - F (1 - L))}.
\]

A banking union always bails out bank $A$ upon default and bank $B$ in the situation where both banks fail independently. If $BK_A$ obtains $R^A_1$ at time $t = 1$ and $BK_B$ obtains zero, then the liquidation decision of $BK_B$ depends on the interbank market size.

The bailout condition for $BK_B$ is $\Delta \text{Welfare} = \text{Welfare}_{\text{Joint Bailout}} - \text{Welfare}_{\text{Joint Liquidation}} \geq 0$. Alternatively,

\[
\Delta \text{Welfare} = \begin{cases} 
\gamma^I (R_2 (1 - F (1 - L)) - (F - 1) r^I) + \Theta(\gamma, \phi, r, F, L), & \text{if } R^A_1 + \gamma - \gamma_I - \phi (1 + \gamma) \geq 0, \\
\Delta \text{Welfare}_{\text{Joint Contagion}} + (1 - F) (R^A_1 + \gamma - \gamma_I - \phi (1 + \gamma)), & \text{if } R^A_1 + \gamma - \gamma_I - \phi (1 + \gamma) < 0,
\end{cases}
\]

where $\Theta(\gamma, \phi, r, F, L) = (1 - \gamma) (R_2 (1 - F (1 - L)))+ (F - 1) (1 - \phi) (1 - \gamma) r > 0$.

The function $\Delta \text{Welfare}$ is continuous and decreases with $r^I$. The maximum interbank market size is thus achieved for $r^I = 1$.

For $R_2 (1 - F (1 - L)) - (F - 1) > 0$, $\Delta \text{Welfare}$ increases in $\gamma^I$. A banking union always bails out $BK_B$, regardless of the size of the interbank market. The equilibrium is given by $\gamma^I = \gamma$ and $r^I = 1$.

If $R_2 (1 - F (1 - L)) - (F - 1) < 0$, then $\Delta \text{Welfare}$ decreases with $\gamma^I$ if $\gamma^I < R^A_1 + \gamma - \phi (1 + \gamma)$, the no contagion case, and increases with $\gamma^I$ if $\gamma^I > R^A_1 + \gamma - \phi (1 + \gamma)$.

\(^3\)It takes the value $\mathbb{P}(BK_B \text{ succeeds at } t = 1) \gamma^I r^I$ for $R^A_1 + (\gamma - \gamma_I) - \phi (1 + \gamma) < 0$. 

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If
\[ R_2 (1 - F (1 - L)) \geq (F - 1) \left( R_1^A + \gamma - (1 + \gamma) - (1 - \phi) (1 - \gamma) r \right) \geq 0, \]
then a banking union always bails out \( BK_B \), since \( \Delta \text{Welfare} > 0 \) for \( \gamma^I = \gamma \) and \( r^I = 1 \).

It follows that the banking union only liquidates \( BK_B \) for idiosyncratic defaults and if the interbank market is small enough to not generate contagion,
\[ \gamma < \gamma^I_{\text{Union}} = \frac{F - 1 - (1 - \phi) (1 - \gamma) r + (1 - \gamma) R_2 (1 - F (1 - L))}{(F - 1) r^I - R_2 (1 - F (1 - L))} < \gamma^I_{\text{Contagion}} = \frac{R_1^A + \gamma - \phi (1 + \gamma)}{1 - \gamma}, \]
and \( R_2 < R_2 \), where \( R_2 \) is defined as
\[ R_2 = \min \left\{ \frac{F - 1}{1 - F (1 - L)}, \frac{F - 1}{1 - F (1 - L)} \left( R_1^A + \gamma - (1 + \gamma) \phi - (1 - \phi) (1 - \gamma) r \right) \right\}. \]

For any \( r^I \), it follows that \( \gamma^I_{\text{Union}} > \gamma^I_{\text{National}} \), as \( (F - 1) r^I < F r^I \). \( \square \)

**Proposition 9**

*Proof.* From Lemmas 15 and 16, \( BK_A \) chooses between two possible interbank market sizes. Bank \( BK_A \) either lends the full surplus \( \gamma \) or the maximum amount for which \( BK_B \) is bailed out given default.

An equilibrium on the interbank market is defined by an interbank market size \( \gamma^I \) and an interbank interest rate \( r^I \): \((\gamma^I, r^I)\). Only two interbank market equilibria are possible for each regulatory architecture. With national regulation, the equilibrium is either \((\gamma^I_{\text{National}}, 1)\) or \((\gamma, r^I_{\text{National}} \geq 1)\). With a banking union, the equilibrium is either \((\gamma^I_{\text{Union}}, 1)\) or \((\gamma, r^I_{\text{Union}} \geq 1)\).

**Equilibrium interest rates** The unique equilibrium interest rate solves equation (4.70) if \( BK_A \) can lend the whole amount to \( BK_B \) without being affected by contagion,
\[ \gamma^I_{\text{National/Union}} (r^I) (r^I - 1) - \gamma r^I p^* + \gamma = 0, \text{ if } R_1^A - \phi (1 + \gamma) > 0, \]
and equation (4.71) if \( BK_A \) defaults due to contagion,
\[ \gamma^I_{\text{National/Union}} (r^I) (r^I - 1) - \gamma r^I p^* + \gamma + (1 - p^*) (R_1^A - \phi (1 + \gamma)) = 0, \text{ if } R_1^A - \phi (1 + \gamma) \leq 0. \]

Since \( \gamma^I_{\text{National/Union}} (r^I) (r^I - 1) \) decreases with \( r^I \), both equations are monotonous with respect to \( r^I \). Moreover, the expressions are positive for \( r^I = 1 \). An equilibrium
interest rate \( r^I \) exists and is unique for each regulatory regime. From \( \gamma^I_{\text{Union}} > \gamma^I_{\text{National}} \) and monotonicity, \( r^I_{\text{Union}} > r^I_{\text{National}} \). It follows that a unique positive equilibrium interest rate exists for both the national regulation and banking union regimes. Further, \( r^I_{\text{Union}} > r^I_{\text{National}} \).

Bank \( BK_B \) selects to borrow the full \( \gamma \) from the interbank market if \( R^B_1 \) is large enough. Its payoff from borrowing \( \gamma \) and being liquidated upon default is

\[
(4.72) \quad p^* \left( R^B_1 + R_2 - \phi (1 - \gamma) - (1 - \phi) (1 - \gamma) r - \gamma r^I \right),
\]

and, from borrowing \( \gamma^I_{\text{National/Union}} \) and being bailed out is

\[
(4.73) \quad (1 - \gamma + \gamma^*) \left( p^* R^B_1 + R_2 \right) - p^* \left( \phi (1 - \gamma) - (1 - \phi) (1 - \gamma) r - \gamma r^I \right).
\]

The difference between equations (4.72) and (4.73) is given by

\[
(4.74) \quad p^* \left( \gamma - \gamma^I \right) R^B_1 + p^* \left( \gamma^I - \gamma^* \right) + \left( p - (1 - \gamma + \gamma^*) \right) R_2 \geq 0.
\]

Hence, a larger \( R^B_1 \), ceteris paribus, incentivizes \( BK_B \) to lend the full \( \gamma \) at a positive interest rate. Note that since \( \gamma^I_{\text{Union}} > \gamma^I_{\text{National}} \) and the monitoring incentives are better under national regulation, the threshold is higher for a banking union than for national regulation.
Chapter 5

Summary

In this thesis I study the interactions between financial intermediaries and the financial systems’ institutional design. I take a closer look at three different areas of financial regulation: (i) the system of risk-based capital requirements, which is the cornerstone of the modern financial regulatory framework, (ii) the interaction between financial regulation and non-regulated financial intermediation, known as shadow banking, and (iii) optimal regulation of integrated, cross-border financial systems.

I investigate the channels through which regulation affects financial intermediaries’ lending, funding and risk-taking decisions. My primary goal is always answering questions relevant for policy-makers. What are possible market outcomes under the particular regulation? How can policy-makers adjust the regulations in order to avoid inducing unwanted behavior? What are the policy tools that policy-makers can choose from? The thesis offers practical policy recommendations to financial authorities. This is particularly relevant at the current moment: In the post-crisis period, when a major overhaul of the existing regulatory framework is taking place, and new regulatory rules are introduced.

In Chapter 2, together with prof. Sweder van Wijnbergen, we model ex post penalties for violating minimum capital requirements. We show that in the presence of regulatory and “market” penalties banks choose actual capital ratios higher than the regulatory minimum. We argue that those positive capital buffers should be taken into account when designing regulatory rules. For example, under risk-based capital requirements capital buffers are positively correlated with the level of risk in the economy. Therefore, capital requirements independent of the business cycle, such as under Basel II, are even more pro-cyclical than one would expect from the pro-cyclicality of the requirement only. While raising the overall level of capital requirements should not be expected to reduce the pro-cyclicality of the system, our model shows that the
counter-cyclical buffer envisioned under Basel III is likely to significantly reduce fluctuations of actual capital along the business cycle. Finally, we identify a negative effect of considerably higher actual capital ratios under Basel III for the market-disciplining role of unsecured bank debt.

Chapter 3 studies incentives of regulated financial intermediaries to involve in shadow activities. While shadow banks are often perceived as competitors to traditional banks, it was commercial banks who dominated off-balance intermediation in many markets prior to the 2007-2009 financial crisis. A thorough investigation of links between shadow banks and regulated financial intermediaries is of particular importance for regulators, as evidence shows that off-balance entities set-up by commercial banks often enjoyed implicit guarantees from their sponsoring institutions. Such guarantees effectively provided recourse to the government guarantees protecting commercial banks.

The model developed in Chapter 3 focuses on potential economy-wide implications of the guarantees from traditional banks to shadow banks. I show that guarantees can distort lending decisions of intermediaries, and lead to a significant increase in the amount of credit in the economy. In the presence of guarantees, costs of the regulatory safety net provided to traditional banks increase, as defaults of shadow banks spread to the regulated financial sector.

Interestingly, policy recommendations match key regulatory reforms introduced after the 2007-2009 financial crisis. The Dodd-Frank Act in the US, and the ring-fencing proposal in the UK were designed to eliminate links between banks’ lending businesses and other activities. Basel III rules for minimum capital requirements terminated the favourable treatment of liquidity lines to off-balance vehicles, making support to shadow entities more expensive for the sponsors.

In Chapter 4, together with my colleague Marius Zoican we study potential implications of supranational bank regulation in the presence of integrated financial markets. The banking union provides liquidity more efficiently, reducing the taxpayers’ burden. It eliminates international contagion of bank defaults. The drawback is that increased leniency toward internationally-operating institutions makes them take on more risk. The net effect on welfare of the supranational regulation becomes negative whenever the risk-taking incentives are highly distorted.

We then investigate how to restore incentives by a proper design of the banking union. In our model this can be achieved by a partial-mandate banking union: A system where the supranational and national resolution systems coexist, with clearly delimited intervention jurisdictions. Regarding funding of interventions in the banking system, we argue that countries with banking systems that are net lenders in the
international interbank market should contribute most. This is because these banking systems benefit the most from the elimination of cross-border contagion effects.
Bibliography


BIBLIOGRAPHY


BIBLIOGRAPHY


Huang, J., and M. Huang (2003): “How Much of the Corporate-Treasury Yield Spread is Due to Credit Risk?,” *Unpublished*.


Morgan, D., and K. Stiroh (2005): “Too Big to Fail After All These Years,” Federal Reserve Bank of New York Staff Report, No. 220.


Nederlandse samenvatting
(Summary in Dutch)

In dit proefschrift heb ik onderzoek gedaan naar de interacties tussen financiële instellingen en de institutionele structuur van het financiële systeem. Ik heb hierbij gekeken naar drie verschillende aspecten van financiële regulering: (i) het systeem van risico-gewogen kapitaalseisen dat de hoeksteen vormt van de huidige internationale financiële regelgeving, (ii) de interactie tussen gereguleerde financiële instellingen en ongereguleerde financiële bemiddeling, ook wel bekend onder de naam “shadow banking”, en (iii) de optimale regulerings van grensoverschrijdende geïntegreerde financiële markten. Ik heb hierbij gekeken naar de verschillende kanalen waaronder financiële regelgeving invloed heeft op kredietverlening, schuldfinanciering, en het nemen van risico’s door financiële instellingen. Mijn belangrijkste doel is altijd geweest om vragen te onderzoeken die relevant zijn voor toezichthouders en beleidsmakers: wat zijn mogelijke gevolgen van bepaalde regelgeving voor marktuitkomsten? Hoe kunnen beleidsmakers regelgeving aanpassen om ongewenst gedrag te voorkomen? Welke beleidssinstrumenten staan de toezichthouders ter beschikking? Ik heb hierbij altijd geprobeerd om tot praktische beleidsaanbevelingen voor toezichthouders en financiële autoriteiten te komen, iets wat op het moment zeer relevant is nu er grote veranderingen plaatsvinden op het gebied van bestaande financiële regelgeving, en er veel nieuwe regelgeving geïntroduceerd wordt.

In hoofdstuk 2 kijk ik samen met professor Sweder van Wijnbergen naar het effect van boetes die achteraf opgelegd worden wanneer financiële instellingen onder de minimale kapitaalseisen zakken. We laten zien dat banken ervoor kiezen om extra kapitaal aan te houden wanneer zij weten dat toezichthouders achteraf boetes opleggen. Toezichthouders zouden deze extra kapitaalbuffers mee moeten nemen bij het ontwerpen van nieuwe regelgeving. In een systeem van risico-gewogen kapitaalseisen zijn kapitaalbuffers namelijk positief gecorreleerd met de hoeveelheid risico in de economie. Dit betekent dat kapitaalseisen die constant zijn gedurende de gehele conjunctuur-
cyclus, zoals bijvoorbeeld Basel II, voor nog meer procycliciteit zorgen dan men zou verwachten op basis van de kapitaalseisen. Hoewel het verhogen van de kapitaalseisen er waarschijnlijk niet voor zal zorgen dat het financiële systeem minder procyclisch wordt, laten wij zien dat de anticyclusche kapitaalbuffer die onder Basel III regelgeving ingevoerd zal worden, wel degelijk fluctuations in de kapitaalbuffers zal doen afnemen. De aanzienlijk hogere kapitaalseisen onder het Basel III toezichtsregime zorgen echter wel voor een negatief effect op de disciplinerende rol die financiële markten uitoefenen via ongedekte bankschulden.

In hoofdstuk 3 kijk ik naar de prikkels voor gereguleerde financiële instellingen om actief te worden in zogenaamde schaduwactiviteiten die buiten het toezichtsregime vallen, zoals bijvoorbeeld “shadow banks”. Hoewel shadow banks veelal gezien worden als concurrenten van traditionele banken, waren het in de praktijk voornamelijk de commerciële banken die voor de financiële crisis van 2007-2009 in vele markten actief waren door middel van juridische entiteiten die niet op de balans van de commerciële banken hoefden te worden opgenomen, zogenaamde off-balance sheet entiteiten of shadow banks. Een grondige analyse van de interacties tussen shadow banks en gereguleerde financiële instellingen is vooral van belang voor toezichthouders, omdat economisch onderzoek laat zien dat off-balance sheet entiteiten die door commerciële banken opgezet zijn, vaak impliciete garanties genieten van diezelfde commerciële bank (de sponsor). In de praktijk komt het erop neer dat de off-balance sheet entiteiten hierdoor impliciet onder de overheidsgaranties vallen die op commerciële banken van toepassing zijn. Het model in hoofdstuk 3 richt zich op de mogelijke gevolgen voor de economie van deze impliciete garanties die door de sponsoren (commerciële banken) aan de shadow banks verstrekt worden. De garanties hebben namelijk een verstorend effect op de kredietverlening, en zorgt ervoor dat de hoeveelheid krediet in de economie flink toeneemt. In de aanwezigheid van deze impliciete garanties nemen de kosten voor de belastingbetalers toe, omdat faillissementen van shadow banks ervoor zorgen dat de sponsoren (commerciële banken) moeten bijspringen, en via deze route vaker aanspraak maken op het depositogarantiestelsel. Het valt op dat de beleidsaanbevelingen die volgen uit mijn model overeenkomen met de belangrijkste hervormingen in het toezicht op de financiële sector na de financiële crisis van 2007-2009. Zowel de Dodd-Frank Act in de V.S., als het voorstel in het Verenigd Koninkrijk om verschillende bankactiviteiten van elkaar te isoleren (ring-fencing), hebben als specifiek doel om de connecties tussen de kredietverlening en andere activiteiten te elimineren. De Basel III regelgeving voor de minimale kapitaalseisen heeft ook een einde gemaakt aan de voorkeursbehandeling van kredietlijnen naar off-balance sheet entiteiten, waardoor het duurder wordt voor sponsoren van shadow banks om (impliciete) steun en garanties te geven.
In hoofdstuk 4 kijk ik samen met Marius Zoican naar de potentiele implicaties van supranationaal bankentoezicht in geïntegreerde financiële markten. De bankenunie zorgt voor een meer efficiënte liquiditeitsverschaffing in financiële markten, waardoor de kosten van reddingsoperaties voor de belastingbetaler omlaag gaan. Het risico op internationale besmetting via bankfaillissementen wordt namelijk geëlimineerd. De bankenunie zorgt er echter wel voor dat toezichthouders minder streng worden richting grote, internationaal opererende instellingen, waardoor deze instellingen meer risico gaan nemen. Het netto welvaartseffect van supranationaal toezicht wordt zelfs negatief in het geval de prikkels om risico te nemen verstoord raken. Daarom kijken we vervolgens naar de mogelijkheden om de prikkels te corrigeren via het verbeteren van het institutionele ontwerp van de bankenunie. Dit kan in ons model bereikt worden via het verdelen van bevoegdheden waarbij de supranationale en de nationale resolutie mechanismen naast elkaar bestaan, met duidelijk afgebakende interventie jurisdicties. We concluderen dat de grootste bijdrage voor de interventies in de bancaire sector betaald zouden moeten worden door de landen met een netto crediteurenpositie in de internationale interbancaire markt. De bancaire sector in deze landen profiteert namelijk het meest van het elimineren van grensoverschrijdend besmettingsgevaar.
The Tinbergen Institute is the Institute for Economic Research, which was founded in 1987 by the Faculties of Economics and Econometrics of the Erasmus University Rotterdam, University of Amsterdam and VU University Amsterdam. The Institute is named after the late Professor Jan Tinbergen, Dutch Nobel Prize laureate in economics in 1969. The Tinbergen Institute is located in Amsterdam and Rotterdam. The following books recently appeared in the Tinbergen Institute Research Series:

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