

Bank Bailouts, International Linkages and Cooperation*

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Abstract

Financial institutions are increasingly linked internationally. As a result, financial crises and government intervention have stronger effects beyond borders. We provide a model of international contagion allowing for bank bailouts. While a social planner trades off tax distortions, liquidation losses, and intra- and inter-country income inequality, in the non-cooperative game between governments there are inefficiencies due to externalities, a lack of burden sharing, and free-riding. We show that, in absence of cooperation, stronger interbank linkages make government interests diverge, whereas cross-border asset holdings tend to align them. We analyze different forms of cooperation and their effects on global and national welfare.

Keywords: bailout, contagion, financial crisis, international institutional arrangements

JEL-Codes: F36, F42, G01, G28

*The authors are grateful to Giancarlo Corsetti, Russell Cooper and Elena Carletti for constant advice. They would also like to thank Franklin Allen, Claudia Buch, Douglas Gale, Todd Keister, Isabel Schnabel, Lary Wall, participants at Banque de France and Deutsche Bundesbank Workshop on Current Macroeconomic Challenges, 2010 DNB Annual Conference, Verein fuer Socialpolitik 2010, EEA 2010, FIRS 2010, RIEF 2010, and SMYE 2010. Schmidt-Eisenlohr acknowledges financial support from the ESRC (Grant No RES -060-25-0033). The authors thank the Sloan Foundation for financial support. The views expressed in this paper are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

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Banking crises are a common phenomenon. 144 systemic banking crises have occurred in 114 countries since the late 1970s with government intervention being similarly frequent.¹ The new element today is that crises rarely remain national, but quickly become global as a result of increased financial integration. The financial crisis in 2008/2009 has made this clear and has shown that international conflicts of interest can occur when governments in different countries respond to financial distress.² Accordingly, there is an increasing perception that more international coordination of crisis management is needed.³

In this paper, we present the first theoretical model that studies banking crisis with real international spillover effects and government intervention in a formal framework. We explore inefficiencies from unilateral decision-making and analyze how different forms of cooperation can improve upon the non-cooperative outcome.

In the model, contagion between two countries occurs through international balance sheet connections in the form of interbank deposits in line with Allen and Gale (2000). Interbank deposits allow for international risk sharing of idiosyncratic liquidity shocks, but induce systemic risk. Crisis spreads from one representative bank (located in the *crisis country*) to the other (in the *affected country*) when the former goes bankrupt due to unexpected liquidity

¹See Laeven and Valencia (2010) for a list of banking crisis and measures taken.

²Prominent examples are the AIG bailout as well as the cases of Lehman and Icesave. While the AIG bailout was undertaken unilaterally by the US, it also benefited foreign counterparties, which led to complaints from US taxpayers. In the case of Lehman, British regulators did not consent to an acquisition by Barclays and thereby defeated the ultimate attempt of the US to prevent Lehman's bankruptcy. When Icesave went bankrupt, the Icelandic government did not compensate foreign depositors for their losses in contrast to domestic creditors. This led to diplomatic tensions with the UK and the Netherlands. Another example is the resolution of Dexia and Fortis. Claessens (2009) investigates financial nationalism in the context of the recent financial crisis in more detail.

³A high-level debate on how to improve global crisis management has developed. See e.g. De Larosiere Report (2009) and Claessens et al. (2010).

needs and interbank deposits cannot be repaid fully.⁴ In a recent paper, Iyer and Peydro (2010) provide direct evidence for this type of contagion through interbank linkages caused by the failure of a large bank.⁵

We allow governments to intervene and to prevent bankruptcy by injecting capital when faced with a bankrupt bank. This intervention is financed through a tax on labor, which is distortionary. In fact, the fiscal burden attributed to banking and financial crises, stemming i.a. from direct government measures, has been considerable, as Reinhart and Rogoff (2009) document. Governments spent an average of 10 percent of national GDP on interventions to restore financial stability (direct fiscal costs, Laeven and Valencia (2010)).

A bailout directly affects depositors of the bank that is saved (increase in value of bank claims) and domestic households that have to finance the bailout. Moreover, it benefits the foreign bank and its depositors, either because contagion is avoided (spillover effect on the affected country) or because its liquidation value is raised (spillover effect on the crisis country).⁶

We are interested in the inefficiencies that arise when governments decide nationally how to handle a domestic bank in distress when the bank's bankruptcy has adverse effects across borders. To that end, we determine the optimal continuation allocation by solving the social planner problem. The social planner decides on intervention, taxes, and contribution levels of the

⁴Liquidity problems are considered a central element of the recent crisis. Brunnermeier (2009) observes that it has been "surprisingly close to a 'classical banking crisis'." Blanchard (2009) sees "the sale of assets to satisfy liquidity runs by investors" as one of its key amplifying mechanisms.

⁵Exploiting a natural experiment, they find that exposures to a defaulting financial institution, which they define as losses on interbank assets, lead to large deposit withdrawals. They conclude that "if a highly connected bank fails at a time when the banking system fundamentals are weak, a bailout may be necessary to prevent a systemic crisis".

⁶Several bailouts in the recent crisis, such as the one of AIG in the US and IKB in Germany, have been motivated by the fear of contagion effects through direct exposures of other financial institutions (see e.g. Upper (2011)).

two countries. Therein, she trades off liquidation losses, tax distortions, and income inequality between early and late depositors of a bank as well as a tax smoothing and a consumption smoothing motive between countries. With equal Pareto weights, efficiency requires that the affected country finances a larger part of the bailout, as the crisis country is always poorer in a crisis.

Next, we compare the social planner allocation to the outcome without cooperation. In the bailout game, the crisis country moves first, and the affected country follows. We identify three sources of inefficiencies. First, externalities arise from the fact that governments maximize national welfare, but do not take spillover effects into account. A second inefficiency comes from the fact that governments, in the non-cooperative game, do not share the cost of a bailout (no burden sharing), though this would minimize total tax distortions. Third, there is a free-riding problem related to the sequential nature of the game. A bailout by the affected country benefits the crisis country through increased returns on interbank deposits. The anticipation of the bailout may prevent the crisis country to intervene itself. The larger the interbank linkages, the bigger the incentives to free-ride.

Contributing to the current policy debate on how to improve international crisis management, we study three different cooperation regimes that resemble those recently initiated. We compare them with respect to efficiency and discuss their Pareto properties. The analysis shows when cooperation arrangements are particularly valuable to improve global welfare and when they are desirable from a national perspective. In that, it provides intuition for the factors driving international negotiations regarding greater coordination.

Banks increasingly compete internationally for clients. We take this into account by introducing cross-border asset holdings of depositors and analyze their impact on government intervention. With domestic assets at stake

abroad, governments partially internalize the spillover effects of their bailout decisions. We are also able to study differences in country size. Whether cross-country deposits tend to increase or decrease efficiency of the non-cooperative solution depends on the extent of cross-country deposits and potential asymmetries in country size. If country sizes are equal, cross-country deposits, in general, reduce inefficiencies.

Related literature Contagion has been modeled in different ways. In our setup, as in Allen and Gale (2000), it occurs as banks are linked through inter-bank deposits. Similarly, in Dasgupta (2004) systemic risk stems from balance sheet connections of banks.⁷ Alternatively, contagion can be modeled as an equilibrium phenomenon caused by reductions in available aggregate liquidity (see Diamond and Rajan (2005)) or as being transmitted through informational spillovers (see Acharya and Yorulmazer (2008) and Chen (1999)).

Several papers have studied bailouts within national boundaries. These differ both in the purpose of the bailout as well as in the instrument employed. In our paper, a bailout is done to limit liquidation losses in a Diamond and Dybvig (1983) framework and is financed by taxing labor. In Gale and Vives (2002) the goal of a bailout is also to limit liquidation losses ex post, but it is conducted through monetary policy. Other contributions analyzing bailouts include Diamond and Rajan (2002), Gorton and Huang (2004), Acharya and Yorulmazer (2007), and Farhi and Tirole (2009). In more recent work, Keister (2010) employs a setup similar to ours. He studies the effect of a bailout on financial stability and the probability of runs in a Diamond and Dybvig (1983) model with sunspots, where the intervention is financed from public resources.

⁷He applies the theory of global games, developed by Carlsson and van Damme (1993) and introduced to this setting by Morris and Shin (2003).

Some contributions put banking theory in an international perspective. Work in this area has focused on cooperation with respect to regulation, e.g. capital requirements and closure policies (see Acharya (2003), Holthausen and Roende (2005), Dell’Ariccia and Marquez (2006), and Calzolari and Loranth (2011)). Only a few papers treat international cooperation problems regarding the management of financial crisis. Agur (2009) studies the optimal institutional structure of a lender of last resort in an international framework with informational spillovers from intervention. While national authorities do not internalize the contagion effect, a central authority has limited signaling power. Therefore, the maximum welfare is achieved by central coordination. Freixas (2003) is the first paper that addresses externalities from a bailout, modeled as a public good, in a multi-country setting. There is under-provision of the public good, which can be resolved by commitment. Both costs and benefits of a bailout are exogenous parameters. In an extension, Goodhart and Schoemaker (2009) consider ex ante fiscal burden sharing rules. In this paper, we explicitly model international linkages and bailout decisions in a contagion framework and derive costs and benefits of an intervention.

The remainder of this paper is structured as follows. Section 2 introduces the model. Section 3 derives the solution to the social planner problem and the outcome of the non-cooperative game and draws comparisons between the two. Section 4 studies efficiency properties of different cooperation regimes. Section 5 extends the model by allowing for private cross-country deposits. Section 6 concludes.

I Model

Our model builds on Allen and Gale (2000). We use their basic framework to model interbank linkages and contagion. We extend the analysis to an international setting with two countries and allow for bailouts in case of bankruptcy. Moreover, we introduce a production sector operating at date $t = 1$, employing labor whose income can be taxed by the government in order to finance interventions.

A Setup

There are three time periods indexed by $t = 0, 1, 2$ and a continuum of ex ante identical agents of measure two. Each agent is endowed with one unit of a single consumption good at date $t = 0$. It serves as numéraire and can be invested in two different assets, a short asset and a long asset. Corresponding to storage, the short asset pays out one unit at date $t + 1$ for each unit invested at date t . The long asset yields a return $R > 1$ at date $t = 2$ for each unit invested at date $t = 0$. It can be liquidated at date $t = 1$, but at a loss as only $r < 1$ units are recovered. At date $t = 1$, each agent decides on her supply of labor to the perfectly competitive production sector and production takes place. Consumers have Diamond-Dybvig preferences. With probability λ , an agent only values consumption at date $t = 1$ (early type), while with probability $1 - \lambda$ she is of the late type and values consumption only at date $t = 2$. Individual preferences are given by:

$$(1) \quad U(c_1, c_2) = \begin{cases} u(c_1) & \text{with probability } \lambda \\ u(c_2) & \text{with probability } 1 - \lambda, \end{cases}$$

where u is assumed to be increasing, strictly concave and twice continuously differentiable. Consumption of an agent of type i , c_i , is composed of three different elements: the return from the investment d_i , labor income n , and disutility of work expressed in consumption terms.⁸ That is:

$$(2) \quad c_i = d_i + \eta \left(n - \frac{n^2}{\kappa} - \frac{\kappa}{4} \right).$$

Disutility of work is quadratic, with shape parameters κ and η . Due to our assumptions on the utility function, the labor supply decision of the agent is independent of her type and we can drop the subscript i .⁹ With the last term of Equation 2, we normalize the utility contribution of labor for the optimal labor supply $n = \kappa/2$ to 0.¹⁰

We assume that the population is divided into two groups of consumers (Group A and Group B), each of mass one. Within each group, the fraction of early consumers is stochastic being either low ($\lambda^L > 0$) or high ($1 > \lambda^H > \lambda^L$). Across groups it is perfectly negatively correlated so that the aggregate demand for liquidity is the same in both states. Table 1 summarizes the setup.

B The first-best allocation and its decentralization

As there is no aggregate uncertainty, the first-best allocation implies perfect risk-sharing. The social planner chooses per-capita investment at date $t = 0$

⁸The latter two are not part of the standard Allen and Gale (2000) framework, which does not feature a labor sector. Introducing the labor sector allows us to micro-found convex costs for the financing of government expenditures. Our setup is similar to Cooper et al. (2008).

⁹Late consumers, who only consume at date $t = 2$, store their labor income from date 1 to date 2. The disutility of labor, although conceptually arising at date $t = 1$, unfolds only at $t = 2$.

¹⁰Due to the normalization, the date 0 investment decision of the bank is independent of the expected labor income and the bank's optimization problem that we consider later can be formulated as standard in the literature.

Table 1: Liquidity shocks

	Group A	Group B	Probability
State S_1	λ_H	λ_L	0.5
State S_2	λ_L	λ_H	0.5

so as to maximize overall expected utility treating all consumers alike:

$$(3) \quad \underbrace{\max}_{\{d_1, d_2, x, y\}} \bar{\lambda}u(c_1(d_1)) + (1 - \bar{\lambda})u(c_2(d_2))$$

$$s.t. \quad x + y \leq 1,$$

$$\bar{\lambda}d_1 \leq y,$$

$$(1 - \bar{\lambda})d_2 \leq Rx.$$

x and y are the per capita amounts invested in the long and the short asset, respectively, and $\bar{\lambda} = \frac{\lambda_H + \lambda_L}{2}$. The three inequalities represent the resource constraints at date $t = 0$, $t = 1$ and $t = 2$. As the social planner anticipates the optimal labor supply by the agents, the standard Diamond-Dybvig objective function, which is independent of labor income, results. Optimal consumption of early and late consumers is $\bar{d}_1 = y/\bar{\lambda}$ and $\bar{d}_2 = R(1 - y)/(1 - \bar{\lambda})$, respectively.

The first-best allocation can be decentralized as an equilibrium with competitive banks and an interbank market. Assume that there are two representative banks, Bank A and Bank B. All consumers of Group A can deposit in Bank A and all consumers of Group B in Bank B. Banks offer demand deposit contracts to depositors and other banks, which independently of the state, promise a payment \bar{d}_1 upon withdrawal at date $t = 1$ per unit invested. A late withdrawer receives a pro rata share of the bank assets remaining at date $t = 2$, which in equilibrium is \bar{d}_2 . If the bank cannot serve all withdrawals at

date $t = 1$, it is bankrupt and is liquidated. All depositors, i.e. also banks, receive the same pro rata share of its liquidation value. Late consumers store the return and consume at date $t = 2$. As there is no sequential service constraint, no expectation driven bank runs occur and therefore, in equilibrium, there are no bankruptcies.¹¹ Consumers invest all their funds in their respective bank as this provides them with liquidity insurance. Moreover, each bank puts some of its funds in the other bank. Let z^A and z^B denote the interbank deposits of Bank A and Bank B, respectively. We assume that they equal the minimum amount necessary to implement the first-best allocation, which implies $z^A = z^B = z = y(1 - \frac{\lambda L}{\lambda})$. In principle, however, deposits could be larger.¹² The value of the claims that a bank holds is given by $\bar{d}_1 z$ at date $t = 1$ and $\bar{d}_2 z$ at date $t = 2$, respectively.

C Contagion

Following Allen and Gale (2000), we introduce the possibility of bank runs and contagion. We perturb the banking system by introducing a third state that is assigned a zero probability at date $t = 0$.¹³ In this state, aggregate

¹¹Note that our model does not feature multiple equilibria as e.g. in Diamond and Dybvig (1983) and Cooper and Ross (1998). Therefore, in our model, government intervention is not based on an equilibrium selection motive.

¹²If the interbank deposits were larger, contagion would take place for a larger set of parameters. Furthermore, given contagion, adverse spillover effects would be bigger.

¹³This assumption is a departure from rational expectations as agents do not correctly anticipate the possibility of a system-wide liquidity shortage. When the possibility of bankruptcy and contagion is not anticipated, moral hazard problems do not arise. The role of moral hazard in the context of financial crises and government intervention is the research focus of a growing literature (see e.g. Hellmann et al. (2000), Cooper and Ross (2002), Gale and Vives (2002), Cordella and Yeyati (2003), Farhi and Tirole (2009), and Keister (2010)). If introduced in our model, moral hazard should affect the trade-off between no intervention and a bailout by adding an additional cost to the latter. Our focus in this paper is, however, on the potential inefficiencies arising in the ex post decision process after a crisis occurred. The differences between the social planner solution and the outcome of the sequential game, driven by the three inefficiencies which we identify in our analysis, are

liquidity needs are higher than expected. As illustrated in Table 2, there is an additional fraction ϵ of early consumers in Bank A. As expectations remain unchanged, contracts and investment decisions at date $t = 0$ are the same as before. However, the continuation allocation is different from states S_1 and S_2 .

Table 2: Liquidity shocks with perturbation

	Bank A	Bank B	Probability
State S_1	λ_H	λ_L	0.5
State S_2	λ_L	λ_H	0.5
State \bar{S}	$\bar{\lambda} + \epsilon$	$\bar{\lambda}$	0

In state \bar{S} , the short assets of Bank A are not enough to satisfy its liquidity needs $\bar{d}_1(\bar{\lambda} + \epsilon)$ at date $t = 1$ as the optimal investment decision at date $t = 0$ implies $y = \bar{d}_1\bar{\lambda}$. Facing the additional fraction of early withdrawers, Bank A calls in its interbank claims before starting to liquidate the long asset.¹⁴ This, in turn, entails that Bank B also withdraws its interbank claims early as it faces more liquidity needs than it can satisfy with its short asset.

Bank A is bankrupt if it had to liquidate so much of the long asset in order to satisfy liquidity needs of early consumers that late consumers would receive a payoff smaller than \bar{d}_1 and run on the bank. Bankruptcy of Bank A has an impact on the other bank through the interbank deposits. Bank B,

in principle orthogonal to the problem of moral hazard, in particular, as long as countries and their ex ante expectations of being the crisis or the affected country are symmetric. Shutting down potential effects from ex ante expectations on the real investment allocation allows us to study in detail ex post intervention given bankruptcy and contagion.

¹⁴We assume that $\frac{R}{r} \geq \frac{\bar{d}_2}{\bar{d}_1}$. The condition implies that liquidation of the long asset is the least attractive option to create additional liquidity. It always holds for sufficiently low values of r . To see this note that the right-hand side of the inequality depends on the parameter values of the model, but not on r , as the first-best allocation is independent of the liquidation value of the long asset.

similar to Bank A's private depositors, only receives a pro rata share of Bank A's liquidation value. Whether the losses are sufficient to cause bankruptcy of Bank B depends on how much liquidity it can make available at date $t = 1$ without triggering a run. In the following, we focus on State \bar{S} and assume that the initial liquidity shock ϵ and the interbank linkages z are sufficiently large such that without government intervention both banks go bankrupt.

D Government intervention

The two representative banks operate in an international setting with two countries. Bank A is located in Country A, Bank B in Country B. We call Country A the *crisis country* and Country B the *affected country*. Each country has a government that maximizes welfare of its population and decides whether to intervene at date $t = 1$ when faced with potential bankruptcy of its domestic bank. In order to finance an intervention, it taxes the labor income of domestic agents operating under a balanced budget.¹⁵

Abstracting from spillover effects, consider the decision problem of a government in a banking crisis. Firstly, it may choose not to intervene at all, which leads to bankruptcy of its bank. Then each depositor receives a pro rata share q of the liquidated bank and the welfare level V of the country is given by:

$$(4) \quad V_n = u(q).$$

Secondly, the government can bail out its bankrupt bank. Let b denote the

¹⁵If we allowed the government to borrow, it would have to raise taxes in the future to pay back its debt. The possibility to smooth taxes over time can reduce distortions. However, as long as raising funds is costly, the main trade-off remains unaffected.

payoff that late depositors receive when the bank is bailed out, gap the additional unexpected liquidity needs that occur in state \bar{S} and λ the fraction of early depositors that the bank faces. Then the general formula for the cost of a bailout is given by:

$$(5) \quad G(b) = gap - r \left((1 - y) - \frac{(1 - \lambda)b}{R} \right).$$

The second term represents the liquidity that the bank can make available at date $t = 1$, while keeping enough of the long asset to pay out b to late consumers at date $t = 2$. For a bailout a government has to supply at least the additional liquidity that the bank needs in order to prevent a bank run, hence $b \geq \bar{d}_1$. If the bailout sum is larger than the minimal amount, the bank liquidates less long assets and late consumers benefit as their payoff is increased.

We assume that consumers observe the bailout and know the tax rate $\tau \geq 0$, which the government imposes in order to finance the intervention. The tax distorts the agents' labor supply decisions. Labor supply is now given by:

$$(6) \quad n(\tau) = (1 - \tau) \frac{\kappa}{2}.$$

This implies the following Laffer curve for the government:

$$(7) \quad G = \tau n(\tau) = \frac{\kappa}{2} \tau (1 - \tau),$$

where G is government income raised. The tax rate $\tau^{max} = \frac{1}{2}$ yields the maximum tax income $G^{max} = \frac{\kappa}{8}$. As long as this upper bound is sufficiently high, each country can finance a domestic bailout. To facilitate notation, let

$\tau(G)$ denote the tax rate that the government has to set in order to collect G . Furthermore, define $Z(G(b))$ as the total utility loss in terms of consumption due to distortionary taxation. As discussed before, for $\tau = 0$ this effect is normalized to 0 and $Z(0) = 0$.¹⁶

Due to equal taxation, each consumer incurs the same utility loss from taxation $Z(G(b)) > 0$, which increases with b . Welfare in the economy is then:

$$(8) \quad V_{bo}(b) = \lambda u(\bar{d}_1 - Z(G(b))) + (1 - \lambda)u(b - Z(G(b))).$$

For the optimal bailout level, the first-order conditions imply:

$$(9) \quad \frac{\lambda u'(c_1)}{(1 - \lambda)u'(c_2)} = \frac{1 - Z'(G(b))G'(b)}{Z'(G(b))G'(b)}.$$

A government chooses a bailout iff $V_{bo}(b^*) > V_n$, where b^* is the solution to 9.¹⁷ Whether no intervention or a bailout yields higher welfare depends crucially on the curvatures of the utility function and the function $Z(\cdot)$, as well as on the return on the long asset R and the liquidation value r . They all affect the

¹⁶For $\tau > 0$, it is strictly positive and given by:

$$\begin{aligned} Z(G(b)) &= -\eta \left[n(\tau(G(b)))(1 - \tau(G(b))) - \frac{n(\tau(G(b)))^2}{\kappa} - \frac{\kappa}{4} \right] \\ &= \frac{\kappa \eta}{4} \left[1 - \left(\frac{1}{2} + \sqrt{\frac{1}{4} - \frac{2}{\kappa} G(b)} \right)^2 \right], \end{aligned}$$

where we substituted, in the second line of the expression, the optimal labor supply and tax rate, which are functions of $G(b)$. For our analysis, it would be sufficient for $Z(G(b))$ to be increasing, convex and twice continuously differentiable.

¹⁷There is a notable difference between a partial bailout where just enough liquidity is provided to avoid bankruptcy and a bailout where liquidity is provided beyond this minimum amount. From Equations 4 and 8, a necessary condition for a partial bailout to be optimal is $\bar{d}_1 - Z(G(\bar{d}_1)) > q$. A partial bailout, if chosen by the government, thus implies a Pareto improvement. Any liquidity that is provided beyond $b = \bar{d}_1$ benefits late depositors only as all depositors face a higher tax rate and, thus, a stronger distortion of their labor supply decision.

trade-off a government faces between tax distortions, liquidation losses and consumption inequality.

Alternative instruments Intervention in our model takes the form of a bailout. Alternative instruments would be a deposit insurance, stopping convertibility, a central bank who acts as a lender of last resort or ring-fencing.

A deposit insurance that guarantees \bar{d}_1 to all consumers differs from a bailout where $b = \bar{d}_1$. In case of a deposit insurance, the bank goes bankrupt and the government pays the difference between the liquidation value of the bank and the guaranteed deposits. A bailout is less costly as the provided funds avoid the early liquidation of some fraction of the long assets.

Stopping convertibility would avoid a bank run at no direct costs. However, a fraction ϵ of early consumers would not be able to withdraw, which would reduce their consumption to zero. In a related problem, Ennis and Keister (2009) show that such a policy is not ex post credible.

In the Allen and Gale (2000) setting, a lender of last resort that can provide liquidity at no cost could fully resolve the problem by buying long term assets in period 1 and holding them until period 2. Our model thus applies to the case where providing liquidity through the central bank is sufficiently costly, e.g. due to inflationary effects, so that the government prefers to do a bailout.

Ring-fencing is another instrument that has been used, to some extent, during the recent crisis.¹⁸ In the following, define ring-fencing as an asset freeze where foreign depositors (either a bank or consumers) that would like

¹⁸The German government froze assets of Lehman in order for domestic depositors to be reimbursed. See Claessens (2009). Furthermore, in the context of the bankruptcy case of Barings, counterparties and customers faced constraints in accessing their funds during the resolution process. When the Bank for Credit and Commerce International (BCCI) was resolved, California and New York ring-fenced assets in order to secure a higher share of the liquidation value for local depositors. See Herring (2005).

to withdraw early are prevented from doing so. Then, it is straightforward to show that in the simplest case where ring-fencing is costless, the crisis country never chooses to ring-fence assets. In contrast, the affected country always prefers ring-fencing over a bailout as this shields the country from contagion.¹⁹

E International spillover effects from intervention

Besides the direct effects of a bailout on domestic welfare, there are spillover effects on the welfare of the other country as banks are connected through interbank deposits. A bailout of Bank A avoids contagion and fully protects Bank B. In contrast, a bailout of Bank B increases the liquidation value of Bank A as interbank deposits are fully repaid.

Not only spillover effects but also bailout costs differ between countries as the sources of bankruptcy are not the same. While bankruptcy of Bank A is caused by unexpected liquidity needs creating a maturity mismatch, the reason for bankruptcy of Bank B lies in a real loss on assets.²⁰ Equation 5 is valid for both countries, but gap and λ differ. For Bank A the explicit bailout cost is:

$$(10) \quad G^A(b) = \epsilon \bar{d}_1 - r \left((1 - y) - \frac{(1 - \bar{\lambda} - \epsilon)b}{R} \right),$$

where $\epsilon \bar{d}_1$ is the liquidity gap due to the additional early consumers faced by

¹⁹For a more detailed discussion, see Appendix E.

²⁰To gain intuition for this difference, consider the case where a government can raise non-discriminatory lump-sum taxes. Then, Country A always prefers a bailout over no intervention as there is a pure liquidity problem. Bank B faces real losses in assets. Therefore, a bailout of Bank B is desirable if the liquidation loss that can be avoided exceeds resources that have to be provided for the bailout. It can be shown that this is always the case. The free-riding problem, nonetheless, remains. Country A does not necessarily prefer to do a bailout of Bank A over letting Country B bail out its bank. These results on lump-sum taxation are derived in Appendix B.

Bank A. For Bank B, we have:

$$(11) \quad G^B(b) = z(\bar{d}_1 - \hat{q}) - r \left((1 - y) - \frac{(1 - \bar{\lambda})b}{R} \right).$$

The first term represents Bank B's real losses on interbank deposits in case of a bailout. $\hat{q} = \frac{y+r(1-y)+z\bar{d}_1}{1+z}$ is the value of one unit of deposits in Bank A if Bank B is bailed out.²¹ As bailout costs differ and the fractions of early and late depositors are not the same in the two countries, the optimal decision between no intervention and bailout, as well as the choice of b , typically differ between governments.²²

Welfare levels We denote welfare of country j by V_{s^A, s^B}^j , where the first subscript stands for Country A's intervention decision and the second subscript captures the action of Country B. We subsume the pair of actions taken by both countries by a . The general welfare function can then be formulated as:

$$(12) \quad V_a^j = \lambda^j u(c_1^j(a)) + (1 - \lambda^j) u(c_2^j(a, b)).$$

If neither country intervenes, all agents receive a pro rata share of the liquidation value of the bank. As interbank claims cancel out, each consumer, no matter in which bank she deposited her endowment, obtains $\bar{q} = y + (1 - y)r$, the value of the short asset plus the liquidation value of the long asset. There-

²¹There is a positive feedback effect. Because Bank B does not go bankrupt, it can fully repay Bank A's claims. This in turn, raises the liquidation value of Bank A, of which Bank B receives a pro rata share.

²²As the share of late consumers is smaller than expected, the government in Country A could raise the return of late consumers beyond the expected level \bar{d}_2 by providing funds. If the government could provide the funds conditional on becoming a residual claimant of the bank, it could collect the residual value of the bank after it has paid \bar{d}_2 to all late consumers, thereby potentially increasing efficiency. By restricting $b \in [\bar{d}_1, \bar{d}_2]$ in the optimization problem of the government, we do not consider this case. Note that for sufficiently large values of r the optimal b always lies within this interval.

fore:

$$(13) \quad V_{n,n}^A = V_{n,n}^B = u(\bar{q}).$$

If the government of the crisis country decides to bailout its domestic bank, then contagion is avoided and the bank in Country B remains unaffected by the crisis in Country A. Welfare of Country A from bailing out its bank is:

$$(14) \quad V_{bo,n}^A(b) = (\bar{\lambda} + \epsilon)u(\bar{d}_1 - Z(G^A(b))) + (1 - \bar{\lambda} - \epsilon)u(b - Z(G^A(b))).$$

As there is no contagion and Bank B remains unaffected, there is no scope for intervention and Country B's welfare attains the maximum:

$$(15) \quad V_{bo,n}^B = \bar{\lambda}u(\bar{d}_1) + (1 - \bar{\lambda})u(\bar{d}_2).$$

If, however, Country A does not intervene, there is contagion and the government of Country B has to decide whether or not to intervene. If Country B does a bailout, Country A's welfare is raised as Bank A's liquidation value increases to $\hat{q} > \bar{q}$:

$$(16) \quad V_{n,bo}^A = u(\hat{q}).$$

If it does a bailout, the welfare level of the affected country is:

$$(17) \quad V_{n,bo}^B(b) = \bar{\lambda}u(\bar{d}_1 - Z(G^B(b))) + (1 - \bar{\lambda})u(b - Z(G^B(b))).$$

II Equilibrium

In this section we derive the optimal continuation allocation chosen by a social planner as well as the solution to the non-cooperative sequential game played between the two governments.²³ We report mappings between the two outcomes and discuss inefficiencies that arise in the bailout game as compared to the social planner allocation.

A Social planner

The optimal continuation allocation is the solution to the problem of a benevolent social planner. Respecting the terms of the deposit contracts, she decides whether and where a bailout should be done. In case a bailout is optimal, she further decides on the bailout level b and the country-specific contributions X^A and X^B such that the sum of the contributions equals the funds required for the bailout $G^j(b)$, where j denotes the country whose bank is bailed out. We restrict contribution levels to be non-negative.²⁴ The social planner solves the following maximization problem:

$$\begin{aligned}
 (18) \quad & \max_{a \in \{(n,n), (n,bo), (bo,n)\}, X^A, X^B} V = \sum_{i \in \{A, B\}} \Theta^i V_a^i(d_1^i(a), d_2^i(a, b), Z(X^i)) \\
 & s.t. \quad G^j(b) = X^A + X^B, \\
 & \quad X^A \geq 0, \\
 & \quad X^B \geq 0,
 \end{aligned}$$

²³The game with simultaneous moves delivers very similar results. Instead of a free-riding problem, a coordination problem can occur. We analyze this case in detail in Appendix C.

²⁴Note that when there is a bailout of Bank A, optimality requires contribution levels to be non-negative. If there is a bailout of Bank B, it could, however, be optimal to have a positive cash transfer from taxpayers in Country B to consumers in Country A.

where Θ^j is the Pareto weight attributed to country j . The first-order conditions with respect to the contribution levels imply:

$$(19) \quad \frac{\Theta^A}{\Theta^B} = \frac{\bar{\lambda}u'(d_1^B(a) - Z(X^B)) + (1 - \bar{\lambda})u'(d_2^B(a, b) - Z(X^B))}{(\bar{\lambda} + \epsilon)u'(d_1^A(a) - Z(X^A)) + (1 - \bar{\lambda} - \epsilon)u'(d_2^A(a, b) - Z(X^A))} \frac{Z'(X^B)}{Z'(X^A)}.$$

Similar to a government with a single bank before, the social planner trades off tax distortions, early liquidation losses and income inequality between early and late depositors of the same bank. Furthermore, she faces two additional trade-offs. First, the disutilities from labor taxation, which in our setup are independent of individual income levels and convex in taxes raised, prescribe an equalization of contribution levels between countries, i.e. tax smoothing. Second, given the concave utility function, differences in income levels between countries, resulting from asymmetric effects of the banking crisis, make income equalization between countries desirable. The latter implies an additional consumption smoothing motive in the two-country setting.

In general, all three possible sets of actions can be optimal.²⁵ As, given a banking crisis, Country A is always poorer than Country B, the following result regarding contribution levels holds:²⁶

Proposition 1 *Suppose countries have equal welfare weights. Then, the contribution to a bailout of the affected country X^B is larger than the contribution of the crisis country X^A .*

²⁵Bailout costs differ between banks. Therefore, although a bailout of Bank A prevents contagion and raises Country B's welfare to the maximum, a bailout of Bank A does not necessarily dominate a bailout of Bank B. If $G^A(b)$ is sufficiently large, it can be optimal to save Bank B only. Without any restrictions on parameters, any of the three possible combinations of government actions can be optimal.

²⁶This result follows from the utilitarian welfare function, which governs the decisions of the social planner. If the planner was only interested in achieving Pareto-optimality, a redistribution motive would not be present. From an ex-ante perspective, burden sharing can be interpreted as an insurance against being the crisis country.

Proof. See Appendix A.

Note that, by setting contribution levels, the social planner has the ability to induce discriminatory taxes. As consumers have different payoffs in the two countries in case of a banking crisis, this is desirable. This option is not available in a national context where both banks are located in the same country. Then, a government can tax labor but cannot easily condition taxes on where consumers have deposited their endowments.

B Non-cooperative bailout game

When there is no coordination, each government decides on its own whether and how to intervene. Strategic interaction arises as the welfare of one country depends on the action chosen by the other country. Note that the welfare level of each country, however, is independent of the liquidity provision to the foreign bank. Therefore, b is not a strategic variable.

The sets of strategies of the governments in Country A and Country B are given by $S_A = S_B = \{n, bo\}$. We consider subgame-perfect Nash equilibria (SPNE) in pure strategies of the game with sequential moves. The crisis country moves first and the affected country follows.²⁷ There is no bailout iff $V_{n,bo}^B \leq V_{n,n}^B$ and $V_{bo,n}^A \leq V_{n,n}^A$. Country B bails out its bank iff $V_{n,bo}^B > V_{n,n}^B$ and $V_{bo,n}^A \leq V_{n,bo}^A$. Finally, Country A does a bailout iff $V_{bo,n}^A > V_{n,bo}^A$ or $V_{n,bo}^B \leq V_{n,n}^B$ and $V_{bo,n}^A > V_{n,n}^A$.

²⁷We consider a two-stage leader-follower game. An alternative would be to analyze the problem in a dynamic game with step-wise contributions. Admati and Perry (1991) study a contribution game related to our problem and show that even in such an extended setup, inefficiency may persist. See also Gale (2001) for a more general treatment of such games.

C Inefficiencies in the bailout game

When and how can the non-cooperative equilibrium differ from the optimal continuation allocation? To answer this question we derive mappings between these two objects.

Proposition 2 states which actions can be the solution to the social planner's problem for a given equilibrium of the sequential game. We do not consider the bailout levels, which will typically be larger in the case of a social planner as compared to the game given the absence of burden sharing in the latter. Instead we focus only on whether the actions taken differ or coincide.

Proposition 2 *Suppose countries have equal welfare weights.*

- (i) *If the SPNE is $a^* = (bo, n)$, then $a' = (bo, n)$.*
- (ii) *If the SPNE is $a^* = (n, bo)$, then $a' \in \{(bo, n), (n, bo)\}$.*
- (iii) *If the SPNE is $a^* = (n, n)$, then $a' \in \{(bo, n), (n, bo), (n, n)\}$.*

Proof. See Appendix A.

If (bo, n) is the SPNE, the social planner chooses the same outcome. However, when (n, bo) is the SPNE, a bailout of Bank A or Bank B can be optimal. Finally, all actions can be optimal when (n, n) is the SPNE.

We also consider the reverse mapping, i.e. we ask, which actions can be the equilibrium of the sequential game if the social planner finds a certain sequence of actions a' optimal:

Corollary 1 *Suppose countries have equal welfare weights.*

- (i) *If $a' = (bo, n)$, then $a^* \in \{(bo, n), (n, bo), (n, n)\}$.*
- (ii) *If $a' = (n, bo)$, then $a^* \in \{(n, bo), (n, n)\}$.*
- (iii) *If $a' = (n, n)$, then $a^* = (n, n)$.*

Proof. Follows directly from Proposition 2.

First, if the social planner finds a bailout of Bank A optimal, then all three outcomes are possible equilibria of the sequential game and $a^* \in \{(n, n); (n, bo); (bo, n)\}$. Second, if the social planner does not find a bailout of Bank A optimal, then it follows that the government in Country A, itself, does not choose to bailout its domestic bank either. Finally, if the social planner finds that no country should intervene, then $a^* = (n, n)$ is also the SPNE of the sequential game. This follows from the fact that for the social planner to choose no intervention, we must have $u(\bar{q}) > V_{bo,n}^A$ and $u(\bar{q}) > V_{n,bo}^B$, a situation in which neither Country A nor Country B choose a bailout.

Actions taken in the sequential game only differ from the choice of the social planner if a bailout is optimal and Country A does not bail out its bank. Either no bailout is chosen when one would be optimal or there is a bailout of Bank B when global efficiency requires a bailout of Bank A.

Why are there distortions towards too little intervention? Three sources of inefficiencies can be identified when comparing the allocations of the sequential game with those of the social planner, including now both actions taken and bailout levels chosen. The first source of inefficiency, *externalities*, is due to the fact that there are spillovers in both directions that are not taken into account by governments in the non-cooperative game. While a bailout of Bank A completely prevents all adverse effects on Bank B, a bailout of Bank B increases the liquidation value of Bank A. As governments only care about their own consumers, which coincide with domestic depositors, they undervalue the benefits of a bailout from the point of view of a social planner.

The second source of inefficiency is a *lack of burden sharing*. Distortions of the labor supply decision of agents from taxation are convex in tax revenues. Therefore, the inability of the governments in the non-cooperative game to spread bailout costs over both tax bases increases financing costs and results

in an inefficiency.

The third source of inefficiency, *free-riding*, arises due to the sequential structure of the game. A bailout by the affected country raises the welfare of the crisis country. Therefore, the net benefit for Country A of bailing out its bank is smaller when a bailout of Bank B is anticipated. The crisis country may not bail out its bank because it knows that then the affected country will do a bailout.

The strength of the effect of a bailout in the affected country on the crisis country is determined by the size of the interbank deposits.

Proposition 3 *(i) The incentives for a bailout in the affected country decrease in the interbank deposits z .*

(ii) If a bailout by the affected country is anticipated, then the incentives for a bailout in the crisis country decrease in the interbank deposits z .

Proof. See Appendix A.

Equation 11 implies that with increasing interbank deposits z , a bailout in Country B becomes more costly as the loss from bankruptcy of Bank A grows. This makes it less attractive for the affected country to bail out its bank. The gains from a bailout of Bank B for Country A, however, are increasing in the interbank deposits z . Therefore, if, in response to contagion, Country B bails out its bank, the incentive for Country A to do a bailout decreases in the interbank deposits, i.e. the free-riding problem is aggravated.

III Cooperation regimes

To improve upon the equilibrium of the non-cooperative game, governments have to find a way to cooperate. Cooperation can be either determined purely

by ex post negotiations or based on a mechanism established ex ante.

The first option we consider is a central authority with mandating and fiscal power, which can mandate actions to be taken and set contribution levels. It corresponds to the social planner discussed above, i.e. we abstract from any additional frictions that a central authority may encounter.²⁸ The Nordic-Baltic Stability Group, which was formed in August 2010, comes close to this cooperation regime. In its Memorandum of Understanding it is stated that its members will not only coordinate actions and share information, but also the burden in case of crisis.

Second, the central authority with mandating but without fiscal power can prescribe actions, but cannot implement burden sharing. A close equivalent to this cooperation regime is the European Systemic Risk Board (ESRB), a new EU financial institution. It has been established, amongst other things, to advise EU member states on how to deal with banks in distress, but has no mandate with respect to burden sharing between countries.

Third, we model Nash bargaining between governments. An ex post contract fixes a bailout to be implemented by one government and a corresponding transfer payment by the other government. This form of cooperation resembles what could be observed after the crisis, e.g. in the case of Dexia and Fortis, when governments came together to find a solution ex post. We now give a brief description of the different options and discuss whether each of them increases welfare. To that end, we use two distinct concepts. First, we analyze whether each of the cooperation regimes leads to a Pareto improvement compared to the non-cooperative solution. Second, we compare the different

²⁸The correspondence would no longer hold if we took certain problems of social choice into account. For example, there could be asymmetric information between national governments and the central authority with respect to the cost of a bailout.

regimes based on a utilitarian welfare function.

Central authority with mandating and fiscal power The choice of a central authority with mandating and fiscal power, which corresponds to the social planner allocation, implies that the welfare of one country increases, while the other country can experience a gain or a loss relative to the outcome of the non-cooperative game. Consider the case where the actions taken in the non-cooperative game coincide with the choice of the central authority. Then, the central authority only modifies the cost that each country has to bear and b . In this case, no Pareto improvement is possible, as b does not affect the welfare of the country that does not conduct the bailout, while the country has to contribute.

When the central authority not only introduces burden sharing, but also mandates actions different from the ones taken in the bailout game, this can, but does not need to imply welfare improvements for both countries. While for Country A results are ambiguous, Country B gains whenever the central authority mandates a bailout where, without cooperation, no bailout would take place.²⁹ Given that Pareto improvements are not guaranteed, the Nordic Baltic Stability Group may be confronted with commitment problems in the future.

Central authority with mandating power The objective function of the central authority is the weighted sum of national welfare levels. It solves the following problem:

$$(20) \quad \max_{a \in \{(n,n), (n,bo), (bo,n)\}} V = \sum_{j \in \{A,B\}} \Theta^j V_a^j(d_1^j(a), d_2^j(a, b), Z(G^j)).$$

²⁹Proofs and further details are in Appendix D.

It is not necessary for the central authority to have the power to mandate b as governments automatically choose the optimal bailout level given that there is no burden sharing. For the same reason, the allocation can differ from the one of the bailout game only with respect to the actions. This implies that a central authority with mandating power can only increase welfare at the expense of one country:

Proposition 4 *Suppose no country is indifferent between a bailout and no intervention. Then, a central authority with mandating power cannot induce a Pareto improvement.*

Proof. See Appendix A.

This result may explain why the ESRB has been given reputational power only.

Contracts Contracts specify actions to be taken and a burden sharing rule. We model the negotiation process between governments via Nash bargaining with symmetric negotiation power. The Nash bargaining problem is as follows:

$$(21) \quad \max_{a \in \{(n,bo), (bo,n)\}, X^A, X^B} (V^A(a, b, X^A) - V^A(a^*)) (V^B(a, b, X^B) - V^B(a^*))$$

$$s.t. \quad G(a, b) = X^A + X^B.$$

If a contract is signed, it implies, by its very nature, a Pareto improvement compared to the non-cooperative benchmark. One necessary condition for a Pareto improvement is that the actions \tilde{a} that are prescribed by the contract differ from the equilibrium actions a^* of the bailout game. A contract cannot be an agreement on burden sharing or a different set of actions alone as the participation constraint of one government would be violated. A second neces-

sary condition is that the country where the bailout does not take place helps finance the bailout.³⁰ This follows from the fact that governments maximize domestic welfare in the bailout game. A change in actions without compensation must therefore reduce domestic welfare of at least one country. There are two different outcomes of the non-cooperative game that allow for contracts to be signed:

Proposition 5 (i) *If $a^* = (n, n)$ and contracts allow for a Pareto improvement, then $\tilde{a} = (n, bo)$ with $\tilde{X}^A > 0$, or $\tilde{a} = (bo, n)$ with $\tilde{X}^B > 0$.*

(ii) *If $a^* = (n, bo)$ and contracts allow for a Pareto improvement, then $\tilde{a} = (bo, n)$ with $\tilde{X}^B > 0$.*

Proof. Omitted.

Case (i) captures situations where neither country intervenes, but welfare can be improved by a bailout. In order for Country B to agree on bailing out its domestic bank, Country A has to subsidize the bailout and vice versa. In Case (ii), Country B would bailout its bank without any cooperation between countries. However, each country's welfare can be increased if Bank A instead of Bank B is bailed out and Country B subsidizes the bailout.

Welfare rankings

A central authority with mandating and fiscal power implements the optimal continuation allocation chosen by the social planner. A general ranking between contracts and a central authority with mandating power with respect to efficiency is not possible. While a central authority with mandating power

³⁰In this context another type of free-riding arises. If Country B anticipates a bailout by Country A, it will not agree on any kind of burden sharing. Therefore, as Country A cannot commit not to bail out its bank, it has to bear the full cost of the bailout. This is the case even though consumers in Country B are richer than consumers in Country A and might benefit substantially from the intervention.

fully internalizes spillover effects, it cannot alleviate the inefficiency due to a lack of burden sharing. In contrast, contracts allow for some form of burden sharing. Yet, the set of actions \tilde{a} and the burden sharing rule in the form of \tilde{X}^A, \tilde{X}^B usually do not coincide with the optimal choice taken by the social planner. To see this, note that when solving the Nash problem, the marginal utilities of depositors of one country are weighted by the other country's Nash factor, which in general does not equal the welfare weight attributed by the social planner. In addition, redistribution is costly. Moving away from the optimal continuation allocation and choosing $\tilde{X}^j \neq X'^j$ reduces the surplus from the change in actions.³¹ Thus neither contracts nor a central authority with mandating power guarantee the implementation of the efficient actions.

IV Cross-country deposits and country sizes

Banks today compete more and more for clients across borders. As a result, international financial linkages have not only increased due to stronger international balance sheet connections of banks, but also through larger cross-border asset holdings of depositors. Related to this, the relative size of the banking sector differs across countries. Motivated by these facts, we extend the model to include cross-country deposits, which, at the same time, allow us to capture differences in country size.³² We study their effects on government decisions.

³¹This is because moving away from the optimal allocation implies suboptimal tax and consumption smoothing across countries.

³²Whenever some claims in a financial institution are held by foreigners, incentives of a government to support this institution are affected. Narrowly interpreted, cross-country deposits in our model correspond to bank deposits held by foreign natural persons. Our analysis of cross-country deposits, however, captures a problem relevant for a wide range of cross-border financial assets.

A Extended model setup

Now, banks compete for customers in both countries who can decide freely on where to deposit their endowment.³³ Let α (β) denote the fraction of depositors of Bank A (Bank B) that live in Country A (Country B) and let $1 - \alpha$ ($1 - \beta$) denote the fraction of agents that are depositors of Bank A (Bank B) and live in Country B (Country A). Banks remain of equal size, each hosting a unit mass of deposits. We assume that the liquidity shock ϵ hits a bank. Therefore, the bailout cost G is independent of the distribution of depositors. How easily a bailout can be financed depends, however, on the tax base of a country, hence its size. The smaller the population, the higher the tax rate required to raise a fixed amount of funds. Countries differ in size if $\alpha \neq \beta$. The population of Country A is $P^A = \alpha + (1 - \beta)$. In Country B, it is $P^B = \beta + (1 - \alpha)$. With asymmetric country sizes, the distortion of the labor supply decision becomes country-specific and depends on the population size P^j .³⁴

The derivation of the payoffs of the bailout game with cross-country deposits is straightforward. For Country A the general form is:

$$(23) \quad V_a^A = \alpha [\lambda u(c_1^A(a)) + (1 - \lambda)u(c_2^A(a, b))] + (1 - \alpha) [\lambda u(c_1^B(a)) + (1 - \lambda)u(c_2^B(a, b))],$$

³³We assume that each agent deposits its entire endowment either abroad or at home. Ex ante agents are indifferent where to deposit their endowments. This allows us to vary exogenously the distribution of cross-country deposits. In principle, cross-country deposits could be endogenized. For example, a diversification motive would arise if investments were risky and risk was not perfectly correlated across countries.

³⁴Substituting for the tax rate $\tau(G, P^j)$, the following expression is obtained:

$$(22) \quad Z^j(G, P^j) = \frac{\kappa\eta}{4} \left[1 - \left(\frac{1}{2} + \sqrt{\frac{1}{4} - \frac{2}{P^j\kappa}G} \right)^2 \right].$$

where c_i^j now represents the consumption of a type i depositor who invested in bank j . Welfare in Country B can be represented analogously. The equilibrium with cross-country deposits is pinned down by the same conditions as derived for the baseline model.

B Cross-country deposits, country sizes and inefficiencies

If the social planner gives equal weight to every consumer and country sizes are equal, cross-country deposits do not change her problem. Differences in country size, in contrast, have an effect as they imply different tax bases and, thus, country-specific tax distortions.

The bailout game is affected by the introduction of cross-country deposits in two ways. Firstly, governments now take the spillover effects into account because they care about domestic consumers that invested abroad. As a consequence, the amount of liquidity b that is provided by a government enters the welfare function of the other country. Nevertheless, as before, b is not a strategic variable.³⁵ Secondly, as liquidity shocks are attributed to a bank rather than a country, the fraction of early and late depositors of each country in State \bar{S} is altered. The fraction of early depositors in Country A is reduced to $\alpha(\bar{\lambda} + \epsilon) + (1 - \beta)\bar{\lambda}$, while the corresponding fraction in Country B is increased to $(1 - \alpha)(\bar{\lambda} + \epsilon) + \beta\bar{\lambda}$. As a consequence the welfare weights that are attributed to early and late consumers are modified.

Due to the fact that not all domestic agents deposit in the domestic bank, an additional unit of liquidity has a lower marginal contribution to national

³⁵Consider two possible cases. i) If Country A does a bailout, then intervention by Country B is not necessary. ii) If Country B does a bailout, there is no strategic effect as it is the second mover.

welfare and b^* will be lower than without cross-country deposits:

Proposition 6 *For a given country size, the smaller the fraction of domestically held deposits, the lower the optimal bailout level b^* chosen by a government.*

Proof. See Appendix A.

As the incentives for bailouts change, the extent of the free-riding problem changes as well. For equally sized countries, the effects can be summarized in the following proposition:

Proposition 7 *Suppose countries are of equal size ($\alpha = \beta$). Then, an increase in the fraction of deposits abroad*

(i) decreases the incentives for a bailout in the affected country.

(ii) increases the incentives for a bailout in the crisis country if it anticipates no bailout in the affected country.

Proof. See Appendix A.

The incentives for Country B to bail out its bank decrease with the fraction of deposits abroad $1 - \alpha$. This is because the direct effect of a bailout on consumers who have invested in Bank B is larger than its indirect effect on consumers who hold deposits in Bank A. While a partial bailout raises payoffs by $\bar{d}_1 - \bar{q}$ for Bank B depositors, the increase for Bank-A depositors is only a fraction of that, $\hat{q} - \bar{q} = \frac{z}{1+z}(\bar{d}_1 - \bar{q})$. If $b^* > \bar{d}_1$, late consumers that invested domestically benefit more than early consumers, while the additional liquidity support does not impact the payoff to consumers that invested abroad.

If Country A anticipates that Country B will not bail out its bank, then the incentives of Country A to finance a bailout increase with the fraction of domestic deposits abroad. A bailout in Country A prevents contagion and has

therefore a large effect on the payoffs of Country A consumers that invested in Bank B. With a growing fraction of domestic endowments deposited abroad, the benefits from a bailout increase for Country A. Its interests become more aligned with those of Country B. Note that a partial bailout in Country A is enough to guarantee that late depositors that invested in Bank B receive the originally promised amount \bar{d}_2 . Therefore, in order to provide the same welfare for domestic depositors, costs are lower when some of them are depositors of Bank B, i.e. if $1 - \beta > 0$.

Inefficiencies arise due to externalities and free-riding. With an increasing fraction of deposits abroad, the incentives for Country B to bail out its bank decline. Therefore, the incidence of free-riding by Country A decreases. Furthermore, Country A has a larger incentive to bail out its bank. This implies that the cases in which Country A does not bail out its bank, though this would be efficient, become fewer. Thus deposits abroad can move the equilibrium of the non-cooperative game toward the efficient solution.

Differences in country size, which corresponds to the tax base, imply different levels of distortions from taxation to raise the same revenue. This can best be illustrated by considering the special case where half of the consumers in each country deposit abroad:

Proposition 8 *Suppose in each country half of the depositors invest abroad ($\alpha = 1 - \beta$). Then, holding b constant, the incentives for a bailout in the crisis (affected) country increase with its size α (β).*

Proof. See Appendix A.

As an illustration, consider the case of Iceland. Mainly UK and Dutch consumers deposited their savings in the Icelandic bank Icesave. When it went bankrupt, the Icelandic government did not compensate all creditors of the

bank but only absorbed losses of their own nationals. In line with the previous proposition, as the size of the crisis country Iceland α was very small relative to the size of its banking sector, its government did not have strong incentives to do a full bailout. The fiscal burden of compensating all depositors would have been very high. In addition, the liabilities of the domestic bank were mainly held by foreigners, which in model terms corresponds to $1 - \alpha \geq \beta > 1 - \beta \geq \alpha$. For sufficiently small deposit holdings of the Icelandic population abroad ($1 - \beta$), which was arguably the case, the country's incentives to bailout the domestic bank were reduced even further.

V Conclusions

With globalization international linkages between financial systems have strengthened. Therefore, the effects of financial crisis and government intervention in one country on other countries have increased. While international cooperation in bank regulation has been considered extensively by the literature, cooperation with respect to crisis management has not.

In this paper, we provide a model of international contagion with government intervention in response to banking crisis. It allows us to study formally how the interests of countries diverge during crisis when financial institutions are linked through their balance sheets and consumers invest abroad. We study the inefficiencies that arise when governments do not cooperate and show how different forms of cooperation affect welfare ex post.

The cases of Lehman, AIG and Icesave illustrate the different aspects of international conflicts of interest that can arise in a banking crisis. Our model fosters an understanding of the causes and consequences of such conflicts. It shows to what extent they are inherent in decision-making powers in place,

and when they are particularly severe. The analysis presented can help guide institutional reforms and provide intuition for the motivations of governments.

Many results in our paper are applicable to the problem of fiscal support for countries in a currency union. As with bank bailouts, these interventions can improve the economic situation in the crisis country and limit adverse spillover effects. For example, in the wake of the recent European debt crisis, the German and French governments had strong incentives to bailout Greece as their banks were major holders of Greek government bonds. The fact that preventing Greek default avoided losses of German and French banks and potential repercussions in other European countries can justify sharing the burden of the implied costs. Improved cooperation in Europe could help to better internalize these aspects in the future.

Appendix A: Proofs of Propositions

Proof of Proposition 1

Proof.

(1) Interior solution, where Condition 19 holds. For the case (n,bo), we have:

$$(A1) \quad 1 = \frac{\bar{\lambda}u'(\bar{d}_1 - Z(X^B)) + (1 - \bar{\lambda})u'(b - Z(X^B))}{u'(\hat{q} - Z(X^A))} \frac{Z'(X^B)}{Z'(X^A)}.$$

Suppose that $X^A \geq X^B$. Then:

$$(A2) \quad \bar{\lambda}u'(\bar{d}_1 - Z(X^B)) + (1 - \bar{\lambda})u'(b - Z(X^B)) \geq u'(\hat{q} - Z(X^A))$$

$$(A3) \quad \Rightarrow u'(\bar{d}_1 - Z(X^B)) \geq u'(\hat{q} - Z(X^A))$$

$$(A4) \quad \Rightarrow Z(X^B) - Z(X^A) \geq \bar{d}_1 - \hat{q} > 0$$

$$\Rightarrow X^B > X^A,$$

which is a contradiction. Therefore, $X^B > X^A$.

For the case (bo,n), we have:

$$(A5) \quad 1 = \frac{\bar{\lambda}u'(\bar{d}_1 - Z(X^B)) + (1 - \bar{\lambda})u'(\bar{d}_2 - Z(X^B))}{(\bar{\lambda} + \epsilon)u'(\bar{d}_1 - Z(X^A)) + (1 - \bar{\lambda} - \epsilon)u'(b - Z(X^A))} \frac{Z'(X^B)}{Z'(X^A)}.$$

Suppose that $X^A \geq X^B$. Then, given $b \in [\bar{d}_1, \bar{d}_2]$:

$$(A6) \quad \lambda u'(\bar{d}_1 - Z(X^B)) + (1 - \bar{\lambda})u'(\bar{d}_2 - Z(X^B))$$

$$\geq (\bar{\lambda} + \epsilon)u'(\bar{d}_1 - Z(X^A))$$

$$+ (1 - \bar{\lambda} - \epsilon)u'(b - Z(X^A))$$

$$\begin{aligned}
(A7) \quad & \Rightarrow \lambda u'(\bar{d}_1 - Z(X^B)) + (1 - \bar{\lambda})u'(\bar{d}_2 - Z(X^B)) \\
& \geq (\bar{\lambda} + \epsilon)u'(\bar{d}_1 - Z(X^A)) + (1 - \bar{\lambda} - \epsilon)u'(\bar{d}_2 - Z(X^A)) \\
(A8) \quad & \Rightarrow \bar{\lambda}[u'(\bar{d}_1 - Z(X^B)) - u'(\bar{d}_1 - Z(X^A))] + \\
& (1 - \bar{\lambda})[u'(\bar{d}_2 - Z(X^B)) - u'(\bar{d}_2 - Z(X^A))] \\
& \geq \epsilon[u'(\bar{d}_1 - Z(X^A)) - u'(\bar{d}_2 - Z(X^A))] > 0 \\
(A9) \quad & \Rightarrow Z(X^B) > Z(X^A) \Rightarrow X^B > X^A,
\end{aligned}$$

which is a contradiction. Therefore, $X^B > X^A$.

(2) Corner solutions. There are two possible corner solutions:

- (i) $X^B = 0$ and $X^A = G$,
- (ii) $X^A = 0$ and $X^B = G$.

We show that only (ii) can be optimal. Suppose (i), i.e. $X^B = 0$ and $X^A = G$.

Then, the FOC of the social planner with respect to X^A is:

$$\begin{aligned}
(A10) \quad & \frac{\partial V}{\partial X^A} = -[(\bar{\lambda} + \epsilon)u'(d_1^A(a) - Z(G)) + (1 - \bar{\lambda} - \epsilon)u'(d_2^A(a, b) \\
& - Z(G))]Z'(G) + [\bar{\lambda}u'(d_1^B(a)) + (1 - \bar{\lambda})u'(d_2^B(a, b))]Z'(0).
\end{aligned}$$

This can be rearranged to:

$$\begin{aligned}
(A11) \quad & \frac{\partial V}{\partial X^A} = \bar{\lambda}[u'(d_1^B(a))Z'(0) - u'(d_1^A(a) - Z(G))Z'(G)] \\
& + (1 - \bar{\lambda} - \epsilon)[u'(d_2^B(a, b))Z'(0) - u'(d_2^A(a, b) - Z(G))Z'(G)] \\
& + \epsilon[u'(d_2^B(a, b))Z'(0) - u'(d_1^A(a) - Z(G))Z'(G)] < 0,
\end{aligned}$$

as $u(\cdot)$ is concave, $Z(\cdot)$ is convex, $d_2^B \geq d_2^A \geq d_1^A$ and $d_1^B \geq d_1^A$. Welfare could be improved by decreasing X_A and increasing X_B .

Proof of Proposition 2

Proof.

(i) $a^* = (bo, n)$ iff $V_{bo,n}^A > V_{n,bo}^A$ or $V_{n,bo}^B \leq V_{n,n}^B$ and $V_{bo,n}^A > V_{n,n}^A$.

If $V_{bo,n}^A > V_{n,bo}^A$, using $V_{bo,n}^B > V_{n,bo}^B \Rightarrow V_{bo,n}^A + V_{bo,n}^B > V_{n,bo}^A + V_{n,bo}^B$.

Using $V_{n,bo}^A > V_{n,n}^A$ and $V_{bo,n}^B > V_{n,n}^B \Rightarrow V_{bo,n}^A + V_{bo,n}^B > V_{n,n}^A + V_{n,n}^B$.

If $V_{bo,n}^A > V_{n,n}^A$ and $V_{n,n}^B \geq V_{n,bo}^B \Rightarrow V_{bo,n}^A + V_{n,n}^B > V_{n,n}^A + V_{n,bo}^B$.

Using $V_{bo,n}^B - V_{n,n}^B > V_{n,bo}^A - V_{n,n}^A \Rightarrow V_{bo,n}^A + V_{bo,n}^B > V_{n,bo}^A + V_{n,bo}^B$,

and as $V_{bo,n}^B > V_{n,n}^B \Rightarrow V_{bo,n}^A + V_{bo,n}^B > V_{n,n}^A + V_{n,n}^B$.

(ii) $a^* = (n, bo)$ iff $V_{n,bo}^B > V_{n,n}^B$ and $V_{bo,n}^A \leq V_{n,bo}^A$.

As $V_{n,bo}^A > V_{n,n}^A \Rightarrow V_{n,bo}^A + V_{n,bo}^B > V_{n,n}^A + V_{n,n}^B$.

(iii) $a^* = (n, n)$ iff $V_{n,bo}^B \leq V_{n,n}^B$ and $V_{bo,n}^A \leq V_{n,n}^A$.

$\Rightarrow V_{bo,n}^A \leq V_{n,n}^A < V_{n,bo}^A$ and $V_{n,bo}^B \leq V_{n,n}^B < V_{bo,n}^B$.

Proof of Proposition 3

Proof.

(i) $\frac{\partial G^B(b)}{\partial z} = \frac{\bar{d}_1 - \hat{q}}{1+z} > 0 \Rightarrow \frac{\partial(V_{n,bo}^B - V_{n,n}^B)}{\partial z} < 0$.

(ii) $\frac{\partial \hat{q}}{\partial z} = \frac{\bar{d}_1 - (y+r(1-y))}{(1+z)^2} > 0 \Rightarrow \frac{\partial(V_{bo,n}^A - V_{n,bo}^A)}{\partial z} < 0$.

Proof of Proposition 4

Proof. Suppose $a^* = \{(n, n); (n, bo)\}$ and $a' = (bo, n)$. Then, Country A is made worse off as $V_{bo,n}^A < \max\{V_{n,bo}^A; V_{n,n}^A\}$. Suppose $a^* = (n, n)$ and $a' = (n, bo)$. Then, Country B is made worse off as $V_{n,bo}^B < V_{n,n}^B$.

Proof of Proposition 6

Proof. With constant country size implying $\bar{P} - \alpha = (1 - \beta)$, the first-order condition of Country A for b implies:

$$(A12) \quad \frac{\alpha(\bar{\lambda} + \epsilon)u'(\bar{d}_1 - Z(G(b))) + (\bar{P} - \alpha)[\bar{\lambda}u'(\bar{d}_1 - Z(G(b))) + (1 - \bar{\lambda})u'(\bar{d}_2 - Z(G(b)))]}{\alpha(1 - \bar{\lambda} - \epsilon)u'(b - Z(G(b)))} \\ = \frac{1 - Z'(G(b))G'(b)}{Z'(G(b))G'(b)}.$$

The derivative of the left hand side (LHS) with respect to α , holding b constant, implies:

$$(A13) \quad \frac{\partial LHS}{\partial \alpha} \Big|_{b=\bar{b}} [\alpha(1 - \bar{\lambda} - \epsilon)u'(b - Z(G(b)))]^2 \\ = -[\bar{\lambda}u'(\bar{d}_1 - Z(G(b))) + \\ (1 - \bar{\lambda})u'(\bar{d}_2 - Z(G(b)))]\alpha(1 - \bar{\lambda} - \epsilon)u'(b - Z(G(b))) \\ - (\bar{P} - \alpha)[\bar{\lambda}u'(\bar{d}_1 - Z(G(b))) \\ + (1 - \bar{\lambda})u'(\bar{d}_2 - Z(G(b)))](1 - \bar{\lambda} - \epsilon)u'(b - Z(G(b))) < 0.$$

The derivative of the LHS with respect to b implies:

$$(A14) \quad \frac{\partial LHS}{\partial b} [\alpha(1 - \bar{\lambda} - \epsilon)u'(b - Z(G(b)))]^2 = -\alpha(\bar{\lambda} + \epsilon)u'(\bar{d}_1 - Z(G(b))) \\ + (\bar{P} - \alpha)[\bar{\lambda}u'(\bar{d}_1 - Z(G(b))) + (1 - \bar{\lambda})u'(\bar{d}_2 - Z(G(b)))]$$

$$(A15) \quad \alpha(1 - \bar{\lambda} - \epsilon)u''(b - Z(G(b))) > 0.$$

The derivative of $Z'(G(b))G'(b)$ with respect to b is:

$$(A16) \quad \begin{aligned} \frac{\partial Z'(G(b))G'(b)}{b} &= Z''(G(b))(G'(b))^2 + Z'(G(b))G''(b) \\ &= Z''(G(b))(G'(b))^2 > 0. \end{aligned}$$

Therefore, the derivative of the right hand side (RHS) with respect to b is negative. The statements about the derivatives above imply that an increase in α leads to a higher bailout level b being chosen by the government in Country A. The proof for Country B is analogous.

Proof of Proposition 7

Proof.

(i) Country B does a bailout iff $V_{n,bo}^B > V_{n,n}^B$. Now:

$$(A17) \quad \begin{aligned} \frac{\partial(V_{n,bo}^B - V_{n,n}^B)}{\partial(1 - \alpha)} \Big|_{b=\bar{b}} &= u(\hat{q} - Z(G(b))) \\ &- [\bar{\lambda}u(\bar{d}_1 - Z(G(b))) + (1 - \bar{\lambda})u(b - Z(G(b)))] < 0 \\ &\Rightarrow \forall \alpha, \alpha' \in [0, 1] \text{ and } \forall b \in [\bar{d}_1, \bar{d}_2] : \alpha' > \alpha \\ &\Leftrightarrow V_{n,bo}^B(b; \alpha') > V_{n,bo}^B(b; \alpha). \end{aligned}$$

Let $b = \arg \max V_{n,bo}^B(b; \alpha)$ and $b' = \arg \max V_{n,bo}^B(b; \alpha')$ with $\alpha' > \alpha$. Then, from optimal behavior of Country B and above: $V_{n,bo}^B(b'; \alpha') \geq V_{n,bo}^B(b; \alpha') > V_{n,bo}^B(b; \alpha)$.

(ii) Country A does a bailout iff $V_{bo,n}^A > V_{n,n}^A$. Now:

$$\begin{aligned}
\text{(A18)} \quad & \frac{\partial(V_{bo,n}^A - V_{n,n}^A)}{\partial(1 - \beta)} \Big|_{b=\bar{b}} \\
&= - [(\bar{\lambda} + \epsilon)u(\bar{d}_1 - Z^A(G^A(b))) + (1 - \bar{\lambda} - \epsilon)u(b - Z^A(G^A(b)))] \\
&+ [\bar{\lambda}u(\bar{d}_1 - Z^A(G^A(b))) + (1 - \bar{\lambda})u(\bar{d}_2 - Z^A(G^A(b)))] > 0 \\
&\Rightarrow \forall \beta, \beta' \in [0, 1] \text{ and } \forall b \in [\bar{d}_1, \bar{d}_2] : \beta > \beta' \Leftrightarrow V_{bo,n}^A(b; \beta') > V_{bo,n}^A(b; \beta).
\end{aligned}$$

Let $b = \arg \max V_{bo,n}^A(b; \beta)$ and $b' = \arg \max V_{bo,n}^A(b; \beta')$ with $\beta > \beta'$. Then, from optimal behavior of Country A and above: $V_{bo,n}^A(b'; \beta') \geq V_{bo,n}^A(b; \beta') > V_{bo,n}^A(b; \beta)$.

Proof of Proposition 8

Proof.

For the crisis Country A:

$$\text{(A19)} \quad \frac{\partial Z^A}{\partial \alpha} \Big|_{b=\bar{b}} = -\frac{G\eta}{4\alpha^2} \left(\frac{1}{2} + \sqrt{\frac{1}{4} - \frac{G}{\alpha\kappa}} \right) \left(\frac{1}{4} - \frac{G}{\alpha\kappa} \right)^{-\frac{1}{2}} < 0.$$

Country A does a bailout if:

$$\text{(A20)} \quad \frac{V_{bo,n}^A}{V_{n,n}^A} = \frac{(2\bar{\lambda} + \epsilon)u(\bar{d}_1 - Z(G^A(b))) + (1 - \bar{\lambda} - \epsilon)u(b - Z(G^A(b))) + (1 - \bar{\lambda})u(\bar{d}_2 - Z(G^A(b)))}{2u(\bar{q})} > 1,$$

and

$$\text{(A21)} \quad \frac{V_{bo,n}^A}{V_{n,bo}^A} = \frac{(2\bar{\lambda} + \epsilon)u(\bar{d}_1 - Z(G^A(b))) + (1 - \bar{\lambda} - \epsilon)u(b - Z(G^A(b))) + (1 - \bar{\lambda})u(\bar{d}_2 - Z(G^A(b)))}{u(\bar{q}) + \bar{\lambda}u(\bar{d}_1) + (1 - \bar{\lambda})u(b)} > 1.$$

Now:

$$(A22) \quad \frac{\partial(V_{bo,n}^A/V_{n,n}^A)}{\partial Z} \Big|_{b=\bar{b}} = - \frac{(2\bar{\lambda} + \epsilon)u'(\bar{d}_1 - Z(G^A(b))) + (1 - \bar{\lambda} - \epsilon)u'(b - Z(G^A(b))) + (1 - \bar{\lambda})u'(\bar{d}_2 - Z(G^A(b)))}{2u(\bar{q})} < 0$$

$$\Rightarrow \frac{\partial(V_{bo,n}^A/V_{n,n}^A)}{\partial \alpha} \Big|_{b=\bar{b}} > 0, \text{ and}$$

$$(A23) \quad \frac{\partial(V_{bo,n}^A/V_{n,bo}^A)}{\partial Z} \Big|_{b=\bar{b}} = - \frac{(2\bar{\lambda} + \epsilon)u'(\bar{d}_1 - Z(G^A(b))) + (1 - \bar{\lambda} - \epsilon)u'(b - Z(G^A(b))) + (1 - \bar{\lambda})u'(\bar{d}_2 - Z(G^A(b)))}{u(\hat{q}) + \bar{\lambda}u(\bar{d}_1) + (1 - \bar{\lambda})u(b)} < 0.$$

$$\Rightarrow \frac{\partial(V_{bo,n}^A/V_{n,bo}^A)}{\partial \alpha} \Big|_{b=\bar{b}} > 0.$$

For the affected Country B:

$$(A24) \quad \frac{\partial Z^B}{\partial \beta} \Big|_{b=\bar{b}} = - \frac{G\eta}{4\beta^2} \left(\frac{1}{2} + \sqrt{\frac{1}{4} - \frac{G}{\beta\kappa}} \right) \left(\frac{1}{4} - \frac{G}{\beta\kappa} \right)^{-\frac{1}{2}} < 0.$$

Country B does a bailout if:

$$(A25) \quad \frac{V_{n,bo}^B}{V_{n,n}^B} = \frac{u(\hat{q} - Z(G^B(b))) + \bar{\lambda}u(\bar{d}_1 - Z(G^B(b))) + (1 - \bar{\lambda})u(b - Z(G^B(b)))}{2u(\bar{q})} > 1.$$

Now:

$$(A26) \quad \frac{\partial(V_{n,bo}^B/V_{n,n}^B)}{\partial Z} \Big|_{b=\bar{b}} = - \frac{u'(\hat{q} - Z(G^B(b))) + \bar{\lambda}u'(\bar{d}_1 - Z(G^B(b))) + (1 - \bar{\lambda})u'(b - Z(G^B(b)))}{2u(\bar{q})} < 0$$

$$\Rightarrow \frac{\partial(V_{n,bo}^B/V_{n,n}^B)}{\partial \beta} \Big|_{b=\bar{b}} > 0.$$

Appendix B: Lump-Sum Taxation

With lump-sum taxation, Country A always prefers (bo, n) over (n, n) , as long as $\bar{\lambda} < 1$. Due to the free-riding problem, no clear statement can be made on (bo, n) vs. (n, bo) .

Proof.

$$\begin{aligned} V_{bo,n}^A > V_{n,n}^A &\Leftrightarrow (\bar{\lambda} + \epsilon)u(\bar{d}_1 - \epsilon\bar{d}_1) + (1 - \bar{\lambda})u(\bar{d}_2 - \epsilon\bar{d}_1) > u(\bar{q}) \Rightarrow u(\bar{d}_1 - \epsilon\bar{d}_1) > u(\bar{q}) \\ &\Leftrightarrow \bar{d}_1 - \epsilon\bar{d}_1 > \bar{q} \Leftrightarrow \bar{d}_1 = \frac{y}{\lambda} > \frac{y + (1-y)r}{1-\epsilon} = \frac{\bar{q}}{1-\epsilon}. \quad \epsilon \leq 1 - \bar{\lambda} \text{ implies } \frac{y}{\lambda} > \frac{y + (1-y)r}{\lambda}. \end{aligned}$$

This is true as $\bar{\lambda} < 1 \Rightarrow y < 1$.

With lump-sum taxation, Country B always does a bail-out. A full bail-out implies a higher welfare level in Country B than no intervention.

Proof.

$$\begin{aligned} V_{n,bo}^B > V_{n,n}^B &\Leftrightarrow \bar{\lambda}u(\bar{d}_1 - z(\bar{d}_1 - \hat{q})) + (1 - \bar{\lambda})u(\bar{d}_2 - z(\bar{d}_1 - \hat{q})) > u(\bar{q}) \Rightarrow \\ u(\bar{d}_1 - z(\bar{d}_1 - \hat{q})) > u(\bar{q}) &\Leftrightarrow \bar{d}_1 - z(\bar{d}_1 - \hat{q}) > \bar{q} \Leftrightarrow \bar{d}_1(1 - z) + z\frac{\bar{q} + z\bar{d}_1}{1+z} - \bar{q} > 0 \\ \Leftrightarrow \bar{d}_1(1 - z) + \frac{z^2\bar{d}_1 - \bar{q}}{1+z} > 0 &\Leftrightarrow \bar{d}_1 - \bar{q} > 0. \end{aligned}$$

Appendix C: Simultaneous Moves Game

Note that the following three inequalities hold:

- (1) $V_{n,bo}^A > V_{n,n}^A$,
- (2) $V_{bo,n}^B > V_{n,n}^B$,
- (3) $V_{bo,n}^B > V_{n,bo}^B$.

Therefore, possible welfare orderings for Country A are:

- (A-1) $V_{bo,n}^A > V_{n,n}^A$ and $V_{bo,n}^A > V_{n,bo}^A$,
- (A-2) $V_{bo,n}^A > V_{n,n}^A$ and $V_{bo,n}^A \leq V_{n,bo}^A$,
- (A-3) $V_{bo,n}^A \leq V_{n,n}^A$.

For Country B, possible welfare orderings are:

- (B-1) $V_{n,bo}^B > V_{n,n}^B$,
- (B-2) $V_{n,bo}^B \leq V_{n,n}^B$.

Combining the two countries, there are in total 6 different possible orderings.

The following proposition reports the equilibria for all cases:

- Proposition 9** (i) Suppose (A-1) and (B-1), then $a^* = (bo, n)$.
(ii) Suppose (A-1) and (B-2), then $a^* = (bo, n)$.
(iii) Suppose (A-2) and (B-1), then $a_1^* = (bo, n)$ and $a_2^* = (n, bo)$.

(iv) Suppose (A-2) and (B-2), then $a^* = (bo, n)$.

(v) Suppose (A-3) and (B-1), then $a^* = (n, bo)$. (vi) Suppose (A-3) and (B-2), then $a^* = (n, n)$.

Case (iii) implies a coordination problem as opposed to a free-riding problem in the sequential game.

Appendix D: Pareto properties under a central authority with mandating and fiscal power

There are three possible cases in which a central authority with mandating and fiscal power chooses a set of actions different to the outcome of the sequential game. These are:

- (i) $a^* = (n, n)$ and $a' = (n, bo)$,
- (ii) $a^* = (n, n)$ and $a' = (bo, n)$,
- (iii) $a^* = (n, bo)$ and $a' = (bo, n)$.

Results are derived assuming symmetric welfare weights, i.e. $\Theta^A = \Theta^B$.

(i) In Proposition 1, we showed that $X^B > X^A$.

Therefore:

$$(D1) \quad \frac{u'(\hat{q} - Z(X^A))}{\bar{\lambda}u'(\bar{d}_1 - Z(G^B(b) - X^A)) + (1 - \bar{\lambda})u'(b - Z(G^B(b) - X^A))} = \frac{Z'(X^B)}{Z'(X^A)} > 1$$

$$(D2) \quad \Leftrightarrow \bar{\lambda}u'(\bar{d}_1 - Z(G^B(b) - X^A)) + (1 - \bar{\lambda})u'(b - Z(G^B(b) - X^A)) < u'(\hat{q} - Z(X^A)).$$

Due to concavity of $u'(\cdot)$, it follows that:

$$(D3) \quad \bar{\lambda}u(\bar{d}_1 - Z(G^B(b) - X^A)) + (1 - \bar{\lambda})u(b - Z(G^B(b) - X^A)) \\ > u(\hat{q} - Z(X^A))$$

$$(D4) \quad \Leftrightarrow V_{n,bo}^B > V_{n,bo}^A.$$

As both countries have the same welfare level in the sequential game, that is $V_{n,n}^A = V_{n,n}^B = u(\bar{q})$, this implies that the net gain of Country B from the presence of the central authority is larger than that of Country A. Note that while the former is strictly positive, the latter can be negative.

(ii) In Proposition 1, we showed that $X^B > X^A \forall b \in [\bar{d}_1, \bar{d}_2]$. Therefore:

$$(D5) \quad \frac{u'(\bar{d}_1 - Z(X^A))}{u'(\bar{d}_1 - Z(G^B(b) - X^A))} > 1$$

$$(D6) \quad \Leftrightarrow u'(\bar{d}_1 - Z(G^B(b) - X^A)) < u'(\bar{d}_1 - Z(X^A))$$

$$(D7) \quad \Leftrightarrow u(\bar{d}_1 - Z(G^B(b) - X^A)) > u(\bar{d}_1 - Z(X^A))$$

$$(D8) \quad \Leftrightarrow V_{bo,n}^B > V_{bo,n}^A.$$

As welfare in the two countries in the sequential game is equal, this implies that Country B enjoys a larger and strictly positive net gain. Country A can gain or lose.

(iii) The proof on the welfare ordering under $a' = (bo, n)$ from (ii) remains valid. Therefore, welfare in Country B is strictly larger than welfare in Country A. In this case though, no clear statement can be made. As G^A might be larger than G^B , and therefore it is possible that $X^B > G^B$, each country might gain or lose.

Appendix E: Ring-fencing

Another form of government intervention, which can be observed during banking crises, is the ring-fencing of assets, i.e. the freeze of foreign asset holdings in domestic banks. During the recent crisis, the German government froze assets of Lehman in order for domestic depositors to be reimbursed. (See Claessens (2009).) Furthermore, in the context of the bankruptcy case of Barings, counterparties and customers faced constraints in accessing their funds during the resolution process. When the Bank for Credit and Commerce International (BCCI) was resolved, California and New York ring-fenced assets in order to secure a higher share of the liquidation value for local depositors. Ring-fencing applied to all assets up to the total value of liabilities towards local depositors. (See Herring (2005).)

In our model, we define ring-fencing as an asset freeze, that is foreign depositors (either a bank or private households) that would like to withdraw early are prevented from doing so. Governments observe the state of the world and decide on the form of intervention before any claims are paid. Furthermore, we assume that a country only does ring-fencing if this implies a strictly higher welfare than any alternative.

No cross-country deposits To start with, we consider the case with interbank deposits only. In this case, ring-fencing is equivalent to an interbank deposit freeze at date $t = 1$. We extend the bail-out game as illustrated in Figure 1 and introduce the additional form of intervention called *ring-fencing*. The figure is a reduced form of the game given the optimality of mutual ring-fencing. We show in the Appendix that the best response to ring-fencing is ring-fencing. Therefore, it does not matter for the pay-offs to depositors and,

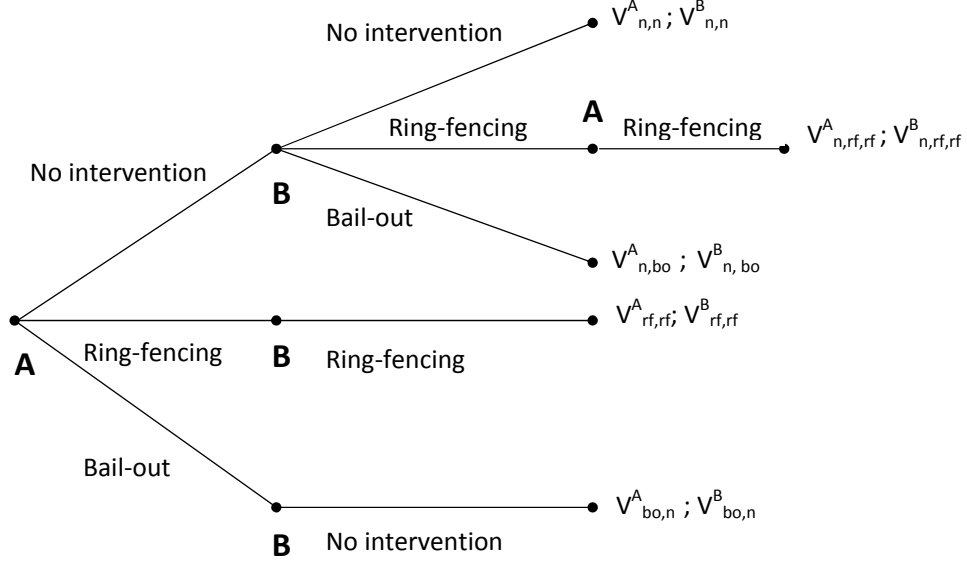


Figure 1: Intervention game in extensive form

thus, the welfare levels of the countries which country chooses to ring-fence interbank deposits first. As interbank claims exactly offset each other, ring-fencing cannot prevent bankruptcy in Country A. Bank A has to be liquidated and the welfare level of Country A is the same as in the case where neither country intervenes:

$$(E1) \quad V_{rf,rf}^A = V_{n,rf,rf}^A = u(\bar{q}).$$

In contrast, ring-fencing has a positive effect on the welfare level of Country B. Because interbank claims net out, contagion is avoided and welfare of Country B attains the first-best:

$$(E2) \quad V_{rf,rf}^B = V_{n,rf,rf}^B = \bar{\lambda}u(\bar{d}_1) + (1 - \bar{\lambda})u(\bar{d}_2).$$

The following result on optimal strategies can be derived:

Proposition 10 *In the non-cooperative game without cross-country deposits, the crisis country never chooses to ring-fence assets although this could avoid contagion. Without any costs to ring-fencing, the affected country will always choose this option.*

Proof. See the Appendix.

As Country B always chooses to ring-fence foreign assets in order to avoid contagion, the number of SPNE reduces to the following two:

Proposition 11 (i) $a^* = (n, rf, rf)$ is a SPNE iff $V_{bo,n}^A \leq V_{n,rf,rf}^A$.
(ii) $a^* = (bo, n)$ is a SPNE iff $V_{bo,n}^A > V_{n,rf,rf}^A$.

Proof. Omitted.

We compare the SPNE of the game with the possible choices of a central authority with mandating power only:

Proposition 12 (i) *If the SPNE is $a^* = (bo, n)$, then this equilibrium coincides with the optimal solution of the central authority with mandating power a' .*

(ii) *If the SPNE is $a^* = (n, rf, rf)$, then $a' \in \{(n, rf, rf), (n, bo)\}$.*

Proof. See the Appendix.

As burden sharing makes bailouts less costly, a central authority with fiscal power may find a bailout of Bank A optimal. Therefore, in Case (ii) the set of possibly efficient actions given fiscal burden sharing changes to $a' \in \{(n, rf, rf), (n, bo), (bo, n)\}$. In the modified game, there is only scope for one specific type of contract as defined in Expression 21 because Country B always attains the maximum welfare level: $\tilde{a} = (n, bo)$ with $X^A = G^B(\bar{d}_2)$ and $X^B = 0$, i.e. Country A fully finances the bailout of Bank B.

So far we have abstracted from any costs that ring-fencing might have. Yet, one can imagine that a country, which ring-fences assets, could be punished for its behavior, for example through the exclusion from the international interbank market in the future. Suppose the country that ring-fences suffers from a utility loss due to some penalty. Then ring-fencing may be no longer the dominant strategy of Country B. The severity of the punishment determines whether ring-fencing initiated by Country B is observed in equilibrium. Punishment could also be endogenous, giving an additional role to cooperation.

With cross-country deposits With cross-country deposits, the scope for ring-fencing increases. Countries can freeze interbank assets as well as private assets. The motivation of a government for ring-fencing becomes twofold. As before, freezing deposits prevents the withdrawal of assets, thereby eventually alleviating the liquidity problem at date $t = 1$ and preventing contagion. Moreover, by ring-fencing assets, a government can change the de facto seniority of claims. It allows for a compensation of domestic depositors at the expense of foreigners. When a large fraction of assets deposited in the domestic bank is owned by foreigners, the incentives to ring-fence may therefore increase. It is crucial that governments can discriminate between interbank and private deposits and freeze these assets independently of each other.

Proofs for Ring-fencing Propositions **Proof.** We consider the two cases where (1) Country A ring-fences first, and (2) Country B ring-fences first. We solve each case by backward induction.

(1) Given ring-fencing by Country A, the welfare levels of Country B for the

different responses (no intervention, bail-out, ring-fencing) are as follows:

$$(E3) \quad V_{rf,n}^B = u(q_r), \text{ with } q_r = \frac{(1-y)r+y}{1+z} < \bar{q},$$

$$(E4) \quad V_{rf,bo}^B = \bar{\lambda}u(\bar{d}_1 - G(b)) + (1 - \bar{\lambda})u(b - G(b)),$$

$$\text{with } G(b) = z\bar{d}_1 - r \left((1-y) - \frac{(1-\bar{\lambda})b}{R} \right),$$

$$(E5) \quad V_{rf,rf}^B = \bar{\lambda}u(\bar{d}_1) + (1 - \bar{\lambda})u(\bar{d}_2).$$

It follows from this that the best response of Country B to ring-fencing by Country A is ring-fencing. The welfare level for Country A, if it ring-fences first, is:

$$(E6) \quad V_{rf,rf}^A = u(\bar{q}).$$

Comparing this with Equations 13, 14, and 16, it can be seen that Country A never chooses to ring-fence first.

(2) Given ring-fencing by Country B, the welfare levels of Country A for the different responses (no intervention, ring-fencing) are:

$$(E7) \quad V_{n,rf,n}^A = u(q_r), \text{ with } q_r = \frac{(1-y)r+y}{1+z} < \bar{q},$$

$$(E8) \quad V_{n,rf,rf}^A = u(\bar{q}).$$

Note that a bail-out by Country A will not be chosen in the third round. If Country A prefers that option, it already chooses it in the first round. Therefore, given that Country B ring-fences, a bail-out cannot be optimally chosen by Country A. The best response of Country A to ring-fencing by Country B is ring-fencing. The welfare level of Country B, if it ring-fences

first, is:

$$(E9) \quad V_{n,rf,rf}^B = \bar{\lambda}u(\bar{d}_1) + (1 - \bar{\lambda})u(\bar{d}_2),$$

which is strictly higher than all other welfare levels except for the case where Country A does a bail-out. Therefore, if Country A does not do a bail-out, Country B always ring-fences.

Proof of Proposition 12

Proof.

(i) $a^* = (bo, n) \Rightarrow V_{bo,n}^A > V_{n,rf,rf}^A$. Therefore, together with $V_{bo,n}^B = V_{n,rf,rf}^B$, we have $V_{bo,n}^A + V_{bo,n}^B > V_{n,rf,rf}^A + V_{n,rf,rf}^B$.

(ii) $a^* = (n, rf, rf) \Rightarrow V_{bo,n}^A \leq V_{n,rf,rf}^A \Rightarrow V_{bo,n}^A + V_{bo,n}^B \leq V_{n,rf,rf}^A + V_{n,rf,rf}^B$.

A clear ranking in terms of welfare between (n, bo) and (n, rf, rf) is not possible because $V_{n,bo}^A > V_{n,rf,rf}^A$, but $V_{n,rf,rf}^B < V_{n,bo}^B$.

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