Too-International-to-Fail?
Supranational Bank Resolution and Market Discipline

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This version: May 19, 2015

Abstract

Supranational resolution of insolvent banks does not necessarily improve welfare. We build an international banking model with costly loan monitoring. A supranational regulator (SR) bails out insolvent banks to prevent cross-border contagion. Contrastingly, national regulators (NR) minimize domestic costs and liquidate high-leveraged international banks: Interbank loans become risky. The SR welfare effect depends on monitoring costs. For low monitoring costs, NR promotes market discipline: interbank loan terms depend on default risk. The SR removes interbank loan risk and destroys market discipline: Monitoring incentives and welfare decrease. For high monitoring costs, SR improves welfare as it eliminates inefficient liquidations and endogenous interbank trading "balkanization."

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Supranational resolution of insolvent banks does not necessarily improve welfare. We build an international banking model with costly loan monitoring. A supranational regulator (SR) bails out insolvent banks to prevent cross-border contagion. Contrastingly, national regulators (NR) minimize domestic costs and liquidate high-leveraged international banks: Interbank loans become risky. The SR welfare effect depends on monitoring costs. For low monitoring costs, NR promotes market discipline: interbank loan terms depend on default risk. The SR removes interbank loan risk and destroys market discipline: Monitoring incentives and welfare decrease. For high monitoring costs, SR improves welfare as it eliminates inefficient liquidations and endogenous interbank trading "balkanization."

JEL classification: G15; G18; G21

Keywords: bank regulation, market discipline, moral hazard, contagion

1 Introduction

> *[The banking union]* is the most ambitious change in Europe since the launch of the euro: to transfer to European authorities the [..] power to wind up euro-zone banks, using a common European fund if necessary.
>
> – The Economist, December 2013

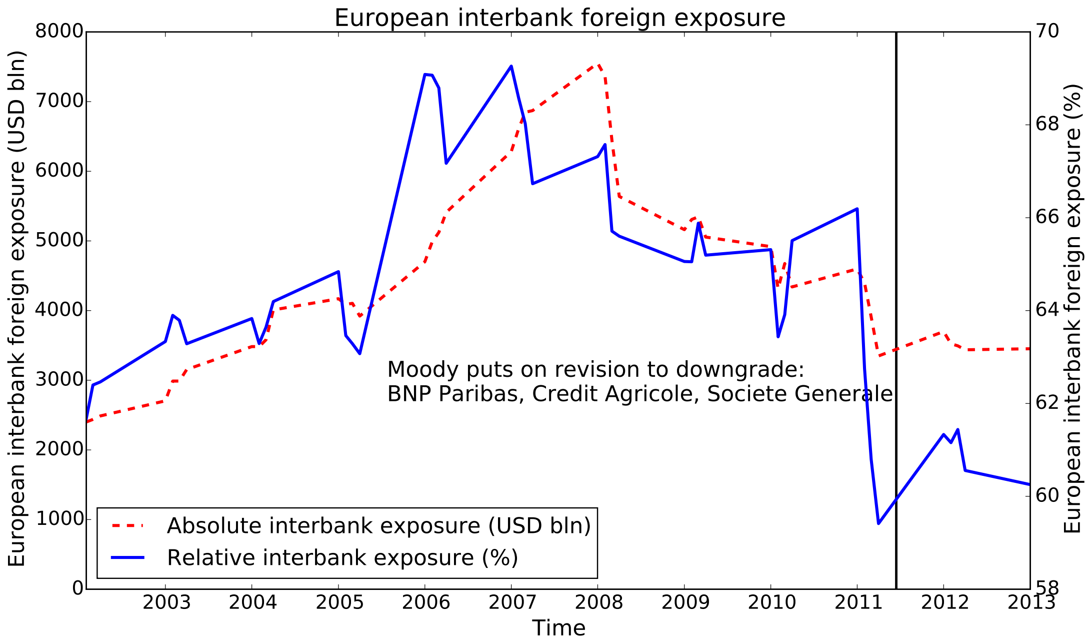
Should international regulators resolve insolvent international banks? The global financial crisis ignited a debate on supranational resolution frameworks. In Europe, the Single Resolution Mechanism (SRM) becomes operational in 2016: It is designed to transfer bank resolution powers from a national to a centralized European level.

The impact of international bank resolution is not trivial. First, it can better contain cross-border contagion risks (International Monetary Fund, 2013), which are especially relevant in today's interconnected financial system. Figure 1 documents banks in Europe had an average international exposure to European assets of 5 trillion USD between 2003 and 2013. Second, centralised resolution bypasses protracted negotiations between national authorities (see the Dexia, Fortis bailouts). Finally, national and supranational regulators may have different objectives. National authorities face a natural tension between domestic taxpayers and foreign creditors; Allen et al. (2011) argue that they "care first and foremost about domestic depositors." Section 2 offers background on the Icesave (2008) and Anglo-Irish Bank (2012) defaults: in both cases, national regulators were reluctant to compensate foreign creditors from taxpayers' money. Therefore, a supranational regulator may be relatively more inclined to bail out insolvent banks.

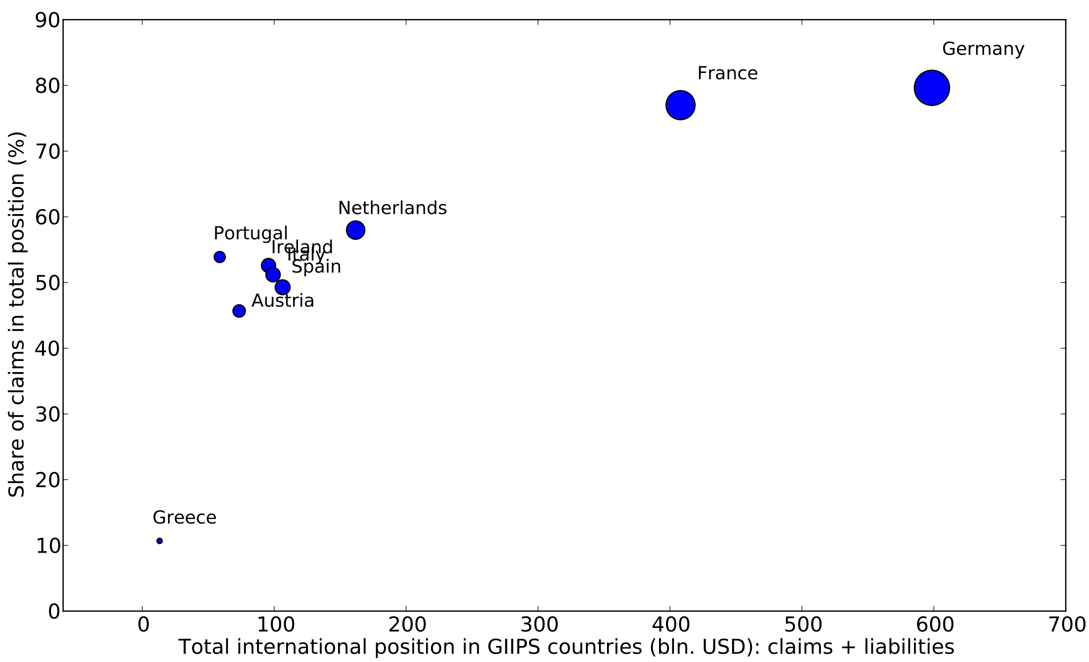
This paper analyzes the impact of supranational bank resolution. We build a two-country model of international banking with endogenous regulatory architecture. There is one bank and one regulator in each country: National regulators have the option to merge. Heterogeneity in banks' investment opportunities generates gains from trade; consequently, there is scope for an interbank market. Interbank contracts are the outcome of Nash bargaining between the two banks. If a bank defaults, the regulator either bails it out or liquidates its assets.

We introduce two frictions. First, there is moral hazard: Bank investments require costly monitoring. Second, liquidation of insolvent banks is inefficient. As a result, bailouts are always ex post efficient.

The main result is that a supranational resolution mechanism can reduce welfare. There is a trade-off between ex post resolution efficiency and ex ante monitoring incentives of banks. National regulators (NR)



(a) Dynamics of Eurozone interbank foreign exposures



(b) Share of claims against GIIPS countries and total positions.

Figure 1: **Eurozone interbank exposures**

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.*

do not internalize welfare of foreign agents and are more likely to liquidate an insolvent bank with large international liabilities. This is ex post inefficient, i.e., there is under-provision of bailouts under NR. From an ex ante perspective however, excessive liquidation may generate a market discipline effect. Under NR international bank creditors bear counterparty risk: They receive only a part of their claims following a liquidation. Consequently, lending terms depend on the monitoring strategies of the borrowing bank. As their default probability is higher, non-monitoring banks receive smaller loan sizes or pay higher interest rates, and therefore have lower expected profits. This offers debtor banks incentives to monitor their investments. However, market discipline under NR is only effective if monitoring costs are low enough.

The supranational regulator (SR) chooses the ex-post efficient resolution, i.e., it bails out insolvent banks. The enhanced efficiency, however, comes at a price. Creditor banks bear no counterparty risk, and market discipline breaks down. For low monitoring costs, i.e., if market discipline is effective under NR, a supranational regulator decreases welfare. For high monitoring costs, however, SR improves welfare: Worse borrowing terms under NR for non-monitoring banks are not enough to improve incentives. Therefore, market discipline breaks down also under national resolution. Depending on the potential gains from interbank trade, the SR welfare improvement is realized either through a *trade efficiency* channel or a *resolution efficiency* channel.

Heterogenous investment opportunities for the two banks generate gains from interbank trade. For low gains from interbank trade, supranational resolution improves *trade efficiency*. Under national resolution there is strategic credit rationing on the interbank market. For the creditor bank the potential interbank market profit is low relative to the loss from a contagion-triggered default. It therefore restricts interbank lending so that the debtor bank's regulator is indifferent between a bailout and a liquidation. Therefore, the debtor bank is always bailed out, and there is no contagion. It follows that the creditor bank bears no counterparty risk, and resolution policies are ex post efficient. However, credit rationing implies that potential gains from trade are not fully realized. Under SR credit rationing is redundant since the supranational regulator always chooses efficient resolution policies. Consequently, SR improves trade efficiency as it stimulates interbank lending. An interpretation of this result is that supranational resolution eliminates the "balkanization" of interbank trading.[1]

For high gains from interbank trade supranational resolution improves *resolution efficiency*. Potential interbank market profits are large. Therefore, the creditor bank is willing to bear the counterparty risk. Accordingly, it is compensated by a higher interest rate, i.e., one that includes a counterparty risk premium.

[1] Stopping the balkanization of interbank markets is one of the goals of the European Banking Union, see, e.g., https://goo.gl/rBZXJF. The Financial Times defines balkanization as "a handy term for the breakdown of cross-border banking."

There is no credit rationing under NR. However, the resolution policy is suboptimal: The insolvent debtor bank is liquidated by the national regulator as bailouts involve large cross-border transfers. A supranational regulator improves welfare as it does not resort to inefficient liquidations.

The paper generates one more result. If SR improves welfare, a merger of national regulators is always feasible. The resolution fund contributions of the two countries depend on the size of interbank trade. However, they do not necessarily depend on bank default probabilities, as counterparty risk is priced in the interbank interest rates.

Policy implications. Perhaps the most salient prediction of our model is that a supranational resolution mechanism can amplify moral hazard. Therefore, a natural policy implication is a stricter Single Supervisory Mechanism (SSM). Stronger ex ante regulatory requirements limit the risk-taking behavior amplified by a more lenient ex post resolution policy. However, there are several caveats to a "tougher" SSM: Colliard (2013) argues agency frictions exist between local and joint bank supervisors. Further, Górnicka (2014) finds that banks respond to tougher capital requirements by moving risky assets off their balance sheets, while using taxpayer money to insure them.

A second insight is that the interbank market reveals the sign of the SR welfare impact. Under a welfare-improving SR interbank lending terms ameliorate, i.e., transaction volumes increase or interest rates decrease.

Finally, the model shows that resolution fund contributions should take into account banks' cross-border net positions. This aspect is not taken into account by the current design of the European Single Resolution Fund, where contributions are proportional to the amount deposits covered by deposit insurance.[2]

Related literature. Our paper is part of a rapidly growing literature on financial institution design and banking regulation. We contribute to this literature in the following ways.

First, the model focuses on the *interaction* between supranational resolution mechanisms and bank moral hazard. We find that supranational regulation may have a negative impact on market discipline. Second, regulatory architecture is endogenous; as a result, the model can establish optimal member contributions to the supranational resolution fund.

Several papers on supranational bank regulation focus on supervision rather than resolution. Colliard (2013) studies the optimal design of the Single Supervisory Mechanism (SSM). He introduces an agency

[2] See Art. 5 from Regulation EU 2015/81 at `https://goo.gl/1ge02h`.

problem between national and central supervisors. Foarţă (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.

Beck et al. (2013) and Niepmann and Schmidt-Eisenlohr (2013) study supranational resolution with interbank contagion. However, their models abstract from banks' risk-taking incentives, and do not consider market discipline effects.

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. In the same spirit, Niepmann and Schmidt-Eisenlohr (2013) propose several welfare-improving supranational regulation mechanisms. Engle et al. (2015) find that, between 2000 and 2012, some banks might be considered "too-big-to-be-saved," i.e., bailouts are very costly for domestic taxpayers. Guembel and Sussman (2014) argue that fragmentation of liquidity markets arises endogenously as national regulators do not internalize contagion effects and apply "beggar-thy-neighbour" policies. However, from a supranational point of view, integration of markets is optimal.

Our paper also 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 et al. (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 et al. (2000) and Kara (2013). Farhi and Tirole (2014) discuss a double moral hazard problem: The bailout of banks by national regulators and of national regulators by supranational ones.

A number of papers study the weak commitment of regulators to liquidate 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 et al. (2014) 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 et al. (2012), and Ferry and Wolff (2012) for fiscal alternatives and Schoenmaker and Siegmann (2014) 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. Avgouleas and Goodhart (2015) discuss the proposed bail-in policies and their effect on banking markets' balkanization.

The rest of the paper is structured as follows. Section 2 presents stylized facts on bank resolution in Europe during the 2007-2009 financial crisis and on the proposed Single Resolution Mechanism. Section 3 describes the model. Section 4 discusses the equilibrium under national resolution mechanisms. Section 5 focuses on the impact of supranational resolution. Particularly, we study welfare implications and optimal resolution fund shares. Section 6 concludes.

2 Stylized facts on European bank resolution

Bank resolution during the crisis. The Icelandic bank Icesave became insolvent in 2008. A bailout would have amounted to a 3.9 billion Euro contribution from Icelandic taxpayers to stop losses from spreading to the United Kingdom and the Netherlands, i.e., 12,000 Euro for each citizen.[3] A referendum in Iceland to repay foreign creditors of Icesave was rejected with a 58% vote against the bailout.

Another case is that of the Anglo-Irish Bank. Following its default in January 2012, the Irish National Bank was willing to impose haircuts. Eventually, the European Central Bank (ECB) insisted that the Irish government repay senior debt in the Anglo-Irish bank at face value.[4]

The cases of Icesave and the Anglo-Irish Bank seem to support the view that national resolution mechanisms do not internalize cross-border contagion losses (Allen et al., 2011). Relative to the ECB, national regulators are less favourable towards bailouts that imply large cross-border transfers. Engle et al. (2015) also document some European banks are "too-big-to-saved" as the cost for the taxpayer to rescue them is too high.

[3] See, for instance, the Deutsche Welle analysis at http://dw.de/p/10qlQ.
[4] See the Reuters report at http://goo.gl/oZC9Pr.

The Single Resolution Mechanism. The Single Resolution Mechanism (SRM) and the Single Supervisory Mechanism (SSM) are the two pillars of the banking union in the European Union. The main goal of the SRM is to enable a more effective and timely management of bank crises, by centralizing the bank resolution mechanism for the participating member states.[5]

The decision to create the SRM was taken in the European Parliament and the European Council on July 15, 2014. The SRM will become operative on January 1, 2016.[6] Under the SRM, the resolution of troubled banks is entrusted to the Single Resolution Board (SRB), formed by representatives of the the European Commission, national authorities, and the European Central Bank (ECB). In the case of bank distress, the decision regarding the future of the insolvent institution is made by the European Commission, based on the SRB's recommendation. The SRM applies to all banks in the member states which also participate in the SSM.

The availability of funding support will be guaranteed through the Single Resolution Fund (SRF) financed with contributions from financial institutions under the SSM. Contributions are established as a percentage of the amount of insured deposits. Appendix B provides more institutional details on the European banking union.

3 Model

3.1 Primitives

We consider an economy with four dates, $t \in \{-1, 0, 1, 2\}$, and two countries, labeled A and B. In each country there is one bank ($\mathrm{BK_A}$ and $\mathrm{BK_B}$), one national regulator ($\mathrm{NR_A}$ and $\mathrm{NR_B}$), a unit measure of depositors, and "deep-pocket" outside investors.

Depositors. Depositors are risk-neutral and care about their $t = 2$ consumption only. Depositors receive a unit endowment at $t = 0$, which they can either store or deposit with the domestic bank. Depositors are fully insured by the regulator. Consequently, there is no bank run equilibrium and the net interest rate on deposits is zero.

[5] See, for instance, the European Central Bank memo from April 2014: http://goo.gl/kRToUq.

[6] The Single Supervisory Mechanism came into force on August 19, 2014.

Assets. The two banks have access to different investment opportunities. Bank BK_A can invest at $t = 0$ in a long-term project that yields a deterministic return of R_A. The return is realized in two stages: γ at $t = 1$, and $R_A - \gamma$ at $t = 2$. Bank BK_B can invest at $t = 1$ in a short-term, risky project that yields $\tilde{R}_B \in \left\{R_B^H, R_B^L\right\}$ at $t = 2$, with $R_B^H > 1$ and $R_B^L < 1$.

The maximum investment in the long-term project is one unit, while there is no limit on the short-term investment. In addition, banks have access to a zero-return cash storage technology.

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.

Monitoring. There is moral hazard as in Holmstrom and Tirole (1997). Bank BK_B can choose whether to invest in monitoring technology at $t = 0$, before the investment takes place. The monitoring technology has cost C. If BK_B monitors, then its return is always R_B^H. If BK_B does not monitor, the investment is risky: it pays off $R_B^L < 1$ with probability p and R_B^H otherwise.

Interbank market. The interbank market opens at $t = 1$, when BK_A collects γ from its domestic investment. BK_A can either store the full amount until $t = 2$, or lend $\gamma^I \in (0, \gamma]$ to BK_B. The gross interest rate $r(\gamma_I)$ is the result of Nash bargaining between the two banks. We denote by $1 - \eta$ and η the bargaining power of BK_A and BK_B respectively, with $\eta \in (0, 1)$.

Regulators. The role of regulators in our model is to resolve banks in default, and to provide deposit insurance. A bank defaults whenever it is not able to repay its creditors at $t = 2$. The resolution strategies for the regulator are modeled as in Acharya and Yorulmazer (2008): The regulator chooses to either bailout or liquidate the insolvent bank.

In the case of a bailout, all creditors receive the face value of their claims. The regulator provides additional liquidity as required. In the case of a liquidation, the regulator sells the insolvent banks' assets to outside investors.[7] Liquidation is costly: Outside investors can only obtain $(1 - L)\, R_L^B$ at $t = 2$ per unit of investment, where $L \in (0, 1)$. Liquidation proceeds are then paid to both depositors and international creditors on a pro-rata basis. The regulator provides additional liquidity such that depositors always receive the face value of debt. Importantly, the bank manager has a zero payoff upon default both after a liquidation or a bailout.

[7] The model outcomes are the same if the liquidated assets are managed by the regulator.

Supranational regulator. At $t = -1$ national regulators decide whether to merge into a supranational regulator SR. While a national regulator maximizes total welfare in its own country at $t = 2$, the supranational regulator maximizes joint welfare of both countries at $t = 2$. The welfare measure is defined as the sum of payoffs for all agents in the economy. The decision to form a SR is non-renegotiable.

Default contagion. Whenever the low return R_B^L is realized at the final date, bank BK_B defaults. Following the insolvency of BK_B, bank BK_A can also potentially default if it does not receive the face value of the interbank loan. For contagion to manifest, the interbank loan has to be sufficiently large. More precisely, for low enough γ, contagion is not possible, as BK_A never defaults, or BK_B is never liquidated. To rule out the trivial equilibria, we assume γ is large enough, i.e.,

Assumption 1: $\gamma > \max\left\{\frac{LR_B^L}{1-R_B^L}, \frac{R_A-1}{1-R_B^L(1-L)}\right\}$.

The rationale behind Assumption 1 is further explained in Section 4.

Timeline. The timeline is illustrated in Figure 2. A list of all model parameters is presented in Appendix A.

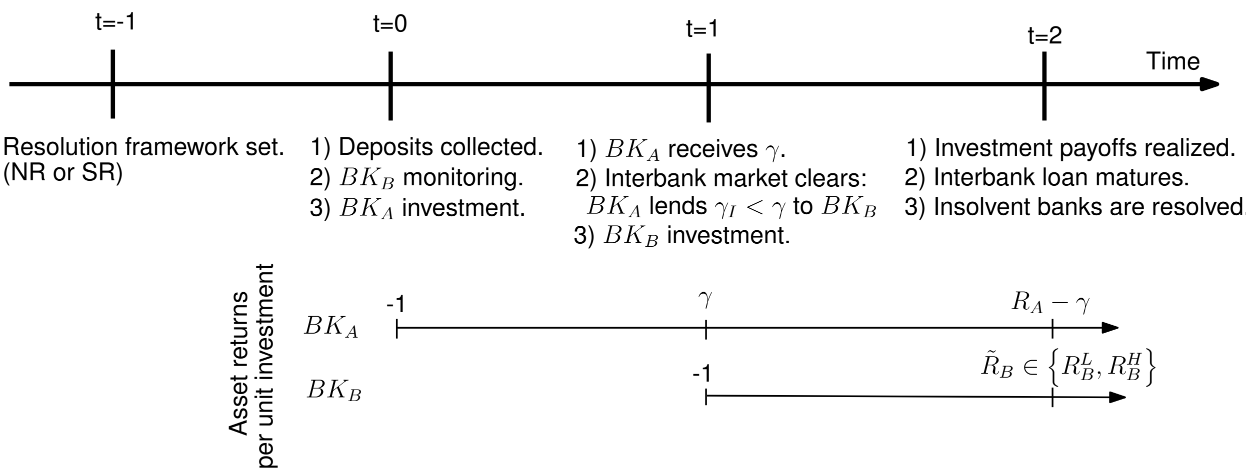


Figure 2: **Model timeline**

3.2 First best equilibrium

To build intuition this section provides a simplified analysis of the first best. To this end, we remove moral hazard: Bank BK_B's investment always yields the high return, R_B^H. Alternatively, the monitoring technology has zero cost, i.e., $C = 0$.

Note that since both banks' investments are riskless, there is no regulatory intervention in the first best. The profit functions of BK_A and BK_B are:

$$\begin{aligned} \pi_A &= R_\text{A} - 1 + \gamma_I (r - 1) \ \text{ and} \\ \pi_B &= R_\text{B}^\text{H} - 1 + \gamma_I \left(R_\text{B}^\text{H} - r\right). \end{aligned} \tag{1}$$

The interbank interest rate solves the Nash bargaining problem:

$$r^{FB} = \arg\max_i \left[\gamma_I (i - 1)\right]^{1-\eta} \left[\gamma_I \left(R_\text{B}^\text{H} - i\right)\right]^\eta . \tag{2}$$

It follows that

$$r^{FB} = R_\text{B}^\text{H} (1 - \eta) + \eta, \tag{3}$$

which does not depend on γ. Further, $r^{FB} \in \left(1, R_\text{B}^\text{H}\right)$ – the BK_A's profit increases in γ_I. Consequently, bank BK_A lends the full amount, $\gamma_\text{I}^{FB} = \gamma$.

The welfare values in countries A and B are

$$\begin{aligned} \text{Welfare}_\text{A}^{FB} &= \underbrace{R_\text{A} - 1 + \gamma\left(r^{FB} - 1\right)}_{\text{bank profit}} + \underbrace{1}_{\text{depositors}} = R_\text{A} + \gamma\left(r^{FB} - 1\right) \ \text{ and} \\ \text{Welfare}_\text{B}^{FB} &= \underbrace{R_\text{B}^\text{H} - 1 + \gamma\left(R_\text{B}^\text{H} - r^{FB}\right)}_{\text{bank profit}} + \underbrace{1}_{\text{depositors}} = R_\text{B}^\text{H} + \gamma\left(R_\text{B}^\text{H} - r^{FB}\right). \end{aligned} \tag{4}$$

The joint first-best welfare,

$$\text{Welfare}^{FB} = R_\text{A} + R_\text{B}^\text{H} + \gamma\left(R_\text{B}^\text{H} - 1\right), \tag{5}$$

does not depend on the interbank rate (which is simply a transfer between the two countries), and increases in γ. A natural interpretation of γ is therefore the size of (potential) gains from international interbank trade.

4 Equilibrium with national regulators

In this section the equilibrium for an economy with national regulators is determined, i.e., we disallow the formation of a supranational regulator at $t = -1$. The equilibrium with a supranational regulator is considered in Section 5, along with welfare impact and feasibility of a joint resolution mechanism.

The solution concept is subgame perfect Nash equilibrium. To determine the equilibrium, we use backward induction: We first solve for the regulators' decision at $t = 2$, then for the interbank loan size and interest rate at $t = 1$, and finally for the monitoring decision of $\mathrm{BK_B}$ at $t = 0$.

4.1 Optimal resolution policy

Bank $\mathrm{BK_B}$ defaults if and only if its return at $t = 2$ is R_B^L. As both depositors and international creditors require a gross return of at least one, the low return $R_\mathrm{B}^\mathrm{L} < 1$ is not enough to repay the debt in full. Conversely, $\mathrm{BK_B}$ never defaults if it obtains the high return $R_\mathrm{B}^\mathrm{H} > 1$.

If the regulator $\mathrm{NR_B}$ bails out $\mathrm{BK_B}$, national welfare is

$$\text{Welfare}_\mathrm{B}^{\text{bailout}} = \underbrace{1}_{\text{Depositors}} - \underbrace{\left[\overbrace{1 + \gamma_I r}^{\text{Debt}} - \overbrace{R_\mathrm{B}^\mathrm{L}\,(1 + \gamma_I)}^{\text{Assets}}\right]}_{\text{Regulator's cost}}. \tag{6}$$

In the case of a bailout, domestic depositors and $\mathrm{BK_A}$ receive the full amount of their claims: 1 and $\gamma_\mathrm{I} r$ respectively. The term in square brackets is the additional amount $\mathrm{NR_B}$ needs to raise to repay all bank creditors. Since $R_\mathrm{B}^\mathrm{L} < 1$ and $r > 1$, the net cost for $\mathrm{NR_B}$ increases in the interbank loan size, γ_I.

The national welfare following liquidation of $\mathrm{BK_B}$ is

$$\text{Welfare}_\mathrm{B}^{\text{liquidation}} = \underbrace{1}_{\text{Depositors}} - \underbrace{\left[\overbrace{1}^{\text{Domestic debt}} - \overbrace{(1 - L)\,R_\mathrm{B}^\mathrm{L}}^{\text{Asset liquidation value}}\right]}_{\text{Regulator's cost}}, \tag{7}$$

where the term $(1 - L)R_\mathrm{B}^\mathrm{L}$ in square brackets represents proceeds from the sale of $\mathrm{BK_B}$'s assets net of the pro-rata payment to $\mathrm{BK_A}$, $\gamma_I\,(1 - L)\,R_\mathrm{B}^\mathrm{L}$. The repayment received by $\mathrm{BK_A}$ is always lower than the amount lent, as $(1 - L)\,R_\mathrm{B}^\mathrm{L} < 1$. Finally, 1 is the full repayment to insured domestic depositors.

If the interbank loan is not repaid in full $\mathrm{BK_A}$ may default as well. The national welfare functions in country A after bailout and liquidation are:

$$\mathrm{Welfare}_{\mathrm{A}}^{\mathrm{bailout}} = \underbrace{1}_{\text{Depositors}} - \underbrace{\left[1 - \overbrace{(R_{\mathrm{A}} - \gamma)}^{\text{Assets}} - \overbrace{(\gamma - \gamma_I)}^{\text{Cash}} - \overbrace{\gamma_I (1 - L) R_{\mathrm{B}}^{\mathrm{L}}}^{\text{Pro-rata loan repayment}}\right]}_{\text{Regulator's cost}} \text{ and}$$

$$\mathrm{Welfare}_{\mathrm{A}}^{\mathrm{liquidation}} = \underbrace{1}_{\text{Depositors}} - \underbrace{\left[1 - \overbrace{(1 - L)(R_{\mathrm{A}} - \gamma)}^{\text{Asset liquidation value}} - \overbrace{(\gamma - \gamma_I)}^{\text{Cash}} - \overbrace{\gamma_I (1 - L) R_{\mathrm{B}}^{\mathrm{L}}}^{\text{Pro-rata loan repayment}}\right]}_{\text{Regulator's cost}}. \tag{8}$$

The term $\gamma_{\mathrm{I}}(1 - L)R_{\mathrm{B}}^{\mathrm{L}}$ stands for the proceeds from liquidation of $\mathrm{BK_B}$, and $\gamma - \gamma_{\mathrm{I}}$ is the residual cash stored by $\mathrm{BK_A}$ from $t = 1$ to $t = 2$.

Lemma 1 describes the optimal resolution policy under national regulation in both countries.

Lemma 1. ***Optimal NR resolution.*** *The national regulator NR_A always bails out BK_A. The national regulator NR_B bails out BK_B if:*

$$\gamma_I < \frac{LR_B^L}{r - R_B^L} = \overline{\gamma}(r), \tag{9}$$

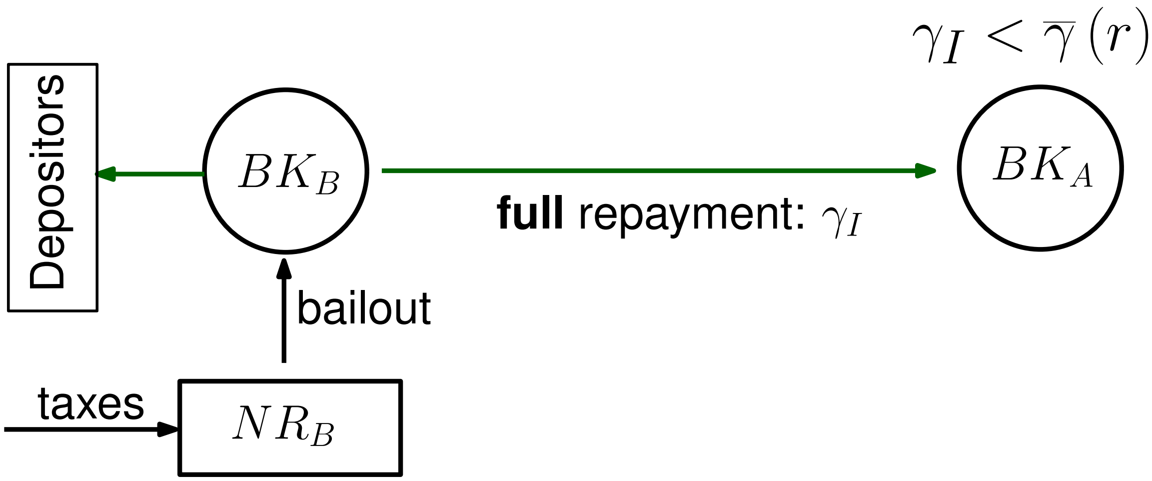
where $\overline{\gamma}(r)$ decreases in r.

From Lemma 1, $\mathrm{BK_B}$ is liquidated for large enough interbank loans. Note that Assumption 1 guarantees that $\gamma > \max_r \overline{\gamma}(r) = \overline{\gamma}(1)$, i.e., there exists an interbank loan threshold above which $\mathrm{BK_B}$ is indeed liquidated.

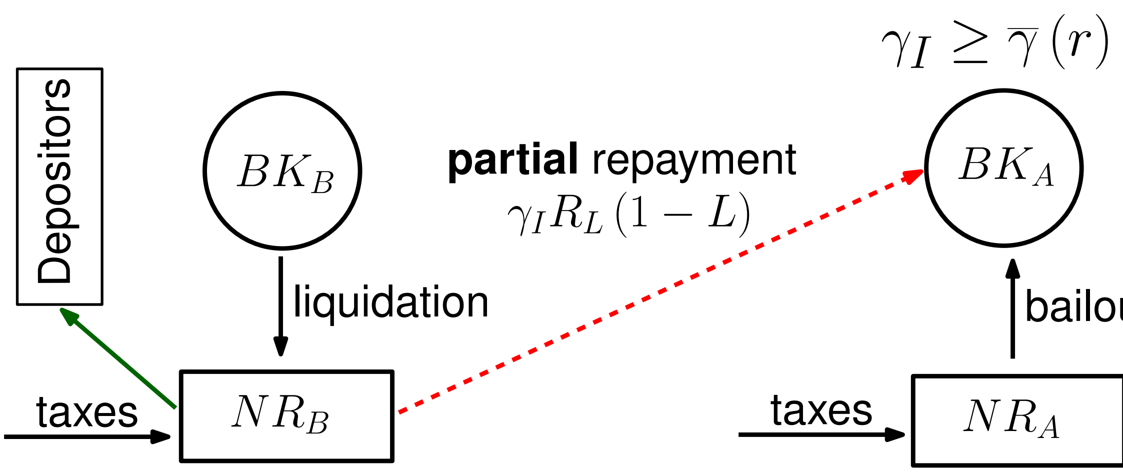
A bailout of $\mathrm{BK_B}$ by $\mathrm{NR_B}$ implies repaying the foreign claims in full. However, the national regulator does not internalize the welfare transfer abroad. As a larger γ_{I} implies a larger international transfer, the cost of a bailout increases in the size of the interbank market. As γ_{I} increases, the cost of liquidation becomes lower than the cost of bailout. Consequently, $\mathrm{BK_B}$ is liquidated.

Unlike $\mathrm{BK_B}$, bank $\mathrm{BK_A}$ has no foreign creditors. Thus, following a bailout of $\mathrm{BK_A}$, all liquidity provided by $\mathrm{NR_A}$ ends up with depositors. In this case bailout is always cheaper than liquidation, as it prevents the inefficiency loss from the sale of bank assets. Consequently, $\mathrm{BK_A}$ is always bailed out.

The contagion mechanism and equilibrium resolution policies are further detailed in Figure 3.



(a) Bank BK_B is bailed out



(b) Bank BK_B is liquidated

Figure 3: **Contagion mechanism following BK_B default**

This figure shows the mechanism through which shocks are transmitted across borders in the model. For $\gamma < \overline{\gamma}(r)$, 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 $\gamma < \overline{\gamma}(r)$, the national regulator liquidates BK_B and BK_A receives a pro-rata share of liquidation proceeds. The national regulator in country A needs to intervene as BK_A also defaults. Dashed, red lines correspond to partial repayments; green, continuous arrows correspond to full repayments.

4.2 Interbank market equilibrium

The interbank market clears in two stages. First, $\mathrm{BK_A}$ proposes a loan size γ_I to $\mathrm{BK_B}$. Second, the interbank rate r is set through Nash bargaining, where the bargaining power coefficients of $\mathrm{BK_A}$ and $\mathrm{BK_B}$ are $1-\eta$ and η respectively.

Let $\tilde{p} \in \{p, 0\}$ be the probability that $\mathrm{BK_B}$ earns the low return R_B^L at $t = 2$; $\tilde{p}$ only depends on the monitoring technology investment at $t = 0$. The expected profit of $\mathrm{BK_B}$, $\pi_B(\gamma_\mathrm{I}, r)$, is then

$$\begin{aligned}\pi_B(\gamma_I, r) &= (1-\tilde{p})\left[R_\mathrm{B}^\mathrm{H} - 1 + \gamma_I\left(R_\mathrm{B}^\mathrm{H} - r\right)\right] + \tilde{p}\underbrace{\max\left\{R_\mathrm{B}^\mathrm{L} - 1 + \gamma_I\left(R_\mathrm{B}^\mathrm{L} - r\right), 0\right\}}_{=0,\text{ since } R_\mathrm{B}^\mathrm{L}<1} \\ &= (1-\tilde{p})\left[R_\mathrm{B}^\mathrm{H} - 1 + \gamma_I\left(R_\mathrm{B}^\mathrm{H} - r\right)\right]. \end{aligned} \tag{10}$$

When R_B^L is realized, the payoff of $\mathrm{BK_B}$ is zero: $R_\mathrm{B}^\mathrm{L} < 1$, and all creditors require return rates larger than one. However, if $\mathrm{BK_B}$ monitors the risky project it never defaults, as $\tilde{p} = 0$.

If $\mathrm{BK_B}$ is liquidated after a default the expected profit of $\mathrm{BK_A}$, $\pi_A(\gamma_\mathrm{I}, r)$, is

$$\begin{aligned}\pi_A(\gamma_I, r | \gamma_I > \overline{\gamma}(r)) = (1-\tilde{p})\left[R_\mathrm{A} - 1 + \gamma_I(r-1)\right] \\ + \tilde{p}\max\left\{R_\mathrm{A} - 1 + \gamma_I\left[R_\mathrm{B}^\mathrm{L}(1-L) - 1\right], 0\right\}. \end{aligned} \tag{11}$$

From Assumption 1 $R_\mathrm{A} - 1 + \gamma\left[R_\mathrm{B}^\mathrm{L}(1-L) - 1\right] < 0$. If $\mathrm{BK_A}$ lends $\gamma_\mathrm{I} = \gamma$ it always defaults upon the liquidation of $\mathrm{BK_B}$.

If $\mathrm{BK_B}$ is bailed out upon default the expected profit of $\mathrm{BK_A}$ is riskless,

$$\pi_A(\gamma_I, r | \gamma_I \le \overline{\gamma}(r)) = (R_\mathrm{A} - 1) + \gamma_I(r-1). \tag{12}$$

The interbank interest rate (as a function of the loan size) solves the following Nash bargaining problem:

$$r = \arg\max_i \left[\pi_B(\gamma_I, i) - \pi_B(0,0)\right]^\eta \left[\pi_A(\gamma_I, i) - \pi_A(0,0)\right]^{1-\eta}. \tag{13}$$

Given the equilibrium interest rate r in equation (13), bank $\mathrm{BK_A}$ sets the interbank loan size γ_I to maximize its expected profit at $t = 2$:

$$\gamma_I = \arg\max_{\ell} \pi_A (\ell, r(\ell)) . \tag{14}$$

From equations (11) and (12), the expected profit of BK_A depends on the resolution strategy of NR_B. From Lemma 1 NR_B bails out BK_B if $\gamma_I \leq \overline{\gamma}(r)$, and liquidates BK_B otherwise. We consider the two cases below.

Interbank market for $\gamma_I \leq \overline{\gamma}(r)$. The interbank loan is risk free. The expected profit for BK_A is given by equation (12), and it increases in γ_I. Therefore, BK_A lends the maximum amount, $\gamma_\text{I} = \overline{\gamma}(r)$. The interest rate takes the first best value r^{FB}; BK_A does not require a risk premium.

At the same time, there is a risk transfer from BK_A to the national regulator NR_B in country B. Through a strategically low choice of interbank lending, $\overline{\gamma}(r) < \gamma$, BK_A guarantees a bailout for its debtor and eliminates counterparty risk. On the other hand, the interbank loan size is lower than the first best, γ.

Interbank market for $\gamma_I > \overline{\gamma}(r)$. The interbank loan is risky as BK_B is liquidated upon default. The expected profit for BK_A is given by equation (11). Again, the expected profit of BK_A increases in γ^I, so the loan size is maximum possible, γ. If BK_A bears counterparty risk it lends the full amount to maximize its gain in the "good" state. The rate r depends on counterparty risk, measured by p, and the size of the loan, γ.

In general there are two ways to eliminate counterparty risk. First, BK_A can strategically choose a low level of interbank lending, i.e., $\gamma_\text{I} = \overline{\gamma}(r)$. Second, BK_B can eliminate the project risk by investing in the monitoring technology at $t = 0$. If BK_B monitors, all returns are deterministic, and the interbank equilibrium coincides with the first best. Thus, the equilibrium interbank contract $(\gamma_\text{I}(r), r)$ at $t = 1$ is a function of BK_B's monitoring investment at $t = 0$.

Let $\left(\gamma_I^{\text{Mon}}, r^{\text{Mon}}\right)$ and $\left(\gamma_I^{\text{NMon}}, r^{\text{NMon}}\right)$ be the equilibrium loan size and rate if BK_B monitors and does not monitor respectively. The possible equilibrium values are described by Lemma 2.

Lemma 2. ***Interbank market equilibrium under national regulation.***

If BK_B invests in monitoring technology at $t = 0$, the interbank equilibrium coincides with the first best,

$$\left(\gamma_I^{Mon}, r^{Mon}\right) = \left(\gamma, r^{FB}\right) = \left(\gamma, (1-\eta) R_B^H + \eta\right). \tag{15}$$

If BK_B does not invest in monitoring technology at $t = 0$,

$$\left(\gamma_I^{NMon}, r^{NMon}\right) \in \left\{\left(\overline{\gamma}\left(r^{FB}\right), r^{FB}\right), \left(\gamma, r^{Risk}\right)\right\}, \tag{16}$$

where r^{Risk} is

$$r^{Risk} = R_B^H (1 - \eta) + \eta + \frac{\eta}{\gamma (1 - p)} p (R_A - 1) > r^{FB}. \tag{17}$$

4.3 Optimal monitoring

$\mathrm{BK_B}$ internalizes the interbank market equilibrium when deciding on the monitoring technology investment at $t = 0$. The expected profit for $\mathrm{BK_B}$ if it monitors equals

$$\pi_B (\text{monitor}) = \left[R_{\mathrm{B}}^{\mathrm{H}} - 1 + \gamma_I^{\mathrm{Mon}} \left(R_{\mathrm{B}}^{\mathrm{H}} - r^{\mathrm{Mon}}\right)\right] - C. \tag{18}$$

The expected profit for $\mathrm{BK_B}$ if it does not monitor is

$$\pi_B (\text{not monitor}) = (1 - p) \left[R_{\mathrm{B}}^{\mathrm{H}} - 1 + \gamma_I^{\mathrm{NMon}} \left(R_{\mathrm{B}}^{\mathrm{H}} - r^{\mathrm{NMon}}\right)\right]. \tag{19}$$

The monitoring condition follows from the comparison of equations (18) and (19). Bank $\mathrm{BK_B}$ invests in monitoring technology if

$$C \leq p \left(R_{\mathrm{B}}^{\mathrm{H}} - 1\right) + \gamma_I^{\mathrm{Mon}} \left(R_{\mathrm{B}}^{\mathrm{H}} - r^{\mathrm{Mon}}\right) - (1 - p) \gamma_I^{\mathrm{NMon}} \left(R_{\mathrm{B}}^{\mathrm{H}} - r^{\mathrm{NMon}}\right). \tag{20}$$

Market discipline. The interbank market plays a disciplining role, as the creditor bank $\mathrm{BK_A}$ observes the monitoring decision of $\mathrm{BK_B}$ before its lending decision. Therefore, it can use monitoring to condition loan terms. From the discussion in Section 4.2, there are two ways $\mathrm{BK_A}$ can "discipline" $\mathrm{BK_B}$ through the interbank market. First, it can lend more if monitoring is observed, i.e., $\gamma_I^{\mathrm{Mon}} > \gamma_I^{\mathrm{NMon}}$. Second, a higher interest rate if $\mathrm{BK_B}$ does not monitor, $r^{\mathrm{NMon}} > r^{\mathrm{Mon}}$, also has a disciplining effect.

4.4 Equilibrium

From equation (20) the monitoring decision of $\mathrm{BK_B}$ is a function of the interbank loan size and the interbank interest rate. We define a function $C^{NR}(\gamma)$ such that

$$C^{NR}(\gamma) = \begin{cases} p(R_{\mathrm{B}}^{\mathrm{H}} - 1)\left[1 + \frac{\eta}{p}\left(\gamma - (1-p)\overline{\gamma}\left(r^{FB}\right)\right)\right] & \text{if } \gamma < \gamma^*, \\ p\left[(R_{\mathrm{B}}^{\mathrm{H}} - 1)(1 + \eta\gamma) + \eta(R_{\mathrm{A}} - 1)\right] & \text{if } \gamma \geq \gamma^*, \end{cases} \tag{21}$$

where γ^* is defined as

$$\gamma^* = \frac{\overline{\gamma}\left(r^{FB}\right)}{1-p} + \frac{(R_{\mathrm{A}} - 1)\,p}{(1-p)\left(R_{\mathrm{B}}^{\mathrm{H}} - 1\right)}. \tag{22}$$

Proposition 1 summarizes the equilibrium outcomes.

Proposition 1. ***National resolution equilibrium.***

If $C < C^{NR}(\gamma)$, BK_B invests in monitoring technology. From Lemma 2, the equilibrium loan contract is $\left(\gamma, r^{FB}\right)$. The first-best interbank rate does not include a counterparty risk premium, i.e., $r^{FB} = R_B^H(1-\eta) + \eta$. There is no regulatory intervention.

If $C > C^{NR}(\gamma)$, BK_B does not invest in monitoring technology. The equilibrium loan contract is $\left(\overline{\gamma}\left(r^{FB}\right), r^{FB}\right)$ for $\gamma < \gamma^*$ and $\left(\gamma, r^{Risk}\right)$ if $\gamma > \gamma^*$. Regulator NR_A never liquidates BK_A; regulator NR_B liquidates BK_B for $\gamma > \gamma^*$.

The function $C^{\mathrm{NR}}(\gamma)$ gives the threshold cost for which $\mathrm{BK_B}$ is indifferent between monitoring or not. From equation (21) the threshold increases in γ. Bank $\mathrm{BK_B}$ is more likely to monitor if the potential gains from trade are high. Monitoring is also more likely for higher default probability, as $C^{\mathrm{NR}}(\gamma)$ increases in p.

If $\mathrm{BK_B}$ monitors its project the interbank loan bears no counterparty risk. Consequently, $\mathrm{BK_A}$ lends the full intermediate cashflow γ. No bank defaults; there are no interventions by national regulators.

On the other hand, if $\mathrm{BK_B}$ does not monitor, it may default. The creditor bank $\mathrm{BK_A}$ decides whether to bear counterparty risk by choosing the size of the interbank loan.

For low potential gains from trade, i.e., $\gamma < \gamma^*$, bank $\mathrm{BK_A}$ prefers the safe contract. If $\mathrm{BK_A}$ lends the full intermediate cashflow its interbank profit γr^{Risk} increases in γ. However, the limited scale of the interbank market – due to the low value of γ – translates into lower gains for $\mathrm{BK_A}$. For $\gamma < \gamma^*$ potential interbank profits are lower than the default loss if counterparty risk materializes. As a result, whenever BK_B does not monitor its project, BK_A strategically limits its interbank loan to the level that guarantees ex post bailout of BK_B by the regulator NR_B.

For high potential gains from trade, i.e., $\gamma \geq \gamma^*$, the expected profit from the interbank loan is large enough for BK_A to accept a positive counterparty risk. The interest rate includes a counterparty risk premium, and is thus higher than for $\gamma < \gamma^*$. As a result, it is optimal for BK_A to lend γ in the interbank market.

4.5 Welfare under national regulation

From Proposition 1, national regulators implement the joint first best if $C < C^{NR}(\gamma)$ as there is full investment and no default risk. The joint welfare is

$$\text{Welfare}_{NR} = \text{Welfare}^{FB} = R_\text{A} + R_\text{B}^\text{H} + \gamma\left(R_\text{B}^\text{H} - 1\right) \text{if } C < C^{NR}(\gamma). \tag{23}$$

If $C \geq C^{NR}(\gamma)$ and $\gamma < \gamma^*$ all banks are bailed out given default. There are no liquidation losses, but there is under-investment as the interbank loan is scaled down. The joint welfare is

$$\text{Welfare}_{NR} = R_\text{A} + (1-p)\,R_\text{B}^\text{H} + pR_\text{B}^\text{L} + \overline{\gamma}\left(r^{FB}\right)\left((1-p)\,R_\text{B}^\text{H} + pR_\text{B}^\text{L} - 1\right), \tag{24}$$

which is $\left(\gamma - \overline{\gamma}(r^{FB})\right)\left(R_\text{B}^\text{H} - 1\right)$ lower than the first best value.

If $C \geq C^{NR}(\gamma)$ and $\gamma > \gamma^*$ BK_B is liquidated given default. The joint welfare in this case is

$$\text{Welfare}_{NR} = R_\text{A} + (1-p)\,R_\text{B}^\text{H} + p\,(1-L)\,R_\text{B}^\text{L} + \gamma\left((1-p)\,R_\text{B}^\text{H} + p\,(1-L)\,R_\text{B}^\text{L} - 1\right). \tag{25}$$

There is no under-investment, as the interbank loan size is maximum, i.e., γ. However, welfare is below first best as $R_\text{B}^\text{H} > (1-L)\,R_\text{L}$.

In sum, for $C \geq C^{NR}(\gamma)$, market discipline fails. There are two reasons why welfare is lower. First, market discipline fails, and the BK_B return is R_L with positive probability. Second, there are inefficient liquidations.

5 The impact of a supranational regulator

In this section national regulators are replaced by a single supranational regulator SR with resolution powers for both countries. Section 5.1 is concerned with equilibrium strategies of SR. In Section 5.2 we analyze the welfare impact of the single regulator both relative to national regulation and to the first best. Finally, Section 5.3 discusses the feasibility of supranational regulation.

5.1 Equilibrium strategies

To determine the equilibrium under a single regulator for countries A and B, we use backward induction as in Section 4.

5.1.1 Optimal resolution policy

The objective function of the supranational regulator SR is to maximize the *joint* welfare in the two countries. One immediate result of Lemma 1 is that BK_A is always bailed out by the SR, as liquidation brings no benefits. It suffices thus to focus on the joint welfare functions following the bailout or the liquidation of BK_B. From equations (6) through (8) the relevant welfare functions are

$$\begin{aligned}\text{Welfare}_{\text{SR}}^{\text{bailout B}} &= \underbrace{1 - \left[1 + \gamma_I r - R_{\text{B}}^{\text{L}}(1+\gamma_I)\right]}_{\text{Country B}} + \underbrace{R_{\text{A}} + \gamma_I(r-1)}_{\text{Country A}} \text{ and} \\ \text{Welfare}_{\text{SR}}^{\text{liquidation B}} &= \underbrace{1 - \left[1 - (1-L)R_{\text{B}}^{\text{L}}\right]}_{\text{Country B}} + \underbrace{1 - \left[1 - R_{\text{A}} + \gamma_I\left(1 - R_{\text{B}}^{\text{L}}(1-L)\right)\right]}_{\text{Country A}}.\end{aligned} \tag{26}$$

From a joint welfare perspective it is always optimal to bail out BK_B following a default as

$$\text{Welfare}_{\text{SR}}^{\text{bailout B}} - \text{Welfare}_{\text{SR}}^{\text{liquidation B}} = LR_{\text{B}}^{\text{L}}(1+\gamma_I) > 0. \tag{27}$$

Contrary to national regulators SR always bails out BK_B, independently of the size of the interbank market γ_I. The reason is that the supranational regulator internalizes contagion; it optimally avoids the negative effect that a liquidation of BK_B has on BK_A. The welfare difference between bailout and liquidation increases with the size of the interbank loan, as the contagion effect is stronger.

5.1.2 Interbank market equilibrium

As BK_B is always bailed out, the expected profit for BK_A becomes, from equation (12),

$$\pi_A^{SR} = (R_A - 1) + \gamma_I (r - 1). \tag{28}$$

From equations (10), (13), and (28) the equilibrium interest rate solves:

$$r^{SR} = \arg\max_i \left[(1 - \tilde{p})\gamma_I \left(R_B^H - r\right)\right]^\eta [\gamma_I (i - 1)]^{1-\eta} = R_B^H (1 - \eta) + \eta = r^{FB}, \tag{29}$$

where $\tilde{p} \in \{0, p\}$ is the default probability for BK_B. Even though BK_B may default, it is always bailed out: The interbank loan bears no counterparty risk. The interest rate r^{SR} is equal to the first best value.

Since $r^{SR} > 1$, from equation (28) the expected profit for BK_A increases in γ_I. Consequently, it is optimal for BK_A to lend the full intermediate cashflow to BK_B, i.e., $\gamma_I^{SR} = \gamma$.

5.1.3 Optimal monitoring

Under the supranational regulator neither the interest rate nor the interbank loan size depend on the monitoring strategy. From equation (20) BK_B monitors if:

$$C \leq p\left(R_B^H - 1\right) + p\gamma\left[R_B^H - \left(R_B^H (1 - \eta) + \eta\right)\right] = p\left(R_B^H - 1\right)(1 + \gamma\eta). \tag{30}$$

Note that BK_B is more likely to invest in monitoring technology for larger values of p, γ, and η. Large values of p imply a higher default risk; a higher γ suggests higher potential gains from trade. Finally, BK_B's monitoring incentives are proportional to its bargaining power η, as it can capture a larger share of the surplus for a higher η.

5.1.4 Equilibrium

Proposition 2 summarizes the equilibrium outcomes under the supranational regulator.

Proposition 2. ***Supranational regulation equilibrium.*** *Under a supranational regulator,* *(i)* BK_B *monitors at* $t = 0$ *if* $C < C^{SR}(\gamma)$*, where*

$$C^{SR}(\gamma) = p\left(R_B^H - 1\right)(1 + \gamma\eta)\,. \tag{31}$$

(ii) At $t = 1$*,* BK_A *lends* γ *to* BK_B *at rate* $r^{FB} = R_B^H(1 - \eta) + \eta$*.*

(iii) At $t = 2$*, the supranational regulator SR bails out any bank in default.*

We compare the monitoring threshold functions for the national and the supranational regulator, given by equations (21) and (31). It follows that $C^{SR}(\gamma) < C^{NR}(\gamma)$ for all γ in the domain. Corollary 1 formally states this result.

Corollary 1. ***Monitoring under SRM and NRM.***
Monitoring incentives are (weakly) stronger under national regulation than under a supranational regulator.

Bank $\mathrm{BK_B}$ has weaker monitoring incentives under the supranational regulator. If $C < C^{\mathrm{SR}}(\gamma)$, then $C < C^{\mathrm{NR}}(\gamma)$; bank $\mathrm{BK_B}$ monitors under both regimes. If $C > C^{\mathrm{NR}}(\gamma)$, then $C > C^{\mathrm{SR}}(\gamma)$, and bank $\mathrm{BK_B}$ does not monitor under either national or supranational regulation.

From Corollary 1, there exists a cost region for which the supranational regulator SR distorts monitoring incentives. For $C \in \left[C^{\mathrm{SR}}(\gamma), C^{\mathrm{NR}}(\gamma)\right]$ the bank in country B monitors under national regulation, but does not monitor under the supranational regulator. For such values of the monitoring cost market discipline is destroyed by the introduction of SR.

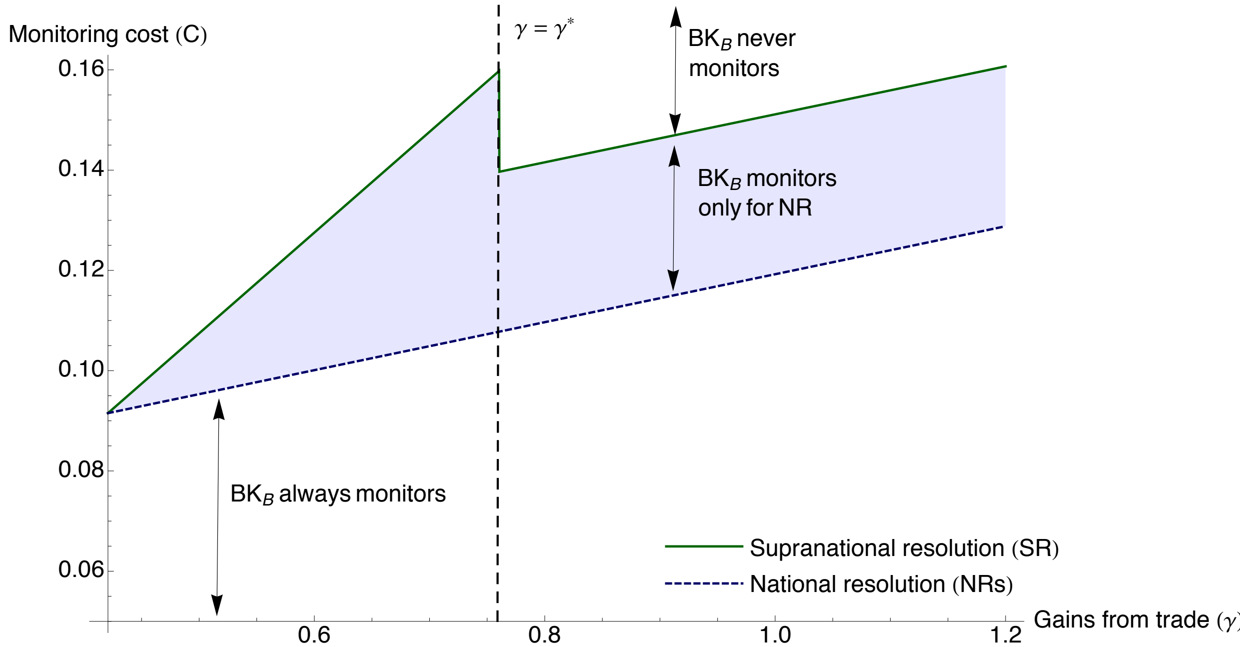


Figure 4: **Equilibrium monitoring for $\mathrm{BK_B}$ under national and supranational regulation**
This figure displays the monitoring indifference curves for BK_B under national and supranational regulation, $C^{NR}(\gamma)$ and $C^{SR}(\gamma)$ respectively. In the shaded region, $\mathrm{BK_B}$ monitors only under national regulation; incentives are worse under a supranational regulator.

From Figure 4 monitoring incentives increase in the gains from trade under both resolution mechanisms. For $\gamma < \gamma^*$ market discipline is implemented through a cap on the interbank loan size. For $\gamma > \gamma^*$ market discipline is implemented through a counterparty risk premium. The higher slope of $C^{\mathrm{NR}}(\gamma)$ for $\gamma < \gamma^*$ indicates that market discipline is more effective than for $\gamma \geq \gamma^*$: Incentives respond more to larger potential gains for trade if interbank lending is rationed.

Table 1 summarizes the equilibrium outcomes for both national and supranational regulation. Note that the optimal interbank contract changes with the regulatory system only for a high monitoring cost, i.e., when market discipline breaks down both under national and supranational regulation.

Table 1: **Equilibrium comparison.**

This table presents the equilibrium monitoring decision of BK_B, resolution policy, and interbank market contract for both national and supranational regulation. We distinguish between different regions for the gains from trade γ and the monitoring cost C. The threshold γ^* is defined as:

$$\gamma^* = \frac{\overline{\gamma}\left(r^{FB}\right)}{1-p} + \frac{(R_A - 1)\,p}{(1-p)\left(R_B^H - 1\right)}.$$

The highlighted cells point out differences between national and supranational resolution systems.

γ range	National regulator			Supranational regulator		
	Monitor	Bailout	Contract	Monitor	Bailout	Contract
Low monitoring cost: $C < C^{SR}(\gamma)$						
all	yes	yes	$\left(\gamma, r^{FB}\right)$	yes	yes	$\left(\gamma, r^{FB}\right)$
Intermediate monitoring cost: $C \in \left[C^{SR}(\gamma), C^{NR}(\gamma)\right]$						
$\gamma < \gamma^*$	yes	yes	$\left(\gamma, r^{FB}\right)$	**no**	yes	$\left(\gamma, r^{FB}\right)$
$\gamma > \gamma^*$	yes	no	$\left(\gamma, r^{FB}\right)$	**no**	**yes**	$\left(\gamma, r^{FB}\right)$
High monitoring cost: $C > C^{NR}(\gamma)$						
$\gamma < \gamma^*$	no	yes	$\left(\overline{\gamma}(r^{FB}), r^{FB}\right)$	no	yes	$\left(\gamma, r^{FB}\right)$
$\gamma > \gamma^*$	no	no	$\left(\gamma, r^{Risk}\right)$	no	**yes**	$\left(\gamma, r^{FB}\right)$

5.2 Welfare impact of the supranational regulator

To evaluate the welfare impact of the supranational regulator SR, we use welfare under national regulation as a benchmark.

The SR welfare effect is not trivial ex-ante. On the one hand, supranational regulation eliminates inefficient liquidations and cross-border contagion. Further, there is no under-investment as the full intermediate cashflow γ is traded on the interbank market. The potential gains from interbank trade are fully realized. On the other hand, SR may be too lenient: It resorts to bailouts in states of the world where national regulators liquidate an insolvent bank. This worsens moral hazard: Banks with large international exposures can take more risk. The disciplining role of the interbank market fails as the counterparty risk is borne by the joint regulator SR rather than creditors.

Proposition 3 presents the conditions under which joint resolution improves welfare.

Proposition 3. ***Welfare impact of SR.*** *Relative to national regulation, a supranational regulator*

(i) ***improves welfare*** *for large monitoring cost values, i.e., $C > C^{NR}(\gamma)$;*

(ii) ***reduces welfare*** *for intermediate monitoring cost values, i.e., $C \in \left[C^{SR}(\gamma), C^{NR}(\gamma)\right]$;*

(iii) ***does not affect welfare*** *for low monitoring cost values, i.e., $C < C^{SR}(\gamma)$.*

Low moral hazard. If $C < C^{SR}(\gamma)$ moral hazard is low. Bank BK_B monitors both under SR and under NR. Introducing a supranational regulator does not distort monitoring incentives for BK_B. There are no bank defaults, and therefore no (inefficient) liquidations. The net welfare effect of the supranational regulator is zero. Both national and supranational regulators can implement the first best welfare.

High moral hazard. If $C > C^{NR}(\gamma)$ moral hazard is high. Bank BK_B does not monitor neither under SR nor under NR. Again, monitoring incentives are not distorted by a supranational regulator. Market discipline breaks down in both regimes. Consequently, joint regulation is welfare-improving in this case. However, the improvement channel depends on whether γ is smaller or larger than γ^* as defined in equation (22).

For $\gamma < \gamma^*$ SR stimulates international trade. From Proposition 1, if the returns from international trade are low, BK_A optimally eliminates counterparty risk. It restricts the loan size such that it is relatively cheap for NR_B to bail out an insolvent BK_B. The default risk is borne by taxpayers in country B, and BK_A accepts a lower expected profit. There is no inefficient liquidation.

Under SR the loan size restriction is redundant. Since the single regulator internalizes contagion, it always bails out BK_B, regardless of the interbank loan size. Consequently, interbank trading is stimulated under a supranational regulator. A natural interpretation of this result is that SR prevents the "balkanization" of cross-border financial intermediation.

For $\gamma \geq \gamma^*$ SR eliminates inefficient liquidations. If returns from international trade are high, BK_A optimally bears counterparty risk. The national regulator NR_B liquidates an insolvent domestic bank. The liquidation is inefficient from a joint welfare perspective. The supranational regulator improves welfare as it eliminates cross-border spillovers. There is also a redistribution effect: The interbank interest rate is lower under SR as there is no counterparty risk premium. Consequently, the expected profit of BK_B increases due to lower funding costs.

However, even though SR improves welfare relative to national regulation, it does not achieve the first-best. The moral hazard friction cannot be eliminated.

Intermediate moral hazard. A supranational regulator distorts risk-taking incentives for bank BK_B if $C \in \left[C^{SR}(\gamma), C^{NR}(\gamma)\right]$. Under national regulation BK_B invests in monitoring technology as there is market discipline either through the loan size or the loan rate. There is no default under NR, and therefore no inefficient liquidation. National regulation can implement the first best. Under the supranational regulator however, BK_B is always bailed out. BK_A does not face counterparty risk, and the interbank contract does no longer depend on monitoring. Consequently, BK_A does not monitor; SR stimulates risk-taking. Welfare is lower than for national regulation and the first best.

Figure 5 illustrates welfare effects of the supranational regulator under the three monitoring cost regions discussed in this section.

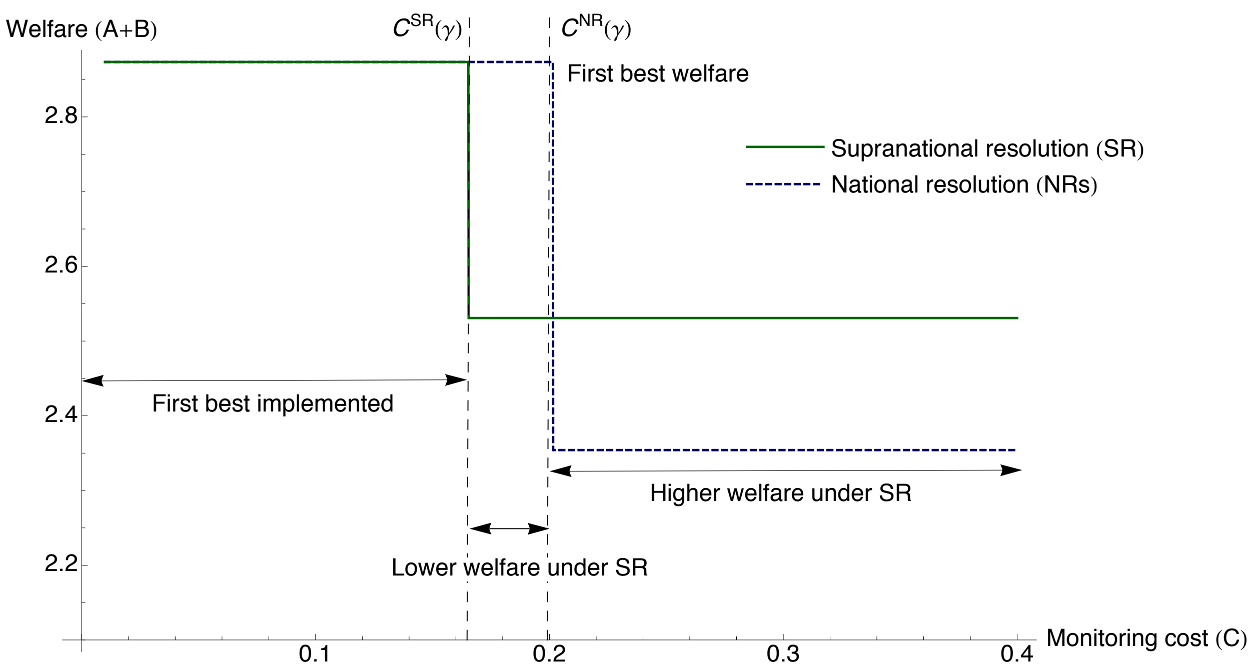


Figure 5: **Welfare under national and supranational regulation**

This figure depicts welfare under both NR and SR as a function of the monitoring cost C. For low values of C, both the national and supranational regulators implement the first best. As C increases, the SR leads to lower welfare as it distorts monitoring incentives relative to national regulation. If C increases even further, market discipline breaks down under both NR and SR: the SR improves welfare as it eliminates cross-border contagion.

Corollary 2. ***First-best implementation.***

For low moral hazard, i.e., $C < C^{SR}(\gamma)$, both national and supranational regulators implement the first-best. For intermediate moral hazard, i.e., $C \in \left[C^{SR}(\gamma), C^{NR}(\gamma)\right]$, only the national regulator implements the first-best. For high moral hazard, i.e., $C > C^{NR}(\gamma)$, neither mechanism can implement the first-best.

5.3 Resolution fund contributions

In this section, national regulators endogenously decide whether to merge into SR at $t = -1$. As a result, the supranational regulator emerges only if it is individually optimal for both regulators to give up resolution powers.

For simplicity, we focus on linear resolution fund contracts: NR_A supports a share $\beta \in (0, 1)$ of all intervention costs, whereas NR_B supports $1 - \beta$. Thus, if a bailout requires a liquidity injection ℓ, country A pays $\beta \times \ell$, and country B will pay $(1 - \beta) \times \ell$.

The goal of the analysis is to determine the feasible range for β that offers incentives to both regulators to join SR. The following incentive compatibility constraints should hold simultaneously:

$$\begin{aligned} &\mathbb{E}\left[\text{Welfare}_\text{A}^{SR} - \text{Welfare}_\text{A}^{NR}\right] \geq 0 \text{ and} \\ &\mathbb{E}\left[\text{Welfare}_\text{B}^{SR} - \text{Welfare}_\text{B}^{SR}\right] \geq 0. \end{aligned} \tag{32}$$

The SR improves welfare if and only if $C > C^{NR}(\gamma)$, i.e., if bank BK_B does not monitor under both national and joint regulation. Two cases exist, depending on whether γ is larger or smaller than γ^*.

Proposition 4. ***Endogenous SR participation.*** *If investment in the risky asset is optimal, i.e., if $pR_B^H + (1 - p) R_B^L > 1$, there exists $\beta \in (0, 1)$ such that it is optimal for both national regulators to merge into a supranational regulator.*

From Proposition 4 national regulators always merge at $t = -1$ if SR improves welfare.

Corollary 3. ***Comparative statics.*** *Define $\underline{\beta}(\gamma)$ and $\overline{\beta}(\gamma)$ such that national regulators choose to merge if and only if $\beta \in \left(\underline{\beta}(\gamma), \overline{\beta}(\gamma)\right)$, the* "feasible SR interval".
If $\gamma < \gamma^*$, the size of the interval, i.e., $\overline{\beta}(\gamma) - \underline{\beta}(\gamma)$ increases in γ and p. If $\gamma \geq \gamma^*$, the size of the interval, i.e., $\overline{\beta}(\gamma) - \underline{\beta}(\gamma)$ decreases in γ and does not change in p.

If the supranational regulator improves welfare through boosting interbank trade, i.e., for $\gamma < \gamma^*$, it is easier to form SR if the potential gains from the interbank market are large, and if the risky project has a larger NPV (larger p). The shaded region in Figure 6 widens with γ for $\gamma < \gamma^*$.

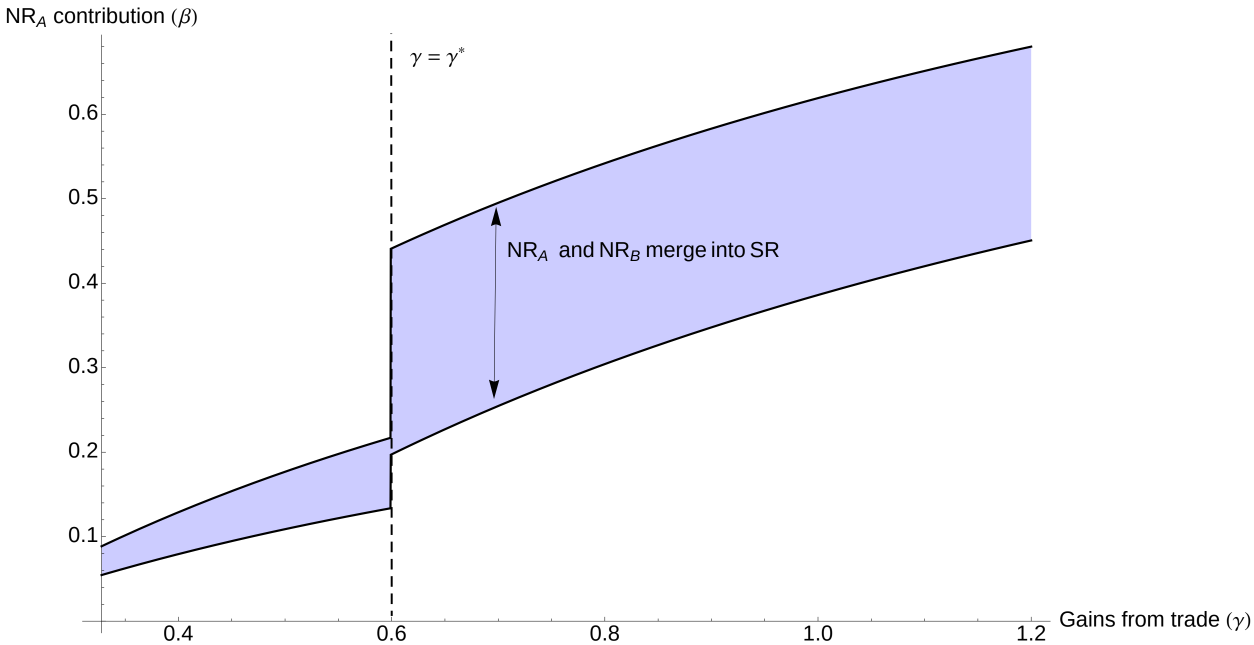


Figure 6: **Feasible resolution fund contributions**

This figure depicts feasible linear resolution fund contributions as a function of the potential gains from trade γ. Country A pays a share β of any regulatory contribution; Country B pays $1 - \beta$. The two national regulators merge at $t = 0$ for values of β in the shaded region.

If the supranational regulator improves welfare through eliminating inefficient liquidations, i.e., for $\gamma \geq \gamma^*$, it is easier to form SR if the potential gains from the interbank market are small, as the intervention costs increase in the interbank market size. Counterparty risk does not influence the feasible SR region, as it translates into a higher interbank interest rate under national regulation.

From Figure 6 both the lower and upper bounds for β increase with γ. As the gains from trade increase, agents in country A have more incentives to join SR, and seize a larger share of foreign investment opportunities while bearing less counterparty risk.

Corollary 4. *The minimum resolution fund contribution for country A, $\underline{\beta}(\gamma)$, jumps upwards at $\gamma = \gamma^*$:*

$$\lim_{\gamma \nearrow \gamma^*} \underline{\beta}(\gamma) < \lim_{\gamma \searrow \gamma^*} \underline{\beta}(\gamma). \tag{33}$$

For $\gamma > \gamma^*$ NR_B is able to partly transfer abroad the domestic default costs, as foreign claims are not covered in full. Under supranational regulation NR_B loses this ability. Therefore, from Corollary 4, it is less willing to contribute to the resolution fund and requires a higher contribution from NR_A.

6 Conclusion

This paper studies the impact of supranational bank resolution. A natural interpretation of the SR in our model is the Single Resolution Mechanism, as recently introduced in the European Union. From this perspective, our paper contributes to the recent European debate on the banking union. We study the welfare impact of a supranational regulator and make policy proposals for the structure of the resolution fund.

From an ex post perspective, supranational resolution is optimal as it eliminates cross-border contagion. However, ex post optimal policies come at the price of reduced market discipline. This is particularly the case if monitoring costs are low, e.g., banks hold few opaque assets – as opaque assets are likely to have high monitoring costs. If banks' monitoring costs are high, a supranational resolution mechanism improves welfare. One channel is higher resolution efficiency. National regulators may prefer inefficient liquidations of insolvent banks as they involve lower cross-border wealth transfers. Contrastingly, the supranational regulator resorts to efficient bailouts, as it internalizes contagion effects. A second channel is higher trade efficiency. Supranational resolution mechanism stimulates interbank trade, as it provides contagion insurance. The "balkanization" of interbank markets is reversed under the SRM.

There are two main policy implications. First, if a supranational resolution mechanism has a negative effect on bank incentives, a more restrictive ex ante supervision of banks might be needed to compensate for the additional moral hazard. Second, the resolution fund contributions should depend on international positions of banks. This is not taken into account in current regulatory proposals, which relate contributions only to the size of the deposit base.

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. Risk-taking behavior can be measured from balance sheet data (Rajan, 2006) or market data (Laeven and Levine, 2009, propose using the distance of insolvency, the volatility of equity prices, and the volatility of earnings.) Second, banks with cross-border liabilities 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 et al., 2012). If there is no enhanced risk-taking, the model predicts an amelioration of interbank conditions: higher volumes and lower interest rates.

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Appendices

A Notation summary

Model parameters and interpretation

Parameter	Definition
γ	Intermediate return for BK_A at $t = 1$.
R_A	Deterministic return for BK_A at $t = 2$.
$\tilde{R}_B \in \left\{R_B^H, R_B^L\right\}$	Stochastic return for BK_B at $t = 2$.
p	Default probability of BK_B if it does not monitor.
C	Cost of monitoring technology for BK_B.
L	Project value percentage loss upon liquidation: $L \in (0, 1)$.
β	Resolution fund share for country A.

B 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 International Monetary Fund.

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.
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 the 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 Resolution Fund (SRF). The SRF will be financed with contributions from financial institutions under the SSM. Each participating institution will be required to add an equivalent of 1% of its covered deposits to the joint fund within eight years from the establishment of SRF. As a result, the total value of the SRF should reach around EUR 55 billion. The use of the SRF 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.

C Proofs

Lemma 1

Proof. In country B, welfare is larger after bailout than after liquidation if

$$\text{Welfare}_B^{\text{bailout}} - \text{Welfare}_B^{\text{liquidation}} = \gamma_I \left(R_{\text{B}}^{\text{L}} - r\right) + LR_{\text{B}}^{\text{L}} > 0 \iff \gamma_I < \frac{LR_{\text{B}}^{\text{L}}}{r - R_{\text{B}}^{\text{L}}}. \tag{C.1}$$

In country A, welfare is larger after bailout than after liquidation if

$$\text{Welfare}_A^{\text{bailout}} - \text{Welfare}_A^{\text{liquidation}} = L\left(R_{\text{A}} - \gamma\right) > 0, \tag{C.2}$$

which is always true. □

Lemma 2

Proof. **Case 1: $\mathbf{BK_B}$ invests in the monitoring technology.** The interbank loan is risk free. The expected profit for BK_A is $(R_\text{A} - 1) + \gamma\left(r^M - 1\right)$, and for BK_B it is $R_\text{B}^\text{H} - 1 + \gamma\left(R_\text{B}^\text{H} - r^M\right)$. The interbank interest rate solves

$$r^M = \arg\max_i \left[\gamma\left(R_\text{B}^\text{H} - i\right)\right]^\eta \left[\gamma\left(i - 1\right)\right]^{1-\eta}, \tag{C.3}$$

and is equal

$$r^M = (1-\eta)R_\text{B}^\text{H} + \eta = r^{FB}. \tag{C.4}$$

Case 2: $\mathbf{BK_B}$ does not invest in the monitoring technology. If Bank BK_A decides to lend $\overline{\gamma}(r)$, the interbank loan is risk free. BK_A's expected payoff is $(R_\text{A} - 1) + \overline{\gamma}(r^{NM})\left(r^{NM} - 1\right)$, and BK_B's expected payoff is $(1-p)\left(R_\text{B}^\text{H} - 1 + \overline{\gamma}(r^{NM})(R_\text{B}^\text{H} - r^{NM})\right)$. Using the definition of $\overline{\gamma}(r) = \frac{LR_\text{B}^\text{L}}{r - R_B^L}$, the interbank interest rate solves

$$r^{NM} = \arg\max_i \left[(1-p)\frac{LR_\text{B}^\text{L}}{i - R_B^L}\left(R_\text{B}^\text{H} - i\right)\right]^\eta \left[\frac{LR_\text{B}^\text{L}}{i - R_B^L}\left(i - 1\right)\right]^{1-\eta}, \tag{C.5}$$

and is again equal to the first best

$$r^{NM} = (1-\eta)R_\text{B}^\text{H} + \eta = r^{FB}. \tag{C.6}$$

If Bank BK_A decides to lend γ, the interbank loan is risky. BK_A's expected payoff is equal to $(1-p)\left[R_\text{A} - 1 + \gamma\left(r^{NM} - 1\right)\right]$, and BK_B's expected payoff is $(1-p)(R_\text{B}^\text{H} - 1 + \gamma\left(R_\text{B}^\text{H} - r^{NM}\right)$. The interbank interest rate solves

$$r^{NM} = \arg\max_i \left[(1-p)\gamma\left(R_\text{B}^\text{H} - r^{NM}\right))\right]^\eta \left[(1-p)(R_\text{A} - 1 + \gamma(r^{NM} - 1)) - (R_\text{A} - 1)\right]^{1-\eta}, \tag{C.7}$$

and is equal

$$r^{\text{NM}} = R_B^H\left(1-\eta\right) + \eta + \frac{\eta}{\gamma\left(1-p\right)} p\left(R_\text{A} - 1\right) > r^{FB}. \tag{C.8}$$

□

Proposition 1

Proof. First, compare payoffs to BK_A from alternative investment policies. If BK_B monitors the risky project, it is always weakly preferred to invest in the interbank market rather than store cash, as for $\eta \in [0, 1]$:

$$R_\text{A} - 1 + \gamma(r^{FB} - 1) \geq R_\text{A} - 1. \tag{C.9}$$

If BK_B does not monitor, BK_A can invest $\overline{\gamma}(r^{FB})$ for the interest rate r^{FB}, or γ for r^{Risk}, defined in Lemma 2.

Bank BK_A prefers to lend γ if it obtains a larger expected payoff, i.e.,

$$(1-p)\left[R_A - 1 + \gamma(r^{Risk} - 1)\right] > R_A - 1 + \overline{\gamma}(r^{FB})(r^{FB} - 1). \tag{C.10}$$

After further manipulation, equation (C.10) becomes

$$\gamma(1-\eta)(R_B^H - 1)(1-p) > \overline{\gamma}(r^{FB})(1-\eta)(R_B^H - 1) + p(R_A - 1)(1-\eta) \Leftrightarrow \tag{C.11}$$

$$\gamma > \frac{\overline{\gamma}(r^{FB})}{1-p} + \frac{(R_A - 1)p}{(1-p)(R_B^H - 1)} \equiv \gamma^*. \tag{C.12}$$

Consider the case when $\gamma < \gamma^*$. BK_B monitors the risky project if

$$C \leq p\left(R_B^H - 1\right) + \gamma\left(R_B^H - r^{FB}\right) - (1-p)\,\overline{\gamma}(r^{FB})\left(R_B^H - r^{FB}\right) \Leftrightarrow \tag{C.13}$$

$$C \leq p(R_B^H - 1)\left[1 + \frac{\eta}{p}\left(\gamma - (1-p)\overline{\gamma}(r^{FB})\right)\right].$$

When $\gamma < \gamma^*$ and BK_B monitors, the interbank contract is (γ, r^{FB}). If BK_B does not monitor, the interbank contract is $(\overline{\gamma}(r^{FB}), r^{FB})$.

Consider the case when $\gamma \geq \gamma^*$. BK_B monitors the risky project if

$$C \leq p\left(R_B^H - 1\right) + \gamma\left(R_B^H - r^{FB}\right) - (1-p)\,\gamma\left(R_B^H - r^{Risk}\right) \Leftrightarrow \tag{C.14}$$

$$C \leq p\left[(R_B^H - 1)(1 + \eta\gamma) + \eta(R_A - 1)\right].$$

When $\gamma \geq \gamma^*$ and BK_B monitors, the interbank contract is (γ, r^{FB}). If BK_B does not monitor, the interbank contract is (γ, r^{Risk}). □

Proposition 2

Proof. From equation (27), the SR always bails out a defaulting bank, and from equation (29), the interest rate r^{SR} is always equal to the first best solution. The interbank loan is risk free, thus BK_A always lends the maximum amount γ. BK_B monitors if:

$$C \leq p\left(R_B^H - 1\right) + p\gamma\left[R_B^H - \left(R_B^H(1-\eta) + \eta\right)\right] = p\left(R_B^H - 1\right)(1 + \gamma\eta) = C^{SR}(\gamma). \tag{C.15}$$

□

Corollary 1

Proof. For $\gamma < \gamma^*$ the comparison of the monitoring thresholds $C^{NR}(\gamma)$ and $C^{SR}(\gamma)$ yields:

$$C^{NR}(\gamma) - C^{SR}(\gamma) = p(R_B^H - 1)\left[1 + \frac{\eta}{p}\left(\gamma - (1-p)\overline{\gamma}(r^{FB})\right)\right] - p\left(R_B^H - 1\right)(1 + \gamma\eta) \tag{C.16}$$

$$= (R_B^H - 1)\left[\eta\left(\gamma - (1-p)\overline{\gamma}(r^{FB})\right) - p\eta\gamma\right] = (R_B^H - 1)(1-p)\eta\left(\gamma - \overline{\gamma}(r^{FB})\right) > 0.$$

For $\gamma \geq \gamma^*$ the comparison yields:

$$C^{NR}(\gamma) - C^{SR}(\gamma) = p\left[(R_B^H - 1)(1 + \eta\gamma) + \eta(R_\text{A} - 1)\right] - p\left(R_\text{B}^\text{H} - 1\right)(1 + \gamma\eta) \\ = p\eta(R_\text{A} - 1) > 0. \tag{C.17}$$

□

Proposition 3

Proof. **High moral hazard.** First, let $C > C^{NR}(\gamma)$. Bank BK_B does not monitor under either national or supranational regulation. If $\gamma \geq \gamma^*$, then at $t = 1$ BK_A lends γ on the interbank market. If BK_B is insolvent, the national regulator liquidates it and the supranational regulator bails it out. The welfare functions under national and supranational regulation are

$$\text{Welfare}_{NR} = (1 - p)\left[R_\text{A} + R_\text{B}^\text{H} + \gamma\left(R_\text{B}^\text{H} - 1\right)\right] + p\left[R_\text{A} - \gamma\left(1 - R_\text{B}^\text{L}(1 - L)\right) + (1 - L)R_\text{B}^\text{L}\right],$$
$$\text{Welfare}_{SR} = (1 - p)\left[R_\text{A} + R_\text{B}^\text{H} + \gamma\left(R_\text{B}^\text{H} - 1\right)\right] + p\left[R_\text{A} + R_\text{B}^\text{L}(1 + \gamma) - \gamma\right]. \tag{C.18}$$

The SR welfare impact is

$$\text{Welfare}_{SR} - \text{Welfare}_{NR} = pLR_\text{B}^\text{L}(1 + \gamma) > 0, \tag{C.19}$$

and therefore supranational resolution improves welfare. If $\gamma < \gamma^*$, then at $t = 1$ BK_A lends γ on the interbank market under SR and $\overline{\gamma}\left(r^{FB}\right)$ under NR. Both the national and supranational regulator bail out BK_B following default. The welfare functions become:

$$\text{Welfare}_{NR} = (1 - p)\left[R_\text{A} + R_\text{B}^\text{H} + \overline{\gamma}\left(r^{FB}\right)\left(R_\text{B}^\text{H} - 1\right)\right] + p\left[R_\text{A} + R_\text{B}^\text{L}(1 + \gamma) - \gamma\right],$$
$$\text{Welfare}_{SR} = (1 - p)\left[R_\text{A} + R_\text{B}^\text{H} + \gamma\left(R_\text{B}^\text{H} - 1\right)\right] + p\left[R_\text{A} + R_\text{B}^\text{L}\left(1 + \overline{\gamma}\left(r^{FB}\right)\right) - \overline{\gamma}\left(r^{FB}\right)\right]. \tag{C.20}$$

The SR welfare impact is

$$\text{Welfare}_{SR} - \text{Welfare}_{NR} = \left(\gamma - \overline{\gamma}\left(r^{FB}\right)\right)\left[(1 - p)R_\text{B}^\text{H} + pR_\text{B}^\text{L} - 1\right] > 0, \tag{C.21}$$

as long as the risky project has positive NPV. Again, supranational resolution improves welfare.

Intermediate moral hazard. Let $C \in \left[C^{SR}(\gamma), C^{NR}(\gamma)\right]$. Bank BK_B monitors under national regulation and does not monitor under supranational regulation. Bank BK_B never defaults under national regulation; under SR, if it defaults it is always bailed out. For both NR and SR, BK_A lends γ on the interbank market. The welfare functions are:

$$\text{Welfare}_{NR} = R_\text{A} + R_\text{B}^\text{H} + \gamma\left(R_\text{B}^\text{H} - 1\right),$$
$$\text{Welfare}_{SR} = (1 - p)\left[R_\text{A} + R_\text{B}^\text{H} + \gamma\left(R_\text{B}^\text{H} - 1\right)\right] + p\left[R_\text{A} + R_\text{B}^\text{L}(1 + \gamma) - \gamma\right]. \tag{C.22}$$

The SR welfare impact is

$$\text{Welfare}_{SR} - \text{Welfare}_{NR} = p\left(R_\text{B}^\text{L} - R_\text{B}^\text{H}\right)(1 + \gamma) < 0. \tag{C.23}$$

Therefore, for $C \in \left[C^{SR}(\gamma), C^{NR}(\gamma)\right]$ the supranational regulator reduces welfare.

Low moral hazard. Finally, let $C < C^{SR}(\gamma)$. Bank $\mathrm{BK_B}$ monitors under both national and supranational regulation. There is never a need for regulatory intervention and $\mathrm{BK_A}$ lends γ on the interbank market. The welfare functions are:

$$\begin{aligned} \text{Welfare}_{NR} &= R_\text{A} + R_\text{B}^\text{H} + \gamma\left(R_\text{B}^\text{H} - 1\right), \\ \text{Welfare}_{SR} &= R_\text{A} + R_\text{B}^\text{H} + \gamma\left(R_\text{B}^\text{H} - 1\right). \end{aligned} \tag{C.24}$$

The introduction of SR has no impact on welfare. □

Corollary 2

Proof. From equation 5, the joint first best welfare is

$$\text{Welfare}^{FB} = R_\text{A} + R_\text{B}^\text{H} + \gamma\left(R_\text{B}^\text{H} - 1\right). \tag{C.25}$$

From equation (C.24), both the national and the supranational regulator implement the first best if $C < C^{SR}(\gamma)$.

From equation (C.22), only the national regulator implement the first best if $C \in \left[C^{SR}(\gamma), C^{NR}(\gamma)\right]$.

From equations (C.18) and (C.20), neither the national or the supranational regulator implement the first best if $C > C^{NR}(\gamma)$. □

Proposition 4

Proof. First, consider the case that $\gamma < \gamma^*$. The welfare functions under national regulation for the two countries are

$$\begin{aligned} \text{Welfare}_\text{A}^\text{NR} &= (1-p)\left(R_\text{A} + \overline{\gamma}\left(r^{FB}\right)\left(r^{FB} - 1\right)\right) + p\left(R_\text{A} + \overline{\gamma}\left(r^{FB}\right)\left(r^{FB} - 1\right)\right) \text{ and} \\ \text{Welfare}_\text{B}^\text{NR} &= (1-p)\left(R_\text{B}^\text{H}\left(1 + \overline{\gamma}\left(r^{FB}\right)\right) - \overline{\gamma}\left(r^{FB}\right)r^{FB}\right) + p\left(R_\text{B}^\text{L}\left(1 + \overline{\gamma}\left(r^{FB}\right)\right) - \overline{\gamma}\left(r^{FB}\right)r^{FB}\right). \end{aligned} \tag{C.26}$$

The welfare functions under the SR for the two countries are

$$\begin{aligned} \text{Welfare}_\text{A}^\text{SR} &= (1-p)\left(R_\text{A} + \gamma\left(r^{FB} - 1\right)\right) + p\left(R_\text{A} + \gamma\left(r^{FB} - 1\right) - \beta\left(1 + \gamma r^{FB} - R_\text{B}^\text{L}(1+\gamma)\right)\right) \text{ and} \\ \text{Welfare}_\text{B}^\text{SR} &= (1-p)\left(R_\text{B}^\text{H}(1+\gamma) - \gamma r^{FB}\right) + p\left(1 - (1-\beta)\left(1 + \gamma r^{FB} - R_\text{B}^\text{L}(1+\gamma)\right)\right). \end{aligned} \tag{C.27}$$

The incentive compatibility constraint for NR_A is

$$\text{Welfare}_\text{A}^\text{SR} > \text{Welfare}_\text{A}^\text{NR} \iff \beta < \overline{\beta}_1 = \frac{\left(\gamma - \overline{\gamma}\left(r^{FB}\right)\right)\left[r^{FB} - 1\right]}{p\left(1 + \gamma r^{FB} - R_\text{B}^\text{L}(1+\gamma)\right)}. \tag{C.28}$$

The incentive compatibility constraint for NR_{B} is

$$\text{Welfare}_{\mathrm{B}}^{\mathrm{SR}} > \text{Welfare}_{\mathrm{B}}^{\mathrm{NR}} \iff \beta > \underline{\beta}_1 = \frac{\left(\gamma - \overline{\gamma}\left(r^{FB}\right)\right)\left[r^{FB} - \left((1-p) R_{\mathrm{B}}^{\mathrm{H}} + pR_{\mathrm{B}}^{\mathrm{L}}\right)\right]}{p\left(1 + \gamma r^{FB} - R_{\mathrm{B}}^{\mathrm{L}}(1+\gamma)\right)}. \tag{C.29}$$

It follows that $\overline{\beta}_1 > \underline{\beta}_1$, so that the interval $\left(\underline{\beta}_1, \overline{\beta}_1\right)$ exists, if and only if $(1-p) R_{\mathrm{B}}^{\mathrm{H}} + pR_{\mathrm{B}}^{\mathrm{L}} > 1$. Moreover, $\overline{\beta}_1 > 0$, such that there exists β for which BK_{A} joins the SR.

Regulator NR_{B} joins the SR if $\underline{\beta}_1 < 1$. Note that

$$\frac{\partial \underline{\beta}_1}{\partial p} = -\frac{\left(R_{\mathrm{B}}^{\mathrm{H}} - r^{FB}\right)\left(r^{FB} - R_{\mathrm{B}}^{\mathrm{L}}\right)\left(\gamma - \overline{\gamma}\left(r^{FB}\right)\right)}{p^2\left(r^{FB} - R_{\mathrm{B}}^{\mathrm{L}}\right)\left(1 - R_{\mathrm{B}}^{\mathrm{L}} + \gamma\left(r^{FB} - R_{\mathrm{B}}^{\mathrm{L}}\right)\right)} < 0. \tag{C.30}$$

The boundary value $\underline{\beta}_1$ decreases in p. It follows that $p = 0$ gives an upper bound for $\underline{\beta}_1$:

$$\underline{\beta}_1 < \frac{\left(\gamma - \overline{\gamma}\left(r^{FB}\right)\right)\left(r^{FB} - R_{\mathrm{B}}^{\mathrm{L}}\right)}{1 + \gamma r^{FB} - R_{\mathrm{B}}^{\mathrm{L}}(1+\gamma)} < 1. \tag{C.31}$$

Therefore, $\underline{\beta}_1 < 1$. Since $\underline{\beta}_1 < 1$ and $\overline{\beta}_1 > 0$, there always exists $\beta \in (0,1)$ such that the national regulators join the S.

Next, consider the case that $\gamma \geq \gamma^*$. The welfare functions under national regulation for the two countries are

$$\begin{aligned} \text{Welfare}_{\mathrm{A}}^{\mathrm{NR}} &= (1-p)\left(R_{\mathrm{A}} + \gamma\left(r^{\mathrm{Risk}} - 1\right)\right) + p\left(R_{\mathrm{A}} - \gamma\left(1 - R_{\mathrm{B}}^{\mathrm{L}}(1-L)\right)\right) \text{ and} \\ \text{Welfare}_{\mathrm{B}}^{\mathrm{NR}} &= (1-p)\left(R_{\mathrm{B}}^{\mathrm{H}}(1+\gamma) - \gamma r^{\mathrm{Risk}}\right) + p(1-L) R_{\mathrm{B}}^{\mathrm{L}}. \end{aligned} \tag{C.32}$$

The welfare functions under the SR for the two countries are the same as in (C.27).

The incentive compatibility constraint for NR_{A} is

$$\text{Welfare}_{\mathrm{A}}^{\mathrm{SR}} > \text{Welfare}_{\mathrm{A}}^{\mathrm{NR}} \iff \beta < \overline{\beta}_2 = \frac{\gamma\left[r^{FB} - \left((1-p) r^{\mathrm{Risk}} + pR_{\mathrm{B}}^{\mathrm{L}}(1-L)\right)\right]}{p\left(1 + \gamma r^{FB} - R_{\mathrm{B}}^{\mathrm{L}}(1+\gamma)\right)}. \tag{C.33}$$

The incentive compatibility constraint for NR_{B} is

$$\text{Welfare}_{\mathrm{B}}^{\mathrm{SR}} > \text{Welfare}_{\mathrm{B}}^{\mathrm{NR}} \iff \beta > \underline{\beta}_2 = \frac{\gamma\left[r^{FB} - \left((1-p) r^{\mathrm{Risk}} + p\frac{R_{\mathrm{B}}^{\mathrm{L}}(\gamma+L)}{\gamma}\right)\right]}{p\left(1 + \gamma r^{FB} - R_{\mathrm{B}}^{\mathrm{L}}(1+\gamma)\right)}. \tag{C.34}$$

It follows that $\overline{\beta}_2 > \underline{\beta}_2$, so that the interval $\left(\underline{\beta}_2, \overline{\beta}_2\right)$ exists.

It also follows that $\overline{\beta}_2 > 0$ if and only if

$$(1-p)\left(r^{\mathrm{Risk}} - r^{FB}\right) < p\left(r^{FB} - R_{\mathrm{B}}^{\mathrm{L}}(1-L)\right). \tag{C.35}$$

Note that $\underline{\beta}_2 < 1$ since

$$\underline{\beta}_2 - 1 = -\frac{1 - (1-L) R_{\mathrm{B}}^{\mathrm{L}} + \eta (R_{\mathrm{A}} - 1)}{1 + \gamma r^{FB} - R_{\mathrm{B}}^{\mathrm{L}} (1+\gamma)} < 0. \tag{C.36}$$

From Assumption 1, since $\gamma > \frac{R_{\mathrm{A}}-1}{1-R_{\mathrm{B}}^{\mathrm{L}}(1-L)}$, it follows that

$$\begin{aligned} \frac{r^{FB} - \left((1-p) r^{\mathrm{Risk}} + pR_{\mathrm{B}}^{\mathrm{L}} (1-L)\right)}{p} &= \left[R_{\mathrm{B}}^{\mathrm{H}} (1-\eta) + \eta - \frac{\eta}{\gamma} (R_{\mathrm{A}} - 1) - R_{\mathrm{B}}^{\mathrm{L}} (1-L)\right] \\ &> \left[R_{\mathrm{B}}^{\mathrm{H}} (1-\eta) + \eta - \frac{\eta\left(1 - R_{\mathrm{B}}^{\mathrm{L}} (1-L)\right)}{R_{\mathrm{A}} - 1} (R_{\mathrm{A}} - 1) - R_{\mathrm{B}}^{\mathrm{L}} (1-L)\right] \\ &= \left(R_{\mathrm{B}}^{\mathrm{H}} - R_{\mathrm{B}}^{\mathrm{L}} (1-L)\right) (1-\eta) > 0. \end{aligned} \tag{C.37}$$

From (C.37), $\overline{\beta}_2 > 0$ since

$$\overline{\beta}_2 = \frac{\gamma\left[r^{FB} - \left((1-p) r^{\mathrm{Risk}} + pR_{\mathrm{B}}^{\mathrm{L}} (1-L)\right)\right]}{p\left(1 + \gamma r^{FB} - R_{\mathrm{B}}^{\mathrm{L}} (1+\gamma)\right)} > \frac{\gamma\left(R_{\mathrm{B}}^{\mathrm{H}} - R_{\mathrm{B}}^{\mathrm{L}} (1-L)\right)(1-\eta)}{\left(1 + \gamma r^{FB} - R_{\mathrm{B}}^{\mathrm{L}} (1+\gamma)\right)} > 0. \tag{C.38}$$

Since $\underline{\beta}_2 < 1$ and $\overline{\beta}_2 > 0$, there always exists $\beta \in (0,1)$ such that the national regulators join the SR. □

Corollary 3

Proof. First, consider the case $\gamma < \gamma^*$. The partial derivative of $\overline{\beta}_1 - \underline{\beta}_1$ with respect to p is:

$$\frac{\partial\left(\overline{\beta}_1 - \underline{\beta}_1\right)}{\partial p} = -\frac{\left(R_{\mathrm{B}}^{\mathrm{H}} - 1\right)\left(\gamma - \overline{\gamma}\left(r^{FB}\right)\right)}{p^2\left(1 - R_{\mathrm{B}}^{\mathrm{L}} + \eta\left(r^{FB} - R_{\mathrm{B}}^{\mathrm{L}}\right)\right)} < 0. \tag{C.39}$$

The partial derivative of $\overline{\beta}_1 - \underline{\beta}_1$ with respect to γ is:

$$\frac{\partial\left(\overline{\beta}_1 - \underline{\beta}_1\right)}{\partial \gamma} = \frac{\left(1 - (1-L) R_{\mathrm{B}}^{\mathrm{L}}\right)\left((1-p) R_{\mathrm{B}}^{\mathrm{H}} + pR_{\mathrm{B}}^{\mathrm{L}} - 1\right)}{p\left(1 - R_{\mathrm{B}}^{\mathrm{L}} + \eta\left(r^{FB} - R_{\mathrm{B}}^{\mathrm{L}}\right)\right)^2} > 0, \tag{C.40}$$

as long as $(1-p) R_{\mathrm{B}}^{\mathrm{H}} + pR_{\mathrm{B}}^{\mathrm{L}} - 1 > 0$. Consequently, the size of the feasible SR interval decreases in p and increases in γ if $\gamma < \gamma^*$.

Next, we consider the case $\gamma \geq \gamma^*$. The partial derivative of $\left(\overline{\beta}_2 - \underline{\beta}_2\right)$ with respect to p is zero, as neither $\overline{\beta}_2$ nor $\underline{\beta}_2$ are functions of p (see proof of Proposition 4).

The partial derivative of $\overline{\beta}_2 - \underline{\beta}_2$ with respect to γ is:

$$\frac{\partial\left(\overline{\beta}_2 - \underline{\beta}_2\right)}{\partial\gamma} = \frac{(\eta-1)\left(R_{\mathrm{B}}^{\mathrm{H}}-1\right)LR_{\mathrm{B}}^{\mathrm{L}}}{\left(1-R_{\mathrm{B}}^{\mathrm{L}}+\eta\left(r^{FB}-R_{\mathrm{B}}^{\mathrm{L}}\right)\right)^2} < 0. \tag{C.41}$$

Consequently, the size of the feasible SR interval decreases in γ if $\gamma \geq \gamma^*$. □

Corollary 4

Proof. From equations (C.29) and (C.34) it follows that

$$\underline{\beta}_2(\gamma^*) - \underline{\beta}_1(\gamma^*) = \frac{1}{1+\gamma^* r^{FB} - R_{\mathrm{B}}^{\mathrm{L}}(1+\gamma^*)} \frac{\eta LR_{\mathrm{B}}^{\mathrm{L}}\left(R_{\mathrm{B}}^{\mathrm{H}}-1\right)}{r^{FB}-R_{\mathrm{B}}^{\mathrm{L}}} > 0. \tag{C.42}$$

Therefore,

$$\underline{\beta} = \begin{cases} \underline{\beta}_1 \text{if } \gamma < \gamma^* \\ \underline{\beta}_2 \text{if } \gamma \geq \gamma^* \end{cases} \tag{C.43}$$

jumps at $\gamma = \gamma^*$. □