Too-many-to-fail and the design of bailout regimes*

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August 2024

Abstract

We show that the *too-many-to-fail* problem can be resolved through an appropriate design of the bailout-regime. In our model, optimal investment balances benefits from more banks investing in high-return projects against higher systemic costs due to more banks failing simultaneously. Under a standard bailout regime, banks herd, anticipating that simultaneous failures trigger bailouts. However, a policy that prioritizes bailing out a predesignated group of banks eliminates herding and achieves the first-best. If such a policy is not feasible, its benefits can be attained by decentralizing bailout decisions to two regulators each responsible for a separate group of banks.

JEL Classification: G1, G2

Keywords: systemic risk, optimal investment, too-many-to-fail, time-consistency, bailouts

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1 Introduction

When banks face joint distress, policymakers are compelled to bail them out to avoid the significant costs associated with widespread systemic failures—a problem known as *too-many-to-fail*. The Global Financial Crisis and the European sovereign debt crisis serve as powerful reminders of large-scale bailouts that may ensue.[1] These interventions, in turn, create perverse incentives for banks. They encourage them to increase their likelihood of benefiting from future bailouts by herding and investing in more correlated assets (Duchin and Sosyura, 2014; Acharya et al., 2021), thereby exacerbating the *too-many-to-fail* problem.

Although significant regulatory reforms have been implemented to reduce systemic risk since the Global Financial Crisis, most efforts have focused on large financial institutions deemed *too-big-to-fail*.[2] However, recent bailouts and policy interventions following distress at mid-sized regional banks in the U.S. highlight the need to address the *too-many-to-fail* problem as well. This paper shows how a properly designed bailout regime can eliminate the herding behaviour arising from *too-many-to-fail*, and thus lower systemic risk.

We study an economy with two central frictions: bank project choices are unobservable and bailouts have to be time-consistent. In our baseline model, banks can choose between two risky projects that differ in their expected returns (high and low). A bank may fail at an interim date, in which case its project can be continued by a surviving bank. The return a surviving bank can generate from the project is decreasing in the total number of other projects it is continuing, reflecting, for instance, capacity constraints. This implies that the

[1] For example, the sector-wide distress resulted in the U.S. government approving $700 billion in funding for the Troubled Asset Relief Program. Similarly, European governments bailed out a large number of banks, to the extent that the resulting costs raised concerns over sovereign risks and the subsequent needs to bail out certain European countries (Lane, 2012).

[2] For example, G20 launched a comprehensive programme of reforms, coordinated through the Financial Stability Board (Financial Stability Board 2021), that lead to significantly higher capital requirements and tighter supervision of large banks such as through stress tests; the European Systemic Risk Board was established in 2011, while 2 additional pillars were added to the Banking Union in 2013-2014: the Single Supervisory Mechanism and the Single Resolution Mechanism.

social cost of a bank failure rises with the number of other banks failing simultaneously; in other words, there is systemic risk.

We show that, under appropriate parameter conditions, the economy's first-best investment allocation is interior, that is, not all banks should invest in the high-return project. The optimal (aggregate) fraction of investment in the more productive project balances higher returns from this project against endogenously higher systemic costs that arise because when more banks invest in it, correlated failures are more costly. Notably, interior investment is optimal even though both projects are in infinite supply in the economy. The first-best solution also requires bailouts whenever bank failures exceed a threshold, with failing banks being bailed out until the marginal systemic cost of bank failure is equalized with the cost of a bailout.

We show that the first-best outcome cannot be achieved under a standard bailout regime. The reason is that bailout expectations are stronger when investing in the high-return project, precisely because this project is more commonly chosen and therefore associated with more simultaneous failures. As a result, bailout expectations distort bank incentives in favour of the high-return project, leading to overinvestment in it.[3] This is the only distortion. As systemic risk is microfounded in our model, banks otherwise fully internalize the systemic implications of both failure and survival (the latter arising because surviving banks can acquire projects from failed banks).

The "standard" bailout regime we have considered involves the regulator randomly selecting–among identical banks–which banks to bail out, meaning that bailouts are non-discriminatory. Since optimal bailouts are always incomplete (as it is never optimal to bail out all failing banks), there are degrees of freedom in the design of the bailout policies. We show that this flexibility can be exploited through the use of *targeted* bailout policies.

Consider the following bailout regime. Banks are allocated ex-ante (before they decide

[3]This is a classic herding problem: many banks investing in a project result in more bailouts, further increasing the incentives to invest in the project. Notably, in our model herding occurs endogenously on the project that is more productive, resulting in excessive investment in that project.

on investment) into two different bailout groups, with the sizes of these groups reflecting the respective first-best investment allocations. Bailouts are ex-post only disbursed to the members of the group designated to the project that actually fails. Specifically, a member of the "low group" will only get bailed out when it fails when the low-return project fails, but not if the high-return project fails.[4] By breaking the link between project choice and bailouts, this regime eliminates herding incentives (i.e., a member of the low group will no longer benefit from more frequent bailouts by switching to the high-return project). The first-best can thus be achieved, i.e., banks in each group find it optimal to invest in the project designated for their group. Importantly, this regime is fully time-consistent, as the total bailout disbursements are the same as under the standard regime.

We consider several extensions to this result. For instance, we study an extension to n ($n \geq 3$) projects that all differ in terms of their expected returns. In another extension, we consider varying project productivity across banks. In both cases, the first-best outcome can still be achieved using two bailout groups. We also examine the consequences of possible institutional limitations to implenting targeted bailout policies. For example, we show that when it is not possible to allocate banks to different bailout groups ex-ante, first-best group choices can be achieved by means of a tax on banks selecting the high group. In practice, such a tax may take the form of a higher regulatory burden associated with a specific banking license. It is also consistent with surcharges for systemic institutions.

We also analyze optimal bailouts when targeted policies are not feasible at all, that is, regulators are restricted to using non-discriminatory bailout policies. We show that there is then a rationale for *decentralizing* bailouts. We examine a regime in which bailout decisions are divided between two separate regulators, each responsible for a subset of banks and only concerned with the welfare of those banks. We show that, that if properly designed, this bailout regime can effectively implement targeted policies and thus eliminate herding incentives as well. The reason is that it now endogenously becomes (strictly) optimal for regulators to disburse bailouts exclusively to banks that do not deviate from their assigned

[4] Discriminatory policies are only needed "off-equilibrium", when a bank deviates.

group. To see the argument, consider the regulator who has authority over the group that is created for the low-return project. If a bank from this group deviates and invests in the high-return project, it will only fail if no other bank under this regulator's authority fails. Consequently, the regulator has no incentives to bail out this bank, implying that any bailouts will be done by the other regulator. This separation of regulatory responsibilities thus decentralizes the implementation of targeted policies. The decentralization comes with a cost though. Each regulator does not internalize the impact bailouts can have on the banks under the authority of the other regulator. Thus, decentralization involves a trade-off: it improves the project choice efficiency by eliminating distortions in banks' incentives, but leads to distorted bailout decisions.[5]

Our paper has important implications for policy. We show that there is a benefit to creating separate regulatory umbrellas, arising purely for systemic reasons. In contrast, assigning all banks to a single regulator who treats them similarly creates herding incentives. This provides a rationale for dual financial architectures, such as the Banking Union in Europe (in which national and supranational supervisors co-exist) and the United States (with state and federal regulators). Importantly, our analysis also suggests that the allocation of financial institutions to different regulators should not only depend on the characteristics of institutions themselves but should also aim to limit *system-wide* herding. In particular, allocating too many institutions to one regulator exacerbates herding by creating excessive bailout expectations.[6] Additionally, our analysis also highlights that there is a systemic

[5]We show that either decentralized regulation or a single regulator can be optimal when (direct) targeted policies are not available. Specifically, decentralized regulation is optimal when the cost of bailouts is sufficiently low, whereas a single regulator becomes optimal when the return advantage of the high-return project is small.

[6]Our analysis thus has direct implications for the design of the rule determining which regulator oversees a specific financial institution. In the Eurozone, for instance, allocation to the ECB is determined by an institution's balance sheet size. As our analysis suggests that the *aggregate* fraction of (banking) assets under a given regulator's control should be limited, this size threshold should be increased when more banks exceed it.

benefit to "egoistic" local regulation. National regulators, for instance, are less inclined to bail out banks that are failing due to investments in other countries' assets (as their failure may then be occurring when the domestic banking system is in good health). This limits cross-border herding and supports the case for maintaining some form of national regulation even in well-integrated financial systems.

Our analysis focuses on the *too-many-to-fail* problem, the tendency of policy-makers to be more forgiving towards financial institutions during periods of widespread stress in the financial system.[7] Acharya and Yorulmazer (2007) have shown that regulators have ex-post incentives to bail out banks if they fail jointly, and that this provides banks with incentives to herd on the same asset. Our model extends the framework of Acharya and Yorulmazer by allowing for a potential benefit from correlated investments, arising because some assets have higher returns than others. Consequently, the policy objective is not only to prevent herding, but also to implement efficient investment decisions at the aggregate level. Moreover, while Acharya and Yorulmazer take the bailout regime as given–analyzing a single regulator that is restricted to randomly allocate bailouts across failing banks–we explicitly consider the design of bailouts.

Several papers have analyzed policies to mitigate collective moral hazard (e.g., Acharya and Yorulmazer (2008), Farhi and Tirole (2012), Stein (2012), Horvath and Wagner (2017) and Segura and Suarez (2017)). Acharya and Yorulmazer (2008) consider ex-post liquidity policies. They show that providing liquidity to surviving banks mimics the allocative effects of bailouts, and that such liquidity provision lowers ex-ante herding incentives (in our model

[7] Studying a sample of developing countries, Brown and Dinc (2011) show that regulators are more likely to be lenient towards a failing bank when the banking system is weak. Additionally, several single-country studies also point to too-many-to-fail policies adopted by national regulators (Kane (1989), Barth (1991), White (1991), Kroszner and Strahan (1996), Hoshi and Kashyap (2001) and Amyx (2004)). Hoggarth et al. (2004) analyze resolution policies implemented in 33 systemic crises over the world and document that during systemic crises there is government involvement via liquidity support from the central bank and blanket guarantees, whereas in individual bank failures usually private solutions are applied and losses are passed on to shareholders.

there is no role for liquidity policies at surviving banks as the constraining factor is a capacity constraint). A countervailing force to collective moral hazard is identified in Perotti and Suarez (2000), arising because surviving banks obtain higher rents when other banks fail. Perotti and Suarez show that a policy of promoting takeovers of failing banks by solvent banks improves incentives, and makes banks' risk choices strategic substitutes. In our paper, surviving banks also obtain rents by purchasing assets of failing banks at discounted prices, which (in the absence of bailouts) results in strategic substitutability as well.

Phillipon and Wang (2022) show that allocating bailouts through tournaments can be used to address moral hazard in the form of traditional risk-taking. They show that focusing bailouts on ex-post stronger banks lowers their ex-ante incentives to take risks. In contrast, the friction in our model involves moral hazard arising from correlated investments (i.e., too-many-to-fail), and we show that this creates a rationale for targeted policies based on an *ex-ante* grouping of (identical) banks. Several papers have studied other aspects of optimal bailout policies, for instance by employing constructive ambiguity (Freixas (1999)), in terms of affecting charter value (Cordella and Yeyati (2003)), and in the presence of bail-in capital (Keister and Mitkov (2020)).

Our paper also relates to the literature that analyzes optimal investment in the presence of fire-sale risk. While we consider the choice among illiquid assets, this literature has mostly focused the optimal mix of holding illiquid assets and holding liquidity (see, among many others, Shleifer and Vishny (1992), Allen and Gale (1994), Gorton and Huang (2004), Allen and Gale (2005), Acharya, Shin and Yorulmazer (2011)). A central insight in these papers is that this investment mix trades off gains from investing in productive assets against losses incurred when forced to sell at fire-sale prices. Wagner (2011) examines optimal portfolio allocations among different illiquid assets in the presence of liquidation risk, showing that at equilibrium, diversified portfolios trade off a lower probability of forced liquidation against higher liquidation costs due to more investors holding diversified portfolios and hence fire sales being deeper. In our model, the benefit to correlated investments arises from some assets having higher returns than others, not from diversification motives.

Our analysis of decentralized regulation is closely linked to the literature that examines the optimal allocation of supervisory and regulatory powers (e.g., Acharya (2003), Dell'Ariccia and Marquez (2006), Calzolari, Colliard and Lóránth (2019), Carletti, Dell'Ariccia and Marquez (2020), Colliard (2020), Lóránth, Segura and Zeng (2022), Niepmann, and Schmidt-Eisenlohr (2013)). While these papers have studied trade-offs for a single (representative) institution, the analysis in our paper is based on systemic considerations. In particular, we show that there are benefits to heterogeneous, and possibly decentralized, regulatory umbrellas because they can limit herding by financial institutions.[8]

2 The model

The model has three dates: $t = 0, 1, 2$. There is a continuum of banks of measure one. Banks are risk-neutral, and there is no time discounting. Each bank has one unit of funds at $t = 0$.

At $t = 0$, each bank decides to invest its unit of funds in either a high-return (H) project, or a low-return (L) project. At $t = 1$, each project fails with probability π ($< \frac{1}{2}$), with failures occurring in mutually exclusive states of the world. A failed project returns 0 at $t = 1$; if it succeeds it returns R_i ($i \in \{H, L\}$), with $R_H > R_L > 1$.

A bank with a successful project can continue to operate and realize an additional project payoff of $\bar{v}$ at $t = 2$. If a bank has a failing project at $t = 1$, and the bank is not bailed out, the project cannot be continued at the bank. In this case, its project is sold to banks with successful projects, which we assume to occur in a competitive market. The value a successful bank can extract from a project declines in the total amount of projects it has

[8] Several papers have also explored hierarchical regulation and supervision, jointly undertaken by central and local supervisors (Repullo (2020), Colliard (2020), Carletti, Dell'Ariccia and Marquez (2020)). These papers have identified a benefit to hierarchical policy-making in terms of information collection, arguing that a local supervisor may have advantages in information gathering but may face distorted incentives relative to a central supervisor. In our setting, separating regulatory responsibilities can be optimal as well, but the benefit of using a local supervisor (for a fraction of banks) arises because banks under its jurisdiction have fewer incentives to herd.

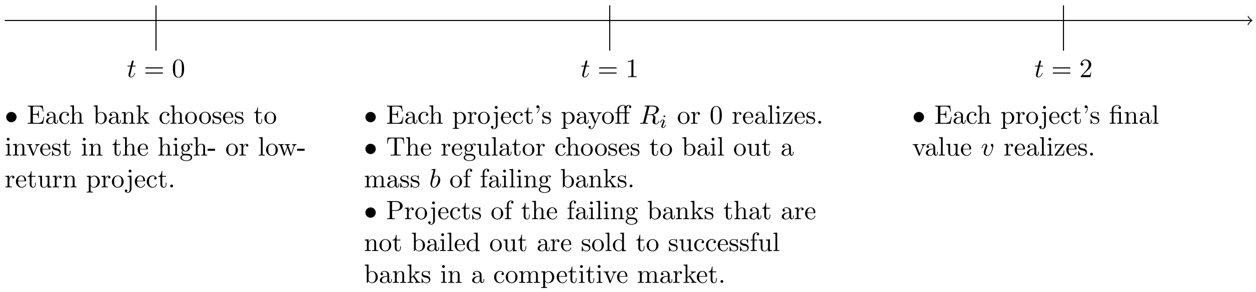

Figure 1: Timeline.

acquired, reflecting for instance capacity constraints. Specifically, a bank that acquires a mass a of projects generates $v(a)$ $(\leq \bar{v})$ from the a^{th}-unit of acquired projects (the average value of acquired projects is hence $\widetilde{v}(a) \equiv \int_0^a v(x)dx/a$).

Banks with failing projects can be bailed out by a regulator. This allows the bank to continue operating its project until $t = 2$ and realize the full value $\bar{v}$.[9] A bailout requires an equity injection $I > 0$ into the bank. The equity injection incurs social costs k, for example, due to the deadweight cost of public funds and/or the (unmodelled) reputation cost to the regulator.

In Appendix A, we provide a microfoundation for both the need to sell projects and for the bailouts. We consider banks that are financed through deposits and face a moral hazard problem in the continuation of their projects. Due to the moral hazard, banks with failed projects cannot continue projects absent bailouts. However, a sufficiently large bailout (of size I) provides incentives for continuation.

The sequence of events is summarized in Figure 1. We impose several parameter restrictions to ensure interior solutions and the uniqueness of the equilibrium. First, we make assumptions on the function $v(a)$. In particular, we assume that the rate at which returns are diminishing is sufficiently strong, which allows for uniqueness of the equilibrium:

Assumption 1. *(i)* $v(0) = \bar{v}$ *and* $v(1) \geq 0$, *(ii)* $v'(a) \leq -(k + I) < 0$, *and (iii)* $v''(a) \leq 0$.

[9]We assume that bailed-out banks cannot acquire projects from other banks. Allowing for this would introduce an additional benefit to bailouts, but does not change the main trade-offs considered in the paper.

Second, we make assumptions on the bailout cost:

Assumption 2. *(i)* $k < \bar{v} - v(1)$, *and (ii)* $k > \frac{1-\pi}{\pi}(R_H - R_L)$.

The first inequality states that bailouts are optimal when the number of acquired projects becomes sufficiently large (in particular, they are optimal at $a = 1$). The second inequality implies that the bailout cost is high enough to make solely investing in the high-return project suboptimal.

Third, we assume that the equity injection I required to bailing out a failing bank is not too high (this is also required for the uniqueness of the equilibrium):

Assumption 3. $I \leq \frac{1}{1-(v^{-1}(-\bar{v}+k))^2} - k$.

3 First-best allocation

An allocation can be characterized by *i)* the fraction of banks $\lambda \in [0, 1]$ that invest in the high-return project at $t = 0$ (with the remaining fraction $1 - \lambda$ of banks investing in the low-return project), *ii)* a bailout policy to bail out a measure $b(f)$ of banks when a measure f of projects fail at $t = 1$, and *iii)* project transfers for the measure $f - b$ of banks not bailed out. We solve the first-best backwards.

Project transfers. At $t = 1$, at the last stage, there is a mass of $f - b$ (≥ 0) of failing banks that have not been bailed out. As long as continuing projects at successful banks has positive value ($v(a) > 0$), all projects at the mass of $f - b$ banks should be transferred to successful banks (of which there is a mass $1 - f > 0$ in an interior solution). Since the return from continuing projects is declining at the bank-level ($v'(a) < 0$), it is optimal to equally distribute projects among all successful banks. An individual successful bank thus continues

$$a(b, f) = \frac{f - b}{1 - f} \tag{1}$$

acquired projects. We refer to a – the ratio of (forced) suppliers of projects to available acquirers – as the economy's *fire-sale pressure.*

Bailout policy. For a mass $f \geq 0$ of banks failing at $t = 1$, the optimal bailout policy, $b^{FB}(f)$, minimizes costs arising because projects of failed banks that are not bailed out can only be continued at a lower value, and the cost of bailouts itself:

$$C^{FB}(f) \equiv \min_{b \leq f} \quad (f - b)(\bar{v} - \widetilde{v}(a(b, f))) + bk. \tag{2}$$

We refer to $C^{FB}(f)$ as the total *systemic costs* in the economy. The first order condition is given by:

$$\bar{v} - v(a(b, f)) = k, \tag{3}$$

where we have used that $\frac{\partial \widetilde{v}(a(b,f))}{\partial b} = \frac{v - \widetilde{v}}{f - b}$. The left-hand side of the equation is the marginal benefit of bailout: Bailing out one more bank allows this bank to continue its project to realize a value of $\bar{v}$, instead of having to transfer the project to another bank and realizing only a value of $v(a)$. The right-hand side is the marginal cost of a bailout, k.

Lemma 1. *The first-best bailout policy is given by*

$$b^{FB}(f) = \begin{cases} 0 & \text{if } f \leq \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}, \\ -\bar{a}^{FB} + f(1 + \bar{a}^{FB}) & \text{if } f > \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}, \end{cases} \tag{4}$$

where the fire-sale-pressure threshold $\bar{a}^{FB}$ ($\bar{a}^{FB} < 1$) is defined by $\bar{v} - v(\bar{a}^{FB}) = k$.

This lemma shows that bailouts are used only when the mass of failing banks is sufficiently large. This reason is that the benefit of a bailout increases in f since project transfers become more costly when f is large. For a small number of banks failing, the marginal benefit is small (in particular, it becomes zero for $f \to 0$ by Assumption 1*(i)*). Therefore, when the mass of failing banks is sufficiently low, the marginal benefit of bailing out a bank is lower than the cost k and bailouts are not optimal. When the mass of failing banks is large, it is optimal to bail out banks until the marginal benefit and cost of bailouts are equalized, which implies that bailouts are used until the fire-sale pressure is brought down to $\bar{a}^{FB}$. The economy's fire-sale pressure (after bailouts) is hence given by

$$a^{FB}(f) = \min\{\frac{f}{1 - f}, \bar{a}^{FB}\}. \tag{5}$$

Two observations about the first-best bailout policy are worth noting. First, one additional bank failure results in bailing out more than one bank ($b^{FB\prime}(f) > 1$) in the range where bailouts are used. This is because project failure creates a failing bank as well as eliminates a potential acquirer. Second, bailouts are incomplete ($b^{FB} < f$), since eliminating all failures is not optimal when there are at least some successful banks ($1 - f > 0$) that can acquire projects.

Lemma 1 implies that the total systemic costs in (2) are (weakly) convex. To see this, consider the marginal systemic costs of an additional bank failure

$$c^{FB}(f) \equiv C^{FB\prime}(f) = s(a^{FB}(f)) + l(a^{FB}(f)), \tag{6}$$

where

$$s(a) \equiv a(\widetilde{v}(a) - v(a)) \tag{7}$$

is the surplus generated from a successful bank acquiring projects and

$$l(a) \equiv \bar{v} - v(a) \tag{8}$$

is the value loss in the failing bank's project (equal to the marginal benefit of bailout, given in the left-hand-side of (3)). For $f \leq \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$, we have that $c^{FB}(f)$ is increasing as no bailouts are used. For $f > \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$, we have $l(a^{FB}(f)) = k$, and $c^{FB}(f) = k + \bar{a}^{FB}(\widetilde{v}(\bar{a}^{FB}) - v(\bar{a}^{FB}))$ becomes a constant.

Investment choice. We now turn to the first-best project choices at $t = 0$. Given optimal project transfers and optimal bailout policies, the expected welfare when a fraction λ of banks invests in the high-return project is given by

$$W(\lambda) = (1 - \pi)(\lambda R_H + (1 - \lambda)R_L) + \overline{v} - \pi C^{FB}(\lambda) - \pi C^{FB}(1 - \lambda). \tag{9}$$

The first term is the expected project return at $t = 1$. The second term is the project return at $t = 2$ if all projects are continued at their originating banks. The last two terms are the expected systemic costs from failures of the high- and low-return projects, respectively.

The derivative with respect to λ is given by

$$W'(\lambda) = (1-\pi)(R_H - R_L) - \pi(c^{FB}(\lambda) - c^{FB}(1-\lambda)). \tag{10}$$

Equation (10) highlights a trade-off. On the one hand, investing more in the high-return project will lead to higher payoffs in the case of project success. On the other hand, it increases the mass of banks failing in the states in which the high-return project fails, while lowering the mass of bank failures when the low-return projects fail. Since systemic costs of project failure are convex in the mass of project failing, an interior investment choice λ can be optimal. The second part of Assumption 2 (which gives $W'(1) < 0$) rules out corner solutions and thus ensures $\lambda^{FB} < 1$.

The efficient investment level trades off the higher project return against higher marginal systemic costs. At the interior solution, the marginal systemic cost of a high-return project's failure $c^{FB}(\lambda)$ thus has to exceed that of a low-return project's failure $c^{FB}(1-\lambda)$. Recall that Lemma 1 implies that bailouts are used when half of the banks fail simultaneously (as $\bar{a}^{FB} < 1$ following from Part *(i)* of Assumption 2). Since the total costs are only convex when no bailouts are used, this implies the first-best λ is sufficiently high ($\lambda > 1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$), such that there are bailouts when the high-return project fails, but no bailouts when the low-return project fails:

Proposition 1. *The first-best* ***investment choice*** λ^{FB} *lies in* $(1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}, 1)$ *and is defined through* $W'(\lambda^{FB}) = 0$*:*

$$W'(\lambda^{FB}) = (1-\pi)(R_H - R_L) - \pi(s(\bar{a}^{FB}) + l(\bar{a}^{FB}) - s(\frac{1-\lambda^{FB}}{\lambda^{FB}}) - l(\frac{1-\lambda^{FB}}{\lambda^{FB}})) = 0. \tag{11}$$

The first-best ***bailout policy*** $b^{FB}(f)$ *is given by Lemma 1. The first-best* ***project transfer*** *is to equally allocate the projects of all failing banks to the successful banks.*

4 Single regulator

In this section we analyze outcomes under a single regulator. This regulator maximizes welfare but faces two frictions in doing so. First, banks' investment choices are unobservable.

Second, bailout decisions have to be time-consistent.

Since the regulator maximizes welfare, the decision of *how many* banks to bail out at $t = 1$ is identical to that analyzed in the previous section. The total amount of bailouts is thus $b^{FB}(f)$, as characterized in Lemma 1. The regulator is indifferent though (at $t = 1$) about *which* failing banks to bail out, so there are degrees of freedom in the implementation of the bailout policy. We first show that *uniform* bailouts (that is, when bailout recipients are randomly chosen) cannot implement the first best. Following this we show that *targeted* bailouts, where bailouts depend on the identity of (failing) banks, can implement the first best.

4.1 Inefficiency of uniform bailouts

In this section we examine banks' equilibrium investment choices that result from uniform bailouts, showing that they are inefficient.

An individual bank's choice to invest in the high-return project (instead of the low-return project) is driven by the same principal considerations as in Section 3: Investing in the high-return project provides a higher payoff in the case of success, but also means that the bank's project fails in a state in which a mass λ of other projects fail (instead of a mass $1-\lambda$). The difference in the expected profits from investing in the high- and low-return project can be expressed as[10]

$$\Delta\Pi^S(\lambda) = (1-\pi)(R_H - R_L) - \pi(c^S(\lambda) - c^S(1-\lambda)). \tag{12}$$

This expression is identical to the marginal social benefit from investing in the high-return project (10), except that the cost of failure is now $c^S(f)$, where

$$c^S(f) = c^{FB}(f) - \frac{b^{FB}(f)}{f}(l(a^{FB}(f)) + I). \tag{13}$$

The first term in (13) is the social cost of bank failure $c^{FB}(f)$, the second term is related to bailout expectations. In other words, absent bailouts, a bank's private cost of failure is

[10]For the formal derivation of (12) see the proof of Proposition 3.

identical to the social one. This is due to competitive market for project transfers at $t = 1$, the market price correctly reflects the social value of a project that needs to be transferred, $v(a^{FB}(f))$. As a result, a bank's profit from acquiring a mass a of failing banks $s(a^{FB}(f))$, and its loss of having to sell projects when failing, $l(a^{FB}(f))$, sum up to the social cost of failure $c^{FB}(f))$.[11]

The second term in (13) is a bank's expected benefit due to receiving bailouts: In the case of a bailout (occurring with a likelihood of $\frac{b^{FB}(f)}{f}$), the bank avoids the loss $l(a^{FB}(f))$ and also gains the equity injection I. These bailout expectations drive a wedge between the private and social cost of failure.

In an (interior) equilibrium, individual banks have to be indifferent to choosing the high-return and low-return project. That is, we need to have $\Delta\Pi^S(\lambda) = 0$.

Proposition 2. *There exists a unique equilibrium under a single regulator employing uniform bailout policies. In this equilibrium a mass $\lambda^S > \lambda^{FB}$ of the banks invest in the high-return project.*

To see the intuition why equilibrium investment in the high-return project is excessive (that is, $\lambda^S > \lambda^{FB}$), consider a (conjectured) equilibrium in which investment is equal to the first best level ($\lambda^S = \lambda^{FB}$). As shown in Section 3, under the first-best, there are bailouts when the high-return project fails, but not when the low-return project fails. This means that a bank's private cost of failure is lower than the social cost when investing in the high-return project as per (13), whereas for the low-return project there is no wedge between private and social costs. Given that the social return from both projects is identical at the first-best, this implies that a bank's expected profit from the high-return project is then strictly higher, contradicting the notion of an equilibrium. In fact, banks that have invested in the low-return project would have incentives to switch to the high-return project, resulting in excessive investment in the high-return project.

[11] Dávila and Korinek (2018) provides a discussion on when pecuniary externalities result in inefficiencies. Like in our setting, they show that in an economy in which risk markets are complete, fire sale does not lead to inefficiencies. Biais, Heider and Hoerova (2021) obtain a similar result.

Coming to the first part of the proposition, why does our setting allow for a unique equilibrium? More banks investing in the high-return project will result in even more bailouts in the event this project fails, increasing the incentives for banks to invest even more in high-return projects. Such strategic complementarity may lead to multiple equilibria. However, there is also a countervailing effect. More banks investing in the high-return project also means fewer potential acquirers when this project fails. This implies that the transfer value of the project becomes very low, providing large incentives to be an acquirer of such assets, and hence to invest in low-return projects (this is essentially the "last-bank-standing" effect of Perotti and Suarez (2002)). Our assumptions (specifically 1 and 3) guarantee that this effect is sufficiently strong relative to the first effect,[12] ensuring a unique solution.

4.2 Optimality of targeted bailouts

In this section we show that targeted bailouts can implement the first best. Suppose that at $t = 0$ banks are assigned to two groups, a high-return project group (H-group) and a low-return project group (L-group). The size of the groups is λ^{FB} and $1-\lambda^{FB}$, respectively. The targeted policy stipulates that when the high-return project fails, the regulator only bails out in the H-group, whereas when the low-return project fails, the regulator only bails out in the L-group. This has the consequence that, if a bank in the L-group chooses the high-return project, it will not be bailed out when it fails (and similarly if a bank in the H-group chooses the low-return project). The bailouts still have to be time-consistent, that is, total bailouts in the case the high-return and the low-return project fails are equal to $b^{FB}(\lambda^{FB})$ and $b^{FB}(1-\lambda^{FB}) = 0$, respectively. The only difference to the uniform policy is that the allocation of bailouts across failing banks depends on the (ex-ante) group assignment.

[12]The strength of the last-bank-standing effect is determined by $v'(a)$: the more negative this derivative the larger the benefit from being an acquirer when a larger amount of high-return projects fail. The strength of the first effect, by contrast, is determined by the wedge between banks' private benefit of bailouts and the social costs, given by $k + I$.

Proposition 3. *The first best can be implemented by separating banks into a high-return project group of measure λ^{FB} and a low-return project group of measure $1 - \lambda^{FB}$, and only bailing out banks that fail when the project of their group fails.*

To understand this result, recall from Section 4.1 that the source of inefficiency under uniform policies is that at the first-best allocation banks that invest in the low-return project have incentives to switch to the high-return project but solely so because this provides them with the chance to receive a bailout (see equation 12). This is no longer the case: these banks are now in the L-group and will not be bailed out when the high-return project fails. As a consequence, their benefit from switching to the high-return project is zero.[13]

4.3 Extensions

In this section, we first show that our main results continue to hold when there are more than two projects and when there is heterogeneity across banks. We then analyze how targeted policies can be implemented when banks cannot be allocated to groups ex-ante. We also examine partially targeted policies. Finally, we extend the model to consider traditional moral hazard at banks, and show that targeted policies alleviate such moral hazard.

4.3.1 Many projects

Appendix C.1 extends our baseline model by allowing for a general number of projects that differ with respect to their return upon success. It can be shown that it is optimal to invest (strictly) higher amounts in projects with higher returns. In an interior equilibrium, benefits from higher returns are exactly offset by the higher (marginal) cost of failure in the event of project failure, arising because more banks investing in the project.

The extension also shows that the first-best can still be implemented with targeted bailouts. Even though there are now multiple projects, two bailout groups are still suffi-

[13] The banks in the H-group strictly prefer to invest in the high-return project (as this provides them with bailouts).

cient. The reason is that, as show in the appendix, it is never optimal to use bailouts for two different projects, and hence there is a single distortion as in the baseline model (which can be corrected by splitting banks into two groups).

4.3.2 Project endowments vary across banks

We have assumed that all banks have identical investment opportunities, and in particular that $R_H - R_L$ is the same for all banks. We have done this purely for expositional clarity: We wanted to show that it can be optimal – solely for systemic reasons – to allocate banks to different bailout regimes. To do this, we have assumed away any other heterogeneity across banks that could "hard-wire" separating banks into groups.

The more realistic setting is for $R_H - R_L$ to vary across banks. In Appendix C.2 we consider an extension to the baseline model where the productivity of the high-project differs across banks (and possibly is also lower than the one of the low-project). We show that targeted policies can still achieve the first-best. However, there are two consequences for optimal allocations. First, project choices at the level of individual banks are no longer undetermined. In particular, for a given aggregate λ, it is optimal to allocate the banks with the highest productivity to the high-return project, and the remaining to the low-return project. Second, there is a new reason (unrelated to systemic risk) for why an interior fraction of λ is optimal, arising because increasing λ means that banks with increasingly lower productivities of the high-return project have to choose this project.

4.3.3 Voluntary group participation

The targeted policy considered in our analysis treats identical banks differently *ex-ante*, by allocating them to separate bailout groups. This may raise issues of fairness, and limit the practical implementation of a targeted policy. However, to obtain the efficient outcome it is not required that the regulator allocates banks to different groups. To see this, consider an environment in which banks themselves can select at $t = 0$ which group to join (H- or L-group). In combination with a tax on joining the H group (or, equivalently, a subsidy from joining the L-group), this can implement the efficient solution:

Corollary 1. *A tax of* $\pi \frac{b^{FB}(\lambda^{FB})}{\lambda^{FB}}(k+I)$ *for joining the* H*-group implements the first best.*

The reason is that, at the first-best allocation, a bank's expected profit in the high group is $\Delta\Pi^S(\lambda^{FB}) = \pi \frac{b^{FB}(\lambda^{FB})}{\lambda^{FB}}(k+I)$ higher than for a bank in the low group (this follows from setting $W'(\lambda^{FB}) = 0$ in (10) and inserting into (12)). The tax thus eliminates the return differential at the first-best allocation. In other words, banks have no incentives to alter their individual group choices when the H-group is of size λ^{FB} and the L-group is of size $1-\lambda^{FB}$. In practice, the tax may take the form of a cost of obtaining a specific bank license, higher regulatory burdens or differential pricing of deposit insurance. Given that banks who chose the H-group are "systemic"(in that they cause more widespread failures), the tax is also consistent with macroprudential regulation that creates more burdensome environments for such institutions (for instance, surcharges for systemic banks).

4.3.4 Partial targeting

Targeting requires discretion in the *ex-post* allocation of bailouts. This seems reasonable for *bank-specific* bailouts, such as capital injections, liquidity support and/or guarantees. However, bailouts in times of crisis can also be of blanket nature, and apply to the entire financial system, as for instance in the case of interest rate reductions by the central bank or relaxation of regulatory standards.

In the online appendix, we consider an extension in which bailouts can only be partially targeted. In particular, we consider that a fraction q ($q \in [0,1]$) of bailouts has to be uniform (as in Section 4.1), and only the remaining fraction $1-q$ can be targeted (as in Section 4.2). We demonstrate that the principal design of the optimal bailout regime is unchanged (it is still optimal to form to two groups, and to allocate all targeted bailouts to the H-group). However, this no longer removes all distortions, as some bailouts will also be disbursed regardless of the group. The first-best can hence no longer be achieved. Still, welfare is strictly higher than in the case of uniform bailouts and increases when a higher fraction of bailouts can be targeted.

This implies that having the option to undertake discretionary bailouts can be valuable. It also suggests that, as much as possible, bailouts should be carried out using instruments that are bank-specific, and not to rely on bailouts that target the financial sector in its entirety. In practical terms, this may mean a sequencing of bailouts, where first bailouts are done using bank-specific instruments, and only if this is not sufficient to safeguard financial stability, blanket bailout measures are employed.

4.3.5 Traditional moral hazard

Our analysis has shown that optimal targeted bailouts remove *systemic* moral hazard (systemic because expectations of bailouts provide banks with incentives to correlate in their project choices). An interesting question is how such bailouts would affect *traditional* moral hazard (that is, moral hazard because bailouts provide incentives for banks to increase project risk). Specifically, one may be concerned that because now all bailouts are concentrated among a set of banks (the ones from the H-group), such moral hazard increases.

To analyze this question, we introduce the possibility for banks to undertake risk-mitigating effort. We then examine whether the potential for banks to engage in moral hazard (that is, not to undertake effort) is higher under targeted or uniform bailouts. Specifically, we modify the baseline model by assuming that in order to limit the likelihood of failure to π, a bank has to engage in risk-mitigating effort at $t = 0$ (after the project is chosen). If it does not do so, the probability of failure increases to $\pi + d\pi$ ($d\pi > 0$) but the bank can also enjoy a private benefit $\beta > 0$. Note that conditional on effort chosen, this model is identical to the baseline model. That is, investment under targeted and uniform policies are λ^{FB} and λ^{S}, respectively.

Consider a bank that chooses the high-return project (low-return projects never lead to bailouts, and hence the question of how bailouts affect effort is irrelevant). When this bank exerts effort, it lowers the likelihood of failure by $d\pi$. This means that the chance to obtain a return of R_H is increased by $d\pi$, and the likelihood of having to incur the cost of failure,

$c^S(\lambda^{FB})$, is reduced by $d\pi$. Given effort cost of β, the condition for effort to be undertaken is thus

$$d\pi[R_H - c^S(\lambda^{FB})] > \beta. \tag{14}$$

Similarly, the condition for a bank under uniform policies to undertaken effort is

$$d\pi[R_H - c^S(\lambda^S)] > \beta. \tag{15}$$

Which condition is stricter depends on $c^S(\lambda^{FB})$ versus $c^S(\lambda^S)$. Given that bailouts are used in either case, we have that $c^{FB}(\lambda^S) = c^S(\lambda^S)$. Hence we have from (13) that $c^S(\lambda^S) - c^S(\lambda^{FB})$ is equal to

$$c^S(\lambda^S) - c^S(\lambda^{FB}) = (\frac{b^{FB}(\lambda^S)}{\lambda^S} - \frac{b^{FB}(\lambda^{FB})}{\lambda^{FB}})(l(a^{FB}(\lambda^{FB}) + I). \tag{16}$$

Since $\lambda^S > \lambda^{FB}$, we have that bailout expectations are stronger under the single regulator $(\frac{b^{FB}(\lambda^S)}{\lambda^S} > \frac{b^{FB}(\lambda^{FB})}{\lambda^{FB}})$, and hence $c^S(\lambda^S) > c^S(\lambda^{FB})$. From this it follows that the effort condition (15) is stricter than (14). Thus effort can be more easily sustained under targeted policies.

The intuition is simple. Under uniform policies, there is more investment in the high-return project ($\lambda^S > \lambda^{FB}$). Such policies thus result in higher bailout expectations, and hence are more susceptible to moral hazard.

5 Decentralized regulation and optimal regulatory form

Targeted bailout policies can address the herding problem arising from too-many-to-fail. However, they may not be feasible in the presence of political and institutional constraints. In this section, we show that we then can mimic their benefits by decentralizing bailout decisions. This comes at a cost though, it makes the *amount* of bailouts inefficient. There is hence a trade-off, and we characterize under which conditions decentralization is optimal.

5.1 Decentralized regulation

We consider the delegation of responsibilities to two independent regulators. Each bank in the economy is allocated to one of the regulators. A regulator can bail its own banks only and it does so with the objective of maximizing the expected payoffs for its banks. The regulators are restricted to using uniform bailout policies and their bailouts have to be time-consistent.

We focus on equilibria in which all banks under the umbrella of one regulator choose the high-return project, whereas all banks under the umbrella of the other regulator choose the low-return project.[14] Henceforth, we refer to the two regulators as the H-regulator and the L-regulator, respectively. We first analyze the the regulators' bailout policies for a given allocation of banks. We then characterize the optimal allocation of banks to regulators, and show that bank project choices are incentive compatible.

Bailout policies. When a project $i \in \{H, L\}$ fails, all banks under the umbrella of the i-regulator fail (and only those banks fail). The i-regulator's bailout policy minimizes the sum of failure costs to its banks plus bailout costs:

$$\min_{b \leq f} \quad (f - b)l(a(f, b)) + bk. \tag{17}$$

The difference to the problem of a single regulator in (2) is that the cost of bank failure is given by $l(a) = \bar{v} - v(a)$ instead of $\bar{v} - \widetilde{v}(a)$. This is because the i-regulator ignores $\widetilde{v}(a) - v(a)$ (> 0), which is the surplus earned by acquiring banks under the umbrella of the other regulator. As a result, the regulator's perceived marginal cost of bank failure is higher than the social one. This is reflected in the new first-order condition:

$$\bar{v} - v(a(b, f)) - a(b, f)v'(a(b, f)) = k, \tag{18}$$

which, compared to (3), has the additional term $-av'(a) > 0$ on the left-hand side.

[14]There is potentially also an equilibrium in which project choices do not differ among regulatory groups, but in this case, there is no benefit to decentralized regulation.

Lemma 2. *The decentralized bailout policy under the equilibrium project choices is given by*

$$b^D(f) = \begin{cases} 0 & \text{if } f \leq \frac{\bar{a}^D}{1+\bar{a}^D}, \\ -\bar{a}^D + f(1+\bar{a}^D) & \text{if } f \geq \frac{\bar{a}^D}{1+\bar{a}^D}, \end{cases} \tag{19}$$

where $\bar{a}^D$ $(< \bar{a}^{FB})$ *is defined by* $\bar{v} - v(\bar{a}^D) - \bar{a}^D v'(\bar{a}^D) = k$.

Lemma 2 shows that the decentralized regulator is more bailout-prone: we have $b^D(f) \geq b^{FB}(f)$, with strict inequality whenever $f > \frac{\bar{a}^D}{1+\bar{a}^D}$. The reason is that under equilibrium project choices, bank failures are concentrated in one regulatory umbrella. That umbrella's regulator hence fully internalizes the benefits of bailing out on the *failing* banks. However, it does not internalize the effect on *surviving* banks (of which all located outside its umbrella). The latter effect arises because when more failing banks are bailed out, surviving banks can acquire less project, lowering their surplus. As the regulator ignores this (negative) effect of bailouts, the resulting level of bailouts is excessive.

Whereas so far we have assumed equilibrium project choices by banks, next, we analyze bailout decisions when a bank unilaterally deviates from its equilibrium project.

Lemma 3. *A bank that deviates from the equilibrium project choice at* $t = 0$ *is never bailed out under decentralized regulation.*

The intuition for Lemma 3 is the exact opposite of Lemma 2. The deviating bank would fail precisely when bank failures are concentrated in the other umbrella. Its regulator then faces only one failing bank, and will hence primarily be concerned about the effect of bailouts on surviving banks. As a result, it will not bail out the bank.

Lemmas 2 and 3 imply that banks are bailed out only if they fail together with the other banks in their group. In other words, decentralization of regulation results in an allocation of bailouts that is optimally targeted (as in Section 4.2).

Investment choice. In an equilibrium, all banks under the umbrella of the H (L) regulator choose the high-return (low-return) project. Assigning a mass of λ banks to the H-regulator and the remaining mass $1-\lambda$ to the L-regulator thus implement an aggregate investment of λ in the high-return project. We proceed to characterize the optimal investment policy λ that maximizes welfare, and show that it is also incentive compatible (in other words, incentive compatibility is not binding).

Expected welfare for a given λ is

$$W^D(\lambda) = (1-\pi)(\lambda R_H + (1-\lambda)R_L) + \bar{v} - \pi C^D(\lambda) - \pi C^D(1-\lambda). \tag{20}$$

This expression only differs from (9) because the decentralized regulators follow a bailout policy of $b^D(f)$ characterized in Lemma 2, resulting in total systemic costs of $C^D(f)$ rather than $C^{FB}(f)$.

Proposition 4. *The optimal investment policy under decentralized regulation can be implemented by allocating a measure λ^D of banks to the H-regulator and the remaining measure $1-\lambda^D$ to the L-regulator, where λ^D lies in $(\lambda^{FB}, 1)$ and is defined through $W^{D'}(\lambda^D) = 0$:*

$$W^{D'}(\lambda^D) = (1-\pi)(R_H - R_L) - \pi(s(\bar{a}^D) + l(\bar{a}^D) - s(\frac{1-\lambda^D}{\lambda^D}) - l(\frac{1-\lambda^D}{\lambda^D})) = 0. \tag{21}$$

The proposition shows that we can ignore incentive compatibility for finding the optimal investment policy λ^D, as the latter is pinned down by only by the first-order condition $W^{D'}(\lambda^D) = 0$. This is because decentralized regulation results in an effectively targeted bailout policy. This discourages banks from deviating from their group's project and, as a result, banks under the umbrella of the i-regulator, $i \in \{H, L\}$, find it optimal to choose the i-project.

The proposition also shows that investment in the high-return project should exceed the first-best level ($\lambda^D > \lambda^{FB}$). The reason is that a higher λ helps here to mitigate inefficiencies in the *amount* of bailouts disbursed. As we have shown in Lemma 2, the H-regulator bails out more banks than in the first-best, essentially because it does not internalize that bailouts reduce the surplus for the banks of the L-regulator. Choosing a higher λ lowers the size of the externality on the L-regulator, simply because there are then fewer banks under its umbrella. The H-regulator will thus internalize a larger share of the social value of bailouts, resulting in more efficient bailout decisions. Compared to the first-best analysis, there is hence an additional benefit to increasing λ, making it desirable to have $\lambda^D > \lambda^{FB}$.

5.2 Optimal regulatory form

We know that under uniform policies, neither a single regulator nor decentralized regulation can achieve the first-best (Section 4.1 has shown this for a single regulator, and the preceding section for decentralized regulation). In this section, we compare welfare under both regulatory regimes, and analyze when which regime is optimal. We also discuss implications for actual regulatory regimes.

We already know that each regulatory form causes an inefficiency. A single regulator causes excessive investment in the high-return project due to herding (Proposition 2) and decentralized regulation results in excessive bailouts (Lemma 2).[15] The optimal regulatory form thus trades off both inefficiencies. The following proposition shows that either mode of regulation can be optimal.

Proposition 5. *There exist thresholds* $\underline{k} > 0$ *and* $\overline{\Delta}_R > 0$*, such that decentralized regulation strictly maximizes welfare for all* $k < \underline{k}$ *and for all* $R_H - R_L > \overline{\Delta}_R$*. There also exist thresholds* $\overline{k} > \underline{k}$ *and* $\underline{\Delta}_R \in (0, \overline{\Delta}_R)$*, such that a single regulator strictly maximizes welfare for all* $k > \overline{k}$ *and* $R_H - R_L < \underline{\Delta}_R$*.*

This proposition shows that decentralized regulation is optimal when the bailout cost (k) is small and/or when the return advantage of the high-return project ($\Delta_R \equiv R_H - R_L$) is large. While Proposition 5 only proves this result for extreme values of the parameters, numerical analysis (see, for example, Figure 2) suggests that the result holds also for the intermediate values of the parameters.

There are several reasons why for low bailout costs decentralized regulation is optimal.

[15] Proposition 4 shows that investment in the high-return asset exceeds the first-best level also in the case of decentralized regulation. However, in this case, investment is optimally chosen (and hence not "excessive" in terms of welfare) and chosen to exceed the first-best in order to mitigate distortions in bailout decisions.

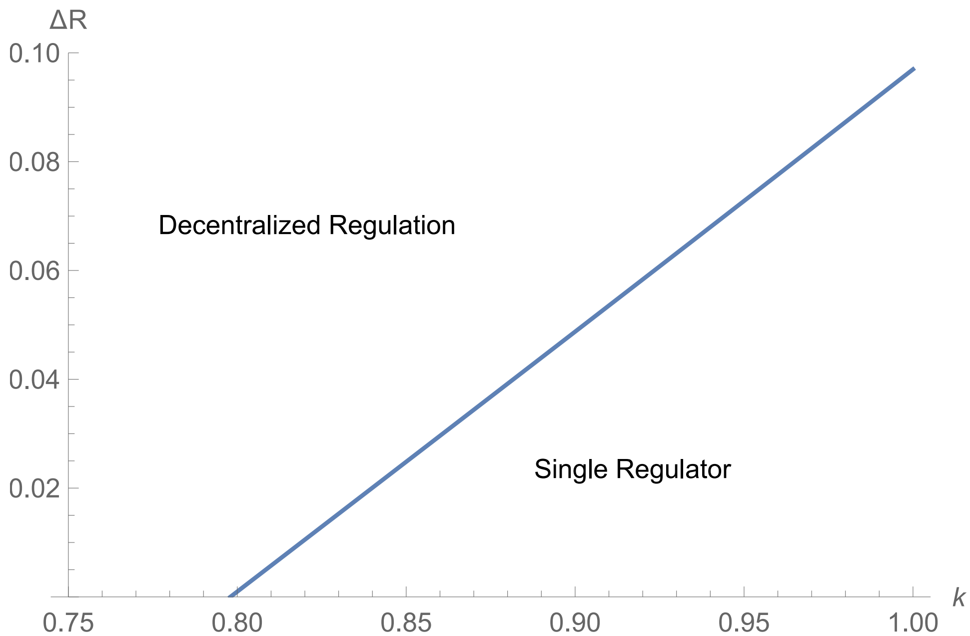

Figure 2: Parameter space in (k, Δ_R) for which centralized and decentralized regulation is optimal. The functional form of $v(a)$ is assumed to be $v(a) = \bar{v} - a$, and the numerical values are: $\bar{v} = 1$, $\pi = 0.2$, $R_L = 1$, and $I = 0.05$.

When bailout costs are low, the propensity for a regulator to bail out a failing bank is high. Under a single regulator with uniform policies, this results in high incentives for banks to choose the high-return project, over and above the social benefits of doing so. The inefficiency under a single regulator is, therefore, high. At the same time, the inefficiencies under decentralized regulation are low. This is because, first, while decentralized regulation results in excessive bailouts, the welfare costs associated with that are low (because the deadweight loss k is small). Second, low bailout costs make it optimal to have a high investment in the high-return project; this implies that the H-regulator has command over a large fraction of the banking system. The regulator hence internalizes a larger fraction of the impact of its actions, lowering the extent to which bailouts are excessive under decentralized regulation (see the last paragraph of Section 5.1).

The effects associated with the bailout cost k are also illustrated in the top panel of Figure 3. As k increases, the investment inefficiency under a single regulator reduces (that is λ^S converges to λ^{FB}, except for when we reach a corner solution for λ), while the bailout inefficiency under decentralized regulation increases (b^D diverges from b^{FB}). As a result, welfare is higher under decentralized regulation for sufficiently low k, but higher for a single regulator for sufficiently high k.

The reason why a single regulator is preferred when the high-return project has a small return advantage is the following. In such a situation, a lower aggregate investment in this project is optimal, moving λ closer to $\frac{1}{2}$. The propensity to bail out when this project fails is then low, and the too-many-to-fail problem is limited. Banks' incentives to overinvest in the high-return project are small as a result, and hence single regulation only induces small welfare losses. At the same time, under decentralization regulation, the L-regulator is responsible for a large fraction of the overall banking system when optimal λ is close to $\frac{1}{2}$. This means that there are large externalities from bailouts undertaken by the H-regulator, resulting in a high bailout inefficiency. This is illustrated in the bottom panel of Figure 3: As Δ_R increases, investment inefficiency under a single regulator increases, while the bailout inefficiency under decentralized regulation reduces. Overall, welfare is higher under a single regulator for a sufficiently small return differential Δ_R but higher for decentralized regulation for a sufficiently high return differential Δ_R.

Supervision in the U.S. and in Europe Our analysis is broadly consistent with the observed financial architectures in the United States and Europe. The regulation of banks in the United States can be interpreted as a model of *decentralized regulation.* The regulation of U.S. banks is broadly divided between three agencies: the Office of the Comptroller of the Currency (OCC) for nationally chartered banks, the Federal Reserve System (FRS) for state chartered member banks, and the Federal Deposit Insurance Corporations (FDIC) for state charted nonmember banks. This is consistent with the costs of bailouts likely to be relatively low in the U.S., evidenced by the rapid implementation of the Troubled Asset Relief Program (TARP) and other bailouts during the Global Financial Crisis. Bank regulation in Europe, with the establishment of the Single Supervisory Mechanism (SSM)

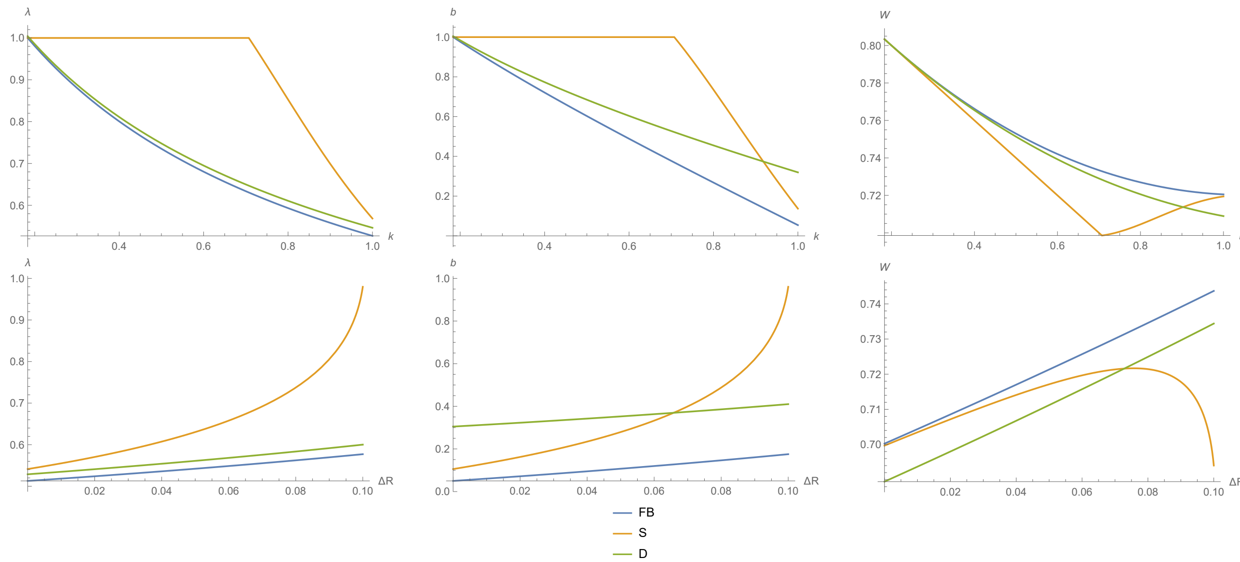

Figure 3: Each column from left to right plots investment (λ), bailouts when the high-return project fails (b), and welfare (W) under first-best allocation (blue line), a single regulator (orange line), and decentralized regulation (green line). The functional form of $v(a)$ is assumed to be $v(a) = \bar{v} - a$, and the numerical values are: $\bar{v} = 1$, $\pi = 0.2$, $R_L = 1$, and $I = 0.05$. In addition, the top panel assumes $R_H = 1.05$, and the bottom panel assumes $k = 0.95$.

and subsequently the Single Resolution Mechanism (SRM), has moved in the direction of a *single regulator*, in which the European Central Bank (ECB) and the national supervisory authorities of the participating countries cooperate via the Joint Supervisory Teams to ensure the implementation of a uniform standard. This is consistent with bailout costs being high in Europe, especially during crises, due to national authorities' inability to provide monetary stimulation and due to the presence of a bank-sovereign doom loop (Acharya, Drechsler, and Schnabl, 2014; Fahri and Tirole, 2018). At the same time, the dispersion in investment opportunities across Europe is likely to have fallen as European economies become more and more financially and economically integrated, also making more centralized supervision optimal.

The Banking Union and systemic risk Our analysis can also be used to generate a prediction how a switch in the regulatory regime affects systemic risk. We can derive the following corollary from Proposition 5:

Corollary 2. *In economies in which both regulatory forms obtain identical welfare, investment in the high-return project is higher under a single regulator than under decentralized regulation ($\lambda^C > \lambda^D$ and $C^{FB}(\lambda^C) > C^D(\lambda^D)$).*

The reason for this result is simple. The two regulatory forms principally trade-off two inefficiencies: there is a tendency for herding (excessive investment in the high-return project) under a single regulator, whereas under decentralization bailouts tend to be inefficient. When both forms provide the same welfare, investment in the high-return project hence has to be strictly more excessive under a single regulator, in order to offset the bailout-inefficiency.

Assuming that in practice, underlying parameters in a given economy change over time in a relatively continuous manner, and that the prevailing regulatory form is optimal given the underlying parameters, one should observe changes in regulatory form precisely when the underlying parameters are such that both regulatory forms achieve (nearly) identical welfare. The corollary hence suggests that an (endogenous) switch to a single regulator leads to higher investments in the high-project, resulting in failures becoming concentrated among a larger set of banks.

An implication of this is that the introduction of the Banking Union may lead to more herding and more correlated banking failures. However, this does not imply lower welfare as at the same time bailouts become more efficient.

6 New material

7 Conclusions

This paper analyzes optimal investment and the design of bailout regimes in the presence of the *too-many-to-fail* problem. In the model under consideration, bank project choices are unobservable and bailouts have to be time-consistent. We show that the resulting first-best allocation equalizes the benefits from investing in high-return projects with higher systemic risk, due to more banks investing in such projects, and entails bailouts whenever bank failures exceed a threshold. Implementing the first-best requires limiting bank herding on the high-return project, which can be achieved by assigning banks to separate bailout regimes. Alternatively, herding can be avoided by decentralizing bailout decisions, as individual regulators perceive lower benefits from bailing out deviating banks. Such decentralization leads to distorted bailouts though, but can still be optimal when the cost of bailouts is small. Our results have important implications for the optimal allocation of regulatory powers, both within countries and internationally.

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Appendices

A Microfoundation of banks' project sales and bailouts

Our baseline model abstracts away from financing issues at banks and assumes that *i)* a bank must sell its project if its project fails at $t = 1$, and *ii)* a bailout allows the bank to continue operating the project. In this section, we provide a microfoundation. We consider banks that are deposit financed and face a moral hazard problem in the continuation of their projects at $t = 1$. This microfoundation results in banks' investment decisions at $t = 0$ and regulators' bailout decisions at $t = 1$ that are identical to those presented in the main model.

A.1 Baseline microfoundation

In this section, we endogenize *i)* the bank's decision to continue or sell its project depending on the success or failure of its project at $t = 1$, and *ii)* the equity injection required to bail out a bank and ensure its continuation. We maintain the assumption that a bank whose project fails at $t = 1$ cannot acquire other failing banks' projects and discuss the implications of relaxing this assumption in Section A.2.

We modify the baseline model in two aspects. First, we assume that each bank is financed at $t = 0$ by 1 unit of deposits that mature at $t = 1$. In addition, we assume that there are deep-pocketed competitive investors who can supply funds to the banks at $t = 1$. The bank enjoys limited liability.

At $t = 1$, the bank can continue operating only if it repays the maturing deposits. Otherwise, the bank defaults and must sell its project to repay the depositors. The bank receives the residual payoff, if any. We supplement Assumption 1 by requiring astronger condition on *v(1)*:

Assumption 1'. $v(1) \geq 1$.

This assumption ensures that, in equilibrium, the bank does not default on its deposits if it sells its project (as in the main model).

As a second modification, we assume that there is a moral hazard problem in the continuation of the bank's projects: The bank must exert unobservable (costless) effort in order to generate the continuation payoff described in the baseline model; otherwise, the projects generate 0 and the bank enjoys a non-pecuniary private benefit B. We make the following assumption regarding the bank's private benefit:

Assumption 4. *$\bar{v} - 1 < B < \bar{v}$.*

A.1.1 Banks' continuation decision

We now analyze the bank's continuation decision at $t = 1$ in the absence of bailouts. We will show that the bank sells its project at $t = 1$ if it fails, and continues operating its project (with effort) if it succeeds.

First, consider the case in which the bank's project fails at $t = 1$. We will show that the bank is unable to continue, and must sell its project at $t = 1$. Suppose by contradiction that the bank continues by raising 1 from competitive investors to repay the maturing deposits. Since continuation without effort generates 0 at $t = 2$, the bank can only raise funds if it exerts continuation effort. As effort results in a certain payoff of $\bar{v}$ at $t = 2$, competitive investors require a repayment equal to 1. Given the bank's continuation, it is incentive compatible for the bank to exert effort if and only if its payoff with effort, less the repayment to the competitive investors, is greater than its private benefit from shirking:

$$\bar{v} - 1 \geq B. \tag{22}$$

This inequality violates Assumption 4. Therefore, we can conclude that the bank is unable to continue its project if its project fails at $t = 1$.

It then follows that the bank defaults and must sell its project to repay the maturity deposits. This results in a payoff of $v(a^e) - 1 > 0$, where a^e denotes the equilibrium fire-sale pressure. Notice that this payoff is strictly positive. This is because, as Lemmas 1 and 2 show, $a^e < 1$ in any equilibrium. Assumption 1' then ensures that the bank's payoff from project sales is strictly positive.

Next, consider the case in which the bank's project succeeds at $t = 1$. We will show that the bank is able to and prefers to continue (with effort), instead of selling its project at $t = 1$, by comparing the bank's expected payoff in these two cases. Suppose first that the bank sells its project. This results in a payoff of $R_i + v(a^e) - 1 > 0$.

Suppose instead that the bank continues by repaying its maturing deposits. In addition, the successful bank may acquire a unit of the failing banks' projects at the competitive market price $v(a^e)$. If $1 + av(a^e) - R_i > 0$, then the bank must raise this amount from competitive investors at $t = 1$, who require the same amount of repayment at $t = 2$. Following backward induction, we first analyze the bank's effort decision upon continuation, then consider the bank's optimal choice of project acquisition. Given the bank's continuation, the bank's payoff with and without effort are given by, respectively,

$$\max\{0, R_i + \bar{v} + \int_0^a v(x)dx - av(a^e) - 1\}, \tag{23}$$

$$\max\{0, R_i + B - av(a^e) - 1\}, \tag{24}$$

where the max operator captures the bank's limited liability. It then follows that the bank always prefers to exert effort upon continuation, as (23) is greater than (24). Next, we consider the bank's optimal choice of project acquisition a that maximizes (23). Due to the optimality of the bank's project acquisition decision, the bank's expected payoff from continuation is greater than $R_i + \bar{v} - 1 > 0$. This also implies that the bank is able to raise $1 + av(a^e) - R_i$ (whenever this is positive) from competitive investors at $t = 1$. Therefore the bank is able to continue with effort, and realizes a payoff that is greater than $R_i + \bar{v} - 1$.

Finally, this continuation payoff is greater than the bank's payoff from project sale, $R_i + v(a^e) - 1$, analyzed above, by the second inequality in Assumption 4. That is, if the bank's project succeeds at $t = 1$, it is able to and prefers to continue (with effort).

A.1.2 Equity injection during bailouts

The previous section has shown that a bank whose project fails at $t = 1$ must sell its project to repay the deposits in the absence of bailouts. We now characterize the equity injection I required to enable a failing bank's continuation, i.e., a bailout.

If a failing bank receives an equity injection I and continues, it must raise $1 - I$ from competitive investors to repay the deposits.[16] Since continuation without effort generates 0 at $t = 2$, the bank can only raise funds if it exerts continuation effort. The incentive compatibility constraint is given by

$$\bar{v} - 1 + I \geq B. \tag{25}$$

Notice that Assumption 4 implies that (25) is not satisfied for $I = 0$ and is indeed satisfied for $I = 1$. Therefore a minimum equity injection $I = B + 1 - \bar{v} \in (0, 1)$ is required to enable a failing bank's continuation.

A.2 Project acquisition by failing banks

In Section A.1, we have maintained the assumption that a failing bank cannot acquire other failing banks' projects even if it were to continue.

If a failing bank would be allowed to do so, the only difference is that the incentive compatibility constraint for a failing bank to exert effort upon continuation, previously given in (22), becomes

$$\bar{v} - 1 + \int_0^a v(x)dx - av(a^e) \geq B. \tag{26}$$

Compared to (22), the two extra terms on the left-hand side of (26) reflect the (potential) profit for the bank from acquiring other failing banks' projects. As a result, in order to ensure that a failing bank is unable to continue, i.e., (26) does not hold for all a and for all $a^e \in [0, 1)$, we supplement Assumption 4 with the following stronger condition:

[16]Recall that we have assumed for simplicity that a bailed-out bank does not acquire other failing banks' projects.

Assumption 4'. $\bar{v} - 1 + \int_0^1 v(a) - v(1)da < B$.

B Proofs

B.1 Proof of Lemma 1

The first-best bailout policy is defined by the minimization problem in (2). The first-order condition of this problem is given in (3), with the second order condition:

$$v'(\frac{f-b}{1-f})\frac{1}{1-f} < 0. \tag{27}$$

This lemma then follows. First, for all $f \leq \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$, we have $a(b,f) \leq a(0,f) \leq \bar{a}^{FB}$. This implies that the left-hand side of the first order condition in (3) is less than the right-hand side for all $b \geq 0$, and therefore the optimal bailout policy is $b^{FB}(f) = 0$. Second, for all $f > \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$, we have $a(0,f) \geq \bar{a}^{FB} > a(f,f) = 0$. This implies that the optimal bailout policy binds the first-order condition in (3) and satisfies $a(b^{FB}(f), f) = \bar{a}^{FB}$. Therefore the optimal bailout policy is $b^{FB}(f) = -\bar{a}^{FB} + f(1+\bar{a}^{FB})$.

B.2 Proof of Proposition 1

Recall that Lemma 1 implies that the optimal bailout policy results in an equilibrium fire-sale pressure $a^{FB}(f)$ given by (5). Notice that $a^{FB}(f)$ is strictly increasing in f for all $f \leq \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$ and constant in f otherwise. Similarly, Lemma 1 implies the same property for the marginal systemic costs of an additional bank failure $c^{FB}(f)$ given in (6): it is strictly increasing in f for all $f \leq \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$ and constant in f otherwise. This follows from the properties of $a^{FB}(f)$ and the fact that both $s(a)$ and $l(a)$ are strictly increasing in a.

We are now equipped to solve for the optimal investment λ^{FB}. We first characterize piecewise the properties of the welfare function $W(\lambda)$ given by (9). There are three cases:

1. $\lambda \leq \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$. In this case, $W'(\lambda)$ given in (10) is strictly positive. This follows because $c^{FB}(\lambda) \leq c^{FB}(\frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}) = c^{FB}(1-\lambda)$ due to the properties of $c^{FB}(f)$ described above.

2. $\lambda \in [\frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}, 1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}]$. In this case, $W'(\lambda)$ given in (10) is strictly positive. This follows because $c^{FB}(\lambda) = c^{FB}(1-\lambda) = c^{FB}(\frac{\bar{a}^{FB}}{1+\bar{a}^{FB}})$ due to the properties of $c^{FB}(f)$ described above.

3. $\lambda \geq 1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$. In this case, we have $a^{FB}(\lambda) = \bar{a}^{FB}$ and $a^{FB}(1-\lambda) = \frac{1-\lambda}{\lambda}$. This implies that $W'(\lambda)$ is given by (11). Since both $s(a)$ and $l(a)$ are increasing in a, we have that $W'(\lambda)$ is strictly decreasing in λ.

These properties of $W(\lambda)$ imply that $W(\lambda)$ is strictly increasing for all $\lambda \leq 1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$ and strictly concave for all $\lambda > 1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$.

Next, we show that the optimal investment λ^{FB} that maximizes $W(\lambda)$ is defined through the first order condition $W'(\lambda) = 0$ and lies in $(1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}, 1)$. First, we have

$$W'(1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}) = (1-\pi)(R_H - R_L) > 0.$$

Second, we have

$$W'(1) = (1-\pi)(R_H - R_L) - \pi(c^{FB}(1) - c^{FB}(0)).$$

Since $c^{FB}(0) = 0$, and $c^{FB}(1) = s(\bar{a}^{FB}) + l(\bar{a}^{FB}) = s(\bar{a}^{FB}) + k$ which is implied by the definition of $\bar{a}^{FB}$ in Lemma 1, we have

$$W'(1) < (1-\pi)(R_H - R_L) - \pi k < 0,$$

where the second inequality follows from Part (ii) of Assumption 2. Therefore we have $W'(1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}) > 0 > W'(1)$, implying that a unique solution to $W'(\lambda) = 0$ exists in $(1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}, 1)$ and maximizes $W(\lambda)$.

B.3 Proof of Proposition 2

We first derive the expression $\Delta\Pi^S(\lambda)$ given in (12). A bank's profit from investing in the high-return project, when the total mass of banks choosing the high-return project is λ and the bailout policy is $b^{FB}(\cdot)$, is given by

$$\Pi_H(\lambda; b^{FB}(\cdot)) = (1-\pi)R_H + \bar{v} + \pi\left[\frac{b^{FB}(\lambda)}{\lambda}I - \frac{\lambda - b^{FB}(\lambda)}{\lambda}l(a^{FB}(\lambda))\right] + \pi s(a^{FB}(1-\lambda)). \tag{28}$$

The first two terms reflect the expected payoff of the high-return project, assuming that the bank is able to continue operating. The second term reflects the incremental payoffs from failing when the high-return project fails (with probability π). With probability $\frac{b^{FB}(\lambda)}{\lambda}$, the bank is bailed out, and the bank enjoys an additional bailout benefit I; with complementary probability, the bank is not bailed out and must sell its project, resulting in a loss $l(\cdot)$, which is given by (8). The last term reflects the incremental payoffs from succeeding when the low-return project fails (with probability π). In this case, the bank purchases the projects of the failing banks and enjoys a surplus of $s(\cdot)$, which is given by (7). Analogously, the bank's project from investing in the low-return project is

$$\Pi_L(\lambda; b^{FB}(\cdot)) = (1-\pi)R_L + \bar{v} + \pi s(a^{FB}(\lambda)) + \pi\left[\frac{b^{FB}(1-\lambda)}{1-\lambda}I - \frac{1-\lambda - b^{FB}(1-\lambda)}{1-\lambda}l(a^{FB}(1-\lambda))\right]. \tag{29}$$

After collecting terms, we have that $\Delta\Pi^S(\lambda) \equiv \Pi_H(\lambda; b^{FB}(\cdot)) - \Pi_L(\lambda; b^{FB}(\cdot))$ is given by (12).

We first show the existence and uniqueness of the equilibrium. We begin by characterizing the piecewise properties of the banks' net incentive to invest in the high-return project, $\Delta\Pi^S(\lambda)$ given in (12). Using (13), we can write it as

$$\Delta\Pi^S(\lambda) = W'(\lambda) + \pi(\frac{b^{FB}(\lambda)}{\lambda}(l(a^{FB}(\lambda)) + I) - \frac{b^{FB}(1-\lambda)}{1-\lambda}(l(a^{FB}(1-\lambda)) + I)). \tag{30}$$

There are three cases:

1. $\lambda \leq \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$. In this case, we have $b^{FB}(\lambda) = 0 < b^{FB}(1-\lambda) = -\bar{a}^{FB} + (1-\lambda)(1+\bar{a}^{FB})$, and $a^{FB}(\lambda) = \frac{\lambda}{1-\lambda} < a^{FB}(1-\lambda) = \bar{a}^{FB}$. After some algebraic manipulation, we have

$$\frac{\partial\Delta\Pi^S(\lambda)}{\partial\lambda} = \frac{\pi}{(1-\lambda)^3}(\bar{a}^{FB}(k+I)(1-\lambda) + v'(\frac{\lambda}{1-\lambda})).$$

Using the fact that $\bar{a}^{FB} < 1$ by Lemma 1, we have

$$\frac{\partial \Delta\Pi^S(\lambda)}{\partial \lambda} < \frac{\pi}{(1-\lambda)^3}((k+I) + v'(\frac{\lambda}{1-\lambda})).$$

Part (ii) of Assumption 1 then implies that the above expression is strictly negative. That is, $\Delta\Pi^S(\lambda)$ is strictly decreasing for all $\lambda \leq \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$.

Moreover, this implies that, for all $\lambda \leq \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$, we have

$$\begin{aligned}\Delta\Pi^S(\lambda) \geq \Delta\Pi^S(\frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}) &= (1-\pi)(R_H - R_L) - \pi \frac{b^{FB}(\frac{1}{1+\bar{a}^{FB}})}{\frac{1}{1+\bar{a}^{FB}}}(k+I) \\ &= (1-\pi)(R_H - R_L) - \pi(1-(\bar{a}^{FB})^2)(k+I) > 0, \quad (31)\end{aligned}$$

where the last inequality follows from Assumption 3. That is, $\Delta\Pi^S(\lambda) > 0$ for all $\lambda \leq \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$.

2. $\lambda \in [\frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}, 1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}]$. In this case, we have $b^{FB}(\lambda) = -\bar{a}^{FB} + \lambda(1+\bar{a}^{FB})$ and $b^{FB}(1-\lambda) = -\bar{a}^{FB} + (1-\lambda)(1+\bar{a}^{FB})$, and $a^{FB}(\lambda) = a^{FB}(1-\lambda) = \bar{a}^{FB}$. After some algebraic manipulation, we have

$$\frac{\partial \Delta\Pi^S(\lambda)}{\partial \lambda} = \pi\bar{a}^{FB}(\frac{1}{(1-\lambda)^2} + \frac{1}{\lambda^2})(k+I) > 0. \quad (32)$$

Therefore $\Delta\Pi^S(\lambda)$ is strictly increasing for all $\lambda \in [\frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}, 1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}]$.

3. $\lambda \geq 1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$. In this case, we have $b^{FB}(\lambda) = -\bar{a}^{FB} + \lambda(1+\bar{a}^{FB}) > b^{FB}(1-\lambda) = 0$, and $a^{FB}(\lambda) = \bar{a}^{FB} > a^{FB}(1-\lambda) = \frac{1-\lambda}{\lambda}$. After some algebraic manipulation, we have

$$\frac{\partial \Delta\Pi^S(\lambda)}{\partial \lambda} = \frac{\pi}{\lambda^3}(\bar{a}^{FB}(k+I)\lambda + v'(\frac{1-\lambda}{\lambda})). \quad (33)$$

Following similar arguments are for Case (i), we have that $\Delta\Pi^S(\lambda)$ is strictly decreasing for all $\lambda \geq 1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$.

The properties of $\Delta\Pi^S(\lambda)$ characterized above then imply that $\Delta\Pi^S(\lambda) > 0$ for all $\lambda \leq 1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$. Therefore, since $\Delta\pi^S(\lambda)$ is strictly decreasing for all $\lambda \geq 1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$, an equilibrium exists and is unique: If $\Delta\Pi^S(1) \geq 0$, then $\lambda^S = 1$; if $\Delta\Pi^S(1) < 0$, then $\lambda^S \in (1 - \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}, 1)$ and is defined by $\Delta\Pi^S(\lambda^S) = 0$. The resulting welfare is given by (11).

Finally, the fact that $\lambda^S > \lambda^{FB}$ follows from the fact that $\Delta\Pi^S(\lambda^{FB}) > 0$ as established by (12).

B.4 Proof of Proposition 3

To prove this proposition, we need to show that, given the optimal investment λ^{FB} and a bailout policy of only bailing out banks that fail when the project of their group fails, each bank indeed finds it optimal to choose its equilibrium project.

Consider first a bank in the L-group. If the bank deviates and invests in the high-return project, it is not bailed out; whereas if it invests in the low-return project, it is also not bailed out, given the equilibrium bailout policy $b^{FB}(1 - \lambda^{FB}) = 0$. In the absence of bailouts, the net incentive for this bank to invest in the project-return project coincides with the social value of a marginal increase in the investment in the high-return project W'^{FB}, which is zero due to the optimality of the first-best investment. A bank in the L-group thus does not benefit from deviating to the high-return project.

Consider next a bank in the H-group. If the bank invests in the high-return project, it is bailed out with probability $\frac{b^{FB}(\lambda^{FB})}{\lambda^{FB}}$, given the equilibrium bailout policy; whereas if it deviates and invests in the low-return project, it is not bailed out. The net incentive for this bank to invest in the high-return project thus coincides with that under a uniform policy and is equal to $\Delta\Pi^S(\lambda^{FB}) > 0$, which is give in (12). A bank in the H-group thus finds it optimal to invest in the high-return project.

B.5 Proof of Lemma 2

The decentralized regulator's bailout policy is defined by the minimization problem in (17). The first-order condition of this problem is given in (18), with the second order condition:

$$[2v'(a(b,f)) + a(b,f)v''(a(b,f))]\,\frac{1}{1-f} < 0. \tag{34}$$

This lemma then follows from analogous arguments as those in the proof of Lemma 1.

B.6 Proof of Lemma 3

In order to formalize the regulator's optimization problem when a single bank under its umbrella deviates and chooses another project than its equilibrium one, we characterize the regulator's problem when a positive mass of banks do so, and then consider the limit as this mass approach 0. In this case, when the equilibrium project of the other regulator fails, both regulators face failing banks under their respective umbrella and choose their bailout policies taking that of the other regulator as given.

Let f_i and f_{-i} denote the mass of banks under the umbrella of regulator i and $-i$ that fail, respectively, with $f = f_i + f_{-i}$, and let b_i and b_{-i} denote the mass of failing banks bailed out by the two regulators, respectively, with $b = b_i + b_{-i}$. In the state in which the $-i$ project fails, we have $f_i \to 0$, since there is only one bank under the umbrella of the i-regulator that deviates and invests in the $-i$ project. We now consider the optimization problem of each regulator separately.

First, the i-regulator's bailout policy is given by

$$\min_{b_i \leq f_i} \quad (f - b)(\bar{v} - \tilde{v}(a(b, f))) - (f_{-i} - b_{-i})l(a(b, f)) + b_i k, \tag{35}$$

where $f_i \to 0$. The difference from the problem of a single regulator in (2) is that a decentralized regulator ignores the value loss $l(a)$ in the projects of those failing banks under the umbrella of the other regulator (that are not bailed out). As a result, the former regulator perceives a lower marginal benefit of bailout than the single regulator, whose incentives coincide with the social trade-off. This is reflected in the additional term, $a(b, f)v'(a) < 0$, on the left-hand side of the first-order condition below, as $f_i, b_i \to 0$:

$$\bar{v} - v(a(b, f)) + a(b, f)v'(a(b, f)) = k. \tag{36}$$

Importantly, this result suggests that the decentralized regulator is less bailout-prone in the state in which the high-return project fails, in stark contrast to the result from Lemma 2.

This is because, in this case, bank failures are concentrated within the other regulator's jurisdiction; the i-regulator, thus, fails to internalize the fact that bailouts help to alleviate fire-sale pressure and raise the competitive equilibrium price $v(a)$, lowering the losses from project transfers borne by the mass $(f-b)$ of failing banks under the umbrella of the other regulator.

Second, as $f_i, b_i \to 0$, the $-i$ regulator's objective function is given by (17), with its first order condition given by (18), since (almost) all failing banks are under its umbrella.

In equilibrium, this implies that the i-regulator strictly prefers not to bail out its single failing bank, as (18) implies that the left-hand side of (36) is strictly less than the right-hand side; that is, the marginal benefit of bailout is strictly lower for the i-regulator than for the $-i$ regulator. Therefore, in equilibrium, if one bank under the umbrella of the i-regulator deviates and chooses another project than its equilibrium one, it is not bailed out. That is, as $f_i \to 0$, the optimal bailout policy satisfies $\frac{b_i}{f_i} = 0$.

B.7 Proof of Proposition 4

We first note that welfare has a similar structure as in the first-best (equation (9)), with the only difference being the total systemic cost in equilibrium: Since the bailouts are carried out by the decentralized regulators, this results in a total systemic cost $C^D(f)$ defined as the objective function in (2) when evaluated at $b = b^D(f)$, compared to $C^{FB}(f)$ in the first best. Analogous to the marginal systemic costs of an additional bank failure under the first-best bailout policy given in (6), the marginal systemic cost under a decentralized regulator's optimal bailout policy is:

$$c^D(f) \equiv C^{D'}(f) = s(a^D(f)) + l(a^D(f)),$$

where $s(a)$ and $l(a)$ are defined in (7) and (8), respectively, and $a^D(f) = \min\{\frac{f}{1+f}, \bar{a}^D\}$ is the equilibrium fire-sale pressure given the decentralized regulator's bailout policy.

The remainder of the proof of this proposition follows three steps. We first show that the investment choice that maximizes welfare given the decentralized regulators' bailout policies, $W^D(\lambda)$, is defined through $W^{D'}(\lambda^D) = 0$. We then show that this investment choice is incentive compatible. We finally show that $\lambda^D > \lambda^{FB}$.

The first step is analogous to the proof of Proposition 1. Following similar arguments, we can show that $W^D(\lambda)$ is strictly increasing for all $\lambda \leq 1 - \frac{\bar{a}^D}{1+\bar{a}^D}$, and strictly concave for all $\lambda > 1 - \frac{\bar{a}^D}{1+\bar{a}^D}$. We can then show that $W^D(1 - \frac{\bar{a}^D}{1+\bar{a}^D}) > 0 > W^D(1)$. Therefore a unique solution to $W^{D'}(\lambda) = 0$ exists in $(1 - \frac{\bar{a}^D}{1+\bar{a}^D}, 1)$ and maximizes $W^D(\lambda)$.

The second step is analogous to the proof of Proposition 3. Following similar arguments, we can show that the net incentive for a bank in the L-group to invest in the high-return project is equal to $W^{D'}(\lambda^D) = 0$, whereas that for a bank in the H-group is equal to $W^{D'}(\lambda^D) + \frac{b^D(\lambda^D)}{\lambda^D}(k + I) > 0$. Therefore banks in each group find it optimal to choose their equilibrium project.

Finally, we show that $\lambda^D > \lambda^{FB}$. Recall that λ^{FB} is defined by (12), while λ^D is defined by (21). Notice that these two expressions differ only in that the former has $\bar{a}^{FB}$ while the latter has $\bar{a}^D$. Therefore, for a given λ, the left-hand side of (12) is smaller than that of (21), because i) $\bar{a}^D$, defined in Lemma 2 is strictly smaller than $\bar{a}^{FB}$, defined in Lemma 1, and ii) $s(a)$ and $l(a)$, defined in (7) and (8), are both increasing in a. Lastly, since the left-hand sides of both (12) and (21) are strictly decreasing in λ, we have $\lambda^D > \lambda^{FB}$.

B.8 Proof of Proposition 5

First, we prove the existence of a threshold $\underline{k} > 0$ such that decentralized regulation strictly maximizes welfare for all $k < \underline{k}$. Recall that, by the proof of Proposition 2, $\lambda^S = 1$ if and only if $\Delta\Pi^S(1) \geq 0$. Using (12) and after some algebraic manipulation, we have

$$\Delta\Pi^S(1) = (1 - \pi)(R_H - R_L) - \pi s(\bar{a}^{FB}) + \pi I, \tag{37}$$

where $s(a)$ is defined in (7) and is increasing in a. It then follows that $\Delta\Pi^S(1)$ is decreasing in a^{FB}, which is defined in Lemma 1 and is increasing in k. Therefore $\Delta\Pi^S(1)$ is decreasing in k. Moreover, as $k \to 0$, we have that $\bar{a}^{FB} \to 0$ and $\Delta\Pi^S(1) \to (1-\pi)(R_H - R_L) + \pi I > 0$. That is, $\lambda^S \to 1$ as $k \to 0$. In this limit, decentralized supervision strictly maximizes welfare, as

$$W(\lambda^S) = W(1) = W^D(1) < \max_\lambda W^D(\lambda) = W^D(\lambda^D).$$

By continuity, there exists $\underline{k} > 0$, such that decentralized supervision strictly maximizes welfare for all $k < \underline{k}$.

Second, we prove the existence of a threshold $\overline{\Delta}_R > 0$, such that decentralized regulation strictly maximizes welfare for all $\Delta_R \equiv R_H - R_L > \overline{\Delta}_R$. $\Delta\Pi^S(1)$ given in (37) is increasing in $(R_H - R_L)$. Therefore as $\Delta_R \to \infty$, $\Delta\Pi^S(1) > 1$ and $\lambda^S \to 1$. It then follows from similar arguments as above that, in this limit, decentralized supervision maximizes welfare. By continuity, there exists $\overline{\Delta}_R > 0$, such that decentralized regulation strictly maximizes welfare for all $\Delta_R \equiv R_H - R_L > \overline{\Delta}_R$.

Finally, we show that there exist thresholds $\overline{k} > \underline{k}$ and $\underline{\Delta}_R \in (0, \overline{\Delta}_R)$, such that a single supervisor strictly maximizes welfare for all $k > \overline{k}$ and $R_H - R_L < \underline{\Delta}_R$. As $k \to \bar{v} - v(1)$ and $\Delta_R \to 0$, we have $\bar{a}^{FB} \to 1$, $\lambda^{FB} \to \frac{1}{2}$, and $b^{FB}(\lambda^{FB}) \to 0$. This implies that $\Delta\Pi^S(\lambda^{FB}) \to 0$, and $\lambda^S \to \lambda^{FB}$. In this limit, a single supervisor strictly maximizes welfare, as $W(\lambda^S) = W(\lambda^{FB}) > W^D(\lambda^D)$. By continuity, there exists $(\overline{k}, \underline{\Delta}_R)$, such that a single supervisor strictly maximizes welfare for all $k > \overline{k}$ and $R_H - R_L < \underline{\Delta}_R$. Moreover, the first parts of this result imply that $\overline{k} > \underline{k}$ and $\underline{\Delta}_R \in (0, \overline{\Delta}_R)$.

B.9 Proof of Corollary 2

We first show that, if both regulatory forms lead to the same welfare, we must have $\lambda^D < \lambda^S$. This follows because, first, since decentralized supervision conducts less efficient bailouts (i.e., $C^D(\lambda) > C^{FB}(\lambda)$), welfare must be lower under decentralized supervision at λ^D: $W^D(\lambda^D) < W(\lambda^D)$; and second, since welfare is decreasing in λ for all $\lambda > \lambda^{FB}$, $W(\lambda^S) = W^D(\lambda^D)$ then implies that $\lambda^S > \lambda^D$.

Next, recall that welfare features a trade-off between investment returns and systemic costs (see (9)). Therefore $\lambda^S > \lambda^D$ and $W(\lambda^S) = W^D(\lambda^D)$ imply that the systemic cost is higher under a single regulator than under decentralized regulation.

C Extensions

C.1 Many projects

We now generalize the model to more than two projects. Specifically, consider that there are n ($n \geq 3$) projects that can be strictly ordered according to their returns R_i ($1 < R_1 < R_2 < ... < R_n$) and that fail in disjunct states of the world.

Assumption 5. *(i) $k < \overline{v} - v(\frac{1}{n})$, and ii) $k > \frac{1-\pi}{\pi}(R_n - R_{n-1})$.*

This is the updated version of Assumption 2. The first part states that bailouts are optimal when a fraction $\frac{1}{n}$ of projects fail, the second part states that the (excess) return on the highest asset should not be too high, as otherwise, it may become optimal to only invest in that asset.

C.1.1 First best

We denote an arbitrary project allocation by $\{\lambda_1, \lambda_2, ..., \lambda_n\}$ ($\lambda_i \geq 0$, $\sum_{i=1}^{n} \lambda_i = 1$).

Project transfers. Consider that project i fails. All other projects then survive, so $f = \lambda_i$. The f failing project should then be distributed equally among $f - b$ surviving banks, as in the baseline model. Equation (1) continues to hold.

Bailout policy. Since we have f banks with failing projects and $1-f$ banks with successful projects, the optimization problem is the same as before. Lemma 1 continues to hold.

Optimal investment. The marginal gain from increasing the fraction of banks investing in project i is given by (derivation identical to equation 10)

$$W'(\lambda_i) = (1 - \pi)R_i - \pi c^{FB}(\lambda_i). \tag{38}$$

We consider an economy without redundant projects, that is, it is optimal to invest positive amounts in all projects ($\lambda_i^* > 0$). Coupled with our assumption that the highest-return project does not dominate, it follows that we have an interior solution for all projects. Hence $W'(\lambda_i)$ is constant across all projects. It follows that $c^{FB\prime}(\lambda_1) < c^{FB\prime}(\lambda_2) < ... < c^{FB\prime}(\lambda_n)$, that is, higher return projects are associated with higher (marginal) failure costs. Given that $c^{FB}(\lambda)$ is weakly convex, this implies that $\lambda_1 \leq \lambda_2 \leq ... \leq \lambda_3$, that is, projects with higher returns are invested in (weakly) higher proportions. It follows that project n is chosen with a measure of at least $1/n$ ($\lambda_n \geq 1/n$), which by our updated Assumption 2 implies that bailouts are still used when the highest-return project fails ($\lambda_n > \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$). Given that $c^{FB}(\lambda)$ is linear in the domain where bailouts are used (that is, when $\lambda > \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$), it follows that bailouts are only used for the highest-return asset (otherwise we would have $W'(\lambda_n^{FB}) > W'(\lambda_{n-1}^{FB})$. It follows that $\lambda_{n-1}^{FB} < \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}$, and since $c^{FB}(\lambda)$ is (strictly) convex on $[0, \frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}]$, we have that $\lambda_1^{FB} < \lambda_2^{FB} < ... < \lambda_n^{FB}$.

Summarizing, at an optimal allocation bailouts are only used for the highest return project, and projects with lower returns are held in strictly lower proportions than projects with higher returns. Note that there is still a benefit from investing in lower-return projects (like in the baseline model) as those projects offer diversification benefits (due to the increasing cost of failures, it is preferable to spread investment among different projects as those fail in different states of the world).

C.1.2 Targeted policies

Consider two bailout groups, as in the baseline model. One for the λ_n^{FB} measure of banks that invest in the highest return project, and one for a measure $1 - \lambda_n^{FB}$ banks that choose other projects. Banks in a group are only bailed out when projects of the group fail (in other words, they are never bailed out when they fail when project(s) from the other group fail). Recall that bailouts only occur when the highest project fails, but not when any other project fails. The analysis in Section 4.2 has shown that distortions only arise because banks without bailout expectations want to switch to a project with bailout expectations. By no longer providing bailouts in such cases for the low group, this distortion is removed, and the first-best is implemented.

C.2 Projects endowments vary across banks

In this section, we consider banks that are endowed with high-return projects that differ in their return R_H. Specifically, we consider a continuous distribution function of high-project returns across banks. We can then order banks on the unit interval in terms of *decreasing* productivity of the high-return project, with a corresponding return function $R_H(\cdot)$ with $R_H(\cdot)$ defined on $[0,1]$ that is decreasing and assumed to be differentiable. We assume that $R_H(\frac{1}{2}) > R_L$ (that is, for the median bank the high-return project is more productive) but do not restrict the high-return project to always have higher returns than the low project.

We first analyze the *first best allocation.* As date-1 asset transfers and the bailout policy do not depend on the (date-1) project return, they are unchanged. As for the date-0 investment choice, consider again an allocation where a mass λ of banks invests in the high project. Since banks differ with respect to the productivity of their high project, it is strictly optimal to allocate all banks with an index below λ to the high-projects and all banks with a higher index than λ to the low-return project. Similar to (9), welfare is now given by

$$W(\lambda) = (1-\pi)(\int_0^\lambda R_H(\lambda)d\lambda + (1-\lambda)R_L) + \overline{v} - \pi C^{FB}(\lambda) - \pi C^{FB}(1-\lambda), \tag{39}$$

and the corresponding derivative is

$$W'(\lambda) = (1-\pi)(R_H(\lambda) - R_L) - \pi(c^{FB}(\lambda) - c^{FB}(1-\lambda)). \tag{40}$$

This expression is identical to the baseline model (equation 10), except that the benefit from increasing the fraction of banks investing in the high-return project is now no longer a constant, but declines as we increase the fraction of banks investing in the high-return project (as $R'_H(\lambda) < 0$).

Assumption 6. *$R_H(\frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}) > R_L$ and $k > \frac{1-\pi}{\pi}(R_H(1) - R_L)$.*

The first assumption ensures that the optimal solution still uses bailouts, which requires the high-return project to be sufficiently attractive so that a sufficiently large fraction is invested in that project. The second assumption is the updated version of the second part of Assumption 2, ensuring that investing only in high-return projects is not desirable.

Following similar arguments as in Section 3, one can show that Proposition 1 still holds (with $W'(\lambda^{FB}) = 0$ now determined by (40)). The analysis of the first-best hence does not change materially. The only difference is that there is now a second reason for why the marginal return from investing in high-return projects is declining (due to assumed declining project returns), thus providing an additional reason for an interior solution.

We next analyze *targeted bailouts*. As in Section 4.2, banks are allocated to two groups. We assume that bank types are observable, so allocation to groups can be based on banks' investment opportunities. For the same reason as in the first best – when using group sizes of λ and $1-\lambda$ – it is optimal to allocate the banks with an index up to λ to the high group, and the remaining banks to the low group.[17]

As before, bailout policies have to be time-consistent, and we consider bailouts that are not used for a bank that fails when the project of the other group fails. The incentive constraints are analogous to those analyzed in the proof of Proposition 3, with R_H in the expressions being replaced by $R_H(\lambda)$. Identical to Proposition 3 we can show that the first-best is still incentive compatible, hence Proposition 3 still applies.

D Partial Targeting

Consider the following modification of the baseline model. Suppose that at $t = 1$, a fraction $q \in [0, 1]$ of bailouts has to be uniform (that is, failing banks are selected randomly), whereas a fraction $1-q$ can be targetted. The total amount of bailouts still has to be time-consistent. In other words, it has to be equal to the first-best amount: $b = b^{FB}(f)$. The cases considered in Section 4.1 and Section 4.2 result for $q = 1$ and $q = 0$, respectively.

At $t = 1$, this means that $qb^{FB}(f)$ banks are indiscriminately bailed out. This leaves the question of how to allocate the remaining $(1 - q)b^{FB}(f)$ bailouts among failed banks not

[17] The assumption on bank types being not observable is hence not an important one as the private benefits from joining the high group are also higher for the low λ-group. In fact, an appropriately set tax (on joining the high group) can implement optimal group selection when types are not observable.

bailed out so far. Following the analysis in Section 4.2, it is clear that it is still optimal to concentrate these bailouts among the banks whose group's project fails.

We demonstrate first that the first-best cannot be implemented. Consider for this, like in Section 4.2, that two groups of sizes λ^{FB} and $1-\lambda^{FB}$ are being formed. Consider the benefits of a member of the low group switching to the high group. Prior to switching, this bank fails only when the low-return project fails. In this case, there are never bailouts, and hence the bank never profits from them. However, if it switches to the high-return project, it fails with probability π at the time the high-return project fails. In this case it receives a bailout with probability $\frac{qb^{FB}(f)}{\lambda^{FB}}$, solely due to indiscriminate bailouts. Similar to equation (12), its incentives to deviate to the high group are thus given by

$$\Delta\Pi^S(\lambda^{FB}) = \pi q \frac{b^{FB}(\lambda^{FB})}{\lambda^{FB}}(k+I). \tag{IA1}$$

We can see that $\Delta\Pi^S(\lambda^{FB}) > 0$ precisely when $q > 0$, hence the first-best cannot be implemented when there is only partial targetting.

Next, we show that welfare is decreasing in q. This analysis follows the proof of Proposition 4 and part of Proposition 5. Presuming an interior equilibrium (that is, $\lambda^S < 1$), we can derive following the logic of Proposition 5 that $\lambda \in [\frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}, 1-\frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}]$ and that hence $\Delta\Pi^S(\lambda) = W'(\lambda) + \pi(q\frac{b^{FB}(\lambda)}{\lambda}(l(a^{FB}(\lambda)) + I))$. At an interior equilibrium we thus have

$$\Delta\Pi^S(\lambda) = W'(\lambda) + \pi(q\frac{b^{FB}(\lambda)}{\lambda}(l(a^{FB}(\lambda)) + I)) = 0. \tag{IA2}$$

Taking partial derivative wrt. λ we obtain

$$\frac{\partial \Delta\Pi^S(\lambda)}{\partial \lambda} = \pi q \frac{b^{FB}(\lambda)}{\lambda}(l(a^{FB}(\lambda)) + I)) > 0. \tag{IA3}$$

It follows that an increase in q increases the incentives to deviate. Since $\Delta\Pi^S(\lambda)$ is strictly decreasing in λ in the range $\lambda \in [\frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}, 1-\frac{\bar{a}^{FB}}{1+\bar{a}^{FB}}]$ (see Proposition 5), this means that λ has to increase in order to fulfill the condition $\Delta\Pi^S(\lambda) = 0$. Since welfare is decreasing in λ for $\lambda > \lambda^{FB}$, welfare falls.