Running Responsibly

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Abstract

We introduce a tractable framework for bank runs with socially responsible depositors who care about nonpecuniary externalities. Although each depositor is vanishingly small, she rationally internalizes the impact of her withdrawal on the risk of bank failure. We apply this framework to examine the effects of divestment on financial gains and social surplus. Any divestment that positively assorts bank investment portfolios and depositor social responsibility generates financial gains. The divestment nonetheless harms social surplus if the average depositor is insufficiently responsible. Our results explain the widespread adoption of exclusion and tilting among financial firms, and caution against their potentially harmful impact on society.

JEL-Classification: G21, G28, D62, M14

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1 Introduction

Socially responsible divestment is widespread among financial institutions, despite an unavoidable trade off between financial payoffs and social impact that existing theories propose (Heinkel, Kraus, and Zechner, 2001; Broccardo, Hart, and Zingales, 2022; Oehmke and Opp, 2024). In their framework, divesting brown assets has a social impact where it suppresses the prices of brown assets or inflates those of green assets. Either case invites profit-seeking capital to clear markets, undoing the divestment. Only sufficiently large and costly divestments leave any impact. Absent in this framework is that markets sometimes fail to clear. Many financial institutions are in fact subject to sudden failures of market clearing—runs—with large financial and social costs. Can runs explain widespread divestment? Are these divestments socially beneficial?

We introduce a tractable framework for runs on banks whose depositors are socially responsible, in that they care about nonpecuniary externalities. Each depositor is vanishingly small relative to her bank. Yet, in equilibrium, she rationally internalizes her marginal contribution to the risk of bank failure, and is therefore less likely to run if her bank holds "green" technologies and more likely to run if its holdings are "brown." We analyze economy-wide financial profits (financial surplus) as banks divest, replacing some brown holdings with some green holdings of other banks. We show that any such divestment strictly raises the financial surplus, whenever divesting banks have the more socially responsible depositors. Sorting highly responsible depositors towards banks with the greener holdings further raises the financial surplus. Taken together, banks reap financial gains from every exchange that positively assorts green holdings with responsible depositors, thus rationalizing the widespread adoption of divestment policies. These financial gains can harm society, as such divestments can strictly reduce social surplus when depositors are insufficiently responsible.

Our framework incorporates the consequentialist preferences of Kaufmann, Andre, and Kőszegi (2024) into a standard global game of bank runs (Goldstein and Pauzner, 2005; Kashyap, Tsomocos, and Vardoulakis, 2024). There are I identical depositors who care about the aggregate externality. As $I \to \infty$, each depositor becomes vanishingly small relative to her bank, and her probability of being the pivotal one who determines whether her bank fails becomes infinitesimal. Meanwhile, the bank and its externality grow on the

order of I—a depositor is unlikely to be pivotal where her action would have an enormous impact conditional on being pivotal. All else equal, a socially responsible depositor is less likely to withdraw her deposit than a less responsible depositor if the bank's holdings are green, and is more likely to withdraw if they are brown.

Section 2 elaborates on this intuition using a two-stage global game. Each of I depositors holds a unit of demand deposit at a bank that funds a production technology. First, each depositor observes a noisy signal about the bank's remaining liquid assets, and chooses whether to run. Running entails withdrawing one's deposit and, if total withdrawals exceed the bank's liquid assets, the bank fails and its technology partially degrades. Second, if the bank survives, its technology yields a financial payoff and a nonpecuniary externality per initial deposit. A depositor is rational and risk-neutral, and her payoff depends on the aggregate externality scaled by a factor λ.[1] We call λ "social responsibility" for brevity.

We show that a depositor's probability of being pivotal is on the order of $1/I$, exactly offsetting the scale of the bank. Upon observing a signal, a depositor expects that others likely observed similar signals. Each signal itself is thus uninformative about its ranking within the population of signals, and each depositor expects her signal's ranking to be uniformly random. As a result, the marginal depositor believes that the number of other depositors observing a lower signal, and running, is uniformly distributed—the well-known Laplacian Property in global games and Rényi's Representation Theorem in probability theory. Therefore, her probability of being pivotal is on the order of $1/I$.

While we model entirely rational depositors, who understand that they will be affected by economy-wide externalities, our framework can be interpreted as a rational foundation for warm-glow preferences. Our depositors' problem is equivalent to that of a warm-glow depositor whose glow depends on the externality corresponding to her own deposit. We thereby discipline the scope and the determinant of the warm glow. In sum, ours is a tractable and disciplined framework to capture the intuition that, for a given financial payoff,

[1]The aggregate externality is the total dollar-equivalent benefits and costs of nonpecuniary externalities in the economy (i.e., willingness-to-pay for public goods and to remove public bads). A depositor experiences utility from these externalities with a sensitivity factor λ. For example, a depositor's personal suffering from climate change and extinctions of species depends on worldwide emissions and habitat loss. In a more local interpretation, air quality around a depositor's home depends on pollution across the geographic region. Depositors' utility function captures this harm through the λ-times-aggregate externality term.

depositors are more willing to withdraw from more socially harmful banks.

Section 3 generalizes our game to analyze the impacts of divestment on financial and social surplus. We partition depositors into K banks that hold arbitrary combinations of heterogeneous technologies. Each bank k differs in its depositors' average social responsibility $\bar{\lambda}_k$, average financial payoff $\bar{R}_k$ and externality $\bar{E}_k$ per unit deposit. We compare financial surplus, $\sum_{k=1}^{K} \mathbb{P}\left(\text{bank } k \text{ survives}\right) \cdot \bar{R}_k$, and social surplus, $\sum_{k=1}^{K} \mathbb{P}\left(\text{bank } k \text{ survives}\right) \cdot (\bar{R}_k + \bar{E}_k)$, as banks divest or as we sort depositors across banks.

Rather than specifying a microstructure through which a divesting trade would reallocate technology holdings, our approach focuses on a natural class of reallocations that banks could easily implement. Precisely, "divestment" is any reallocation of the banks' technology holdings that positively assorts greener technologies (higher $\bar{E}_k$) with the more socially responsible depositors (higher $\bar{\lambda}_k$). Likewise, depositor sorting is any such positive-assortative redistribution of depositors. Our main result is that *any* positive-assortative divestment or sorting of depositors strictly raises the financial surplus. This sorting also strictly increases the social surplus. By contrast, the divestment strictly reduces the social surplus where the average social responsibility $\bar{\lambda}_k$ is low across all banks. Our results apply to divestment and sorting involving any subset of banks, and only need to be positively assortative among the banks involved. For example, any pair of banks with differing technologies or depositor base can bilaterally generate financial gains by selectively exchanging their holdings or attracting more aligned depositors from each other.

Underlying our results is a complementarity between externalities and social responsibility. The more socially responsible depositors are less likely to run on a bank with greener holdings (higher $\bar{E}_k$). All else equal, the greener bank incurs a smaller expected financial loss from runs, especially when its depositors are more socially responsible (higher $\bar{\lambda}_k$). That the financial impacts of social responsibility and nonpecuniary externalities reinforce each other explains the financial gains from positively assorting banks and depositors.

We illustrate the intuition in a two-bank example, where financial payoffs are declining in externalities. A "social" bank has $\bar{\lambda}_s > 0$ and a "private" bank has $\bar{\lambda}_p = 0$. The social bank divests a brown technology with a negative externality and a high financial payoff to the private bank. In exchange, the social bank receives a green technology with a positive externality and a low payoff. Setting aside financial payoffs, this improvement in the social

bank's externalities lowers its expected financial loss from a run (as $\bar{\lambda}_s > 0$), whereas the decline in the private bank's externalities has no impact on its expected financial loss from a run (as $\bar{\lambda}_p = 0$). This positive assorting of externalities and social responsibility strictly raises the financial surplus. Considering financial payoffs, the social bank's payoffs fall while the private bank's payoffs increase, making the social bank more likely to fail and the private bank less so. Because all depositors value financial payoffs equally regardless of their social responsibility, reallocating the financial payoffs merely transfers the financial losses from runs between the two banks. On net, the complementarity effect dictates the financial surplus, raising this surplus whenever banks divest or depositors sort.

Divestment can nonetheless harm social surplus if depositors in the economy have low social responsibility, because then divestment raises the failure risk of banks whose holdings would generate greater positive externalities. In the two-bank example, as the social bank divests, its externality $\bar{E}_s$ improves while its financial payoff $\bar{R}_s$ declines. If depositors have low social responsibility, then the social bank's improved externality hardly reduces its failure risk. Overall, the divestment raises the social bank's failure risk, even as it concentrates more green technologies at this bank. The resulting larger expected loss in positive externalities does not enter in the financial surplus. It does, however, enter the social surplus: The larger expected loss in externalities can dominate the complementarity from positively assorting. Therefore, the divestment reduces the social surplus when depositors are insufficiently responsible.[2] Sorting of depositors always strictly improves the social surplus, because moving depositors affects neither the banks' externalities $\bar{E}_k$ nor their financial payoffs $\bar{R}_k$.

Section 4 shows that positive-assortative divestments encompass most common environmental, social, and governance (ESG) investment strategies, including exclusion, tilting, and spinoffs. A natural empirical question that arises is whether depositors know and care about the composition of their bank's holdings. Section 4.2 summarizes the evidence. Depositors are indeed more likely to withdraw from a bank whose holdings do not align with their social preferences (e.g., Homanen, 2022). Motivated by this evidence, we consider the selection of more responsible depositors into greener banks. Such selection strictly increases the financial

[2]This result pinpoints a core difference between our setting and those with heterogeneous preferences over attributes of cash flows. The latter settings do not feature non-pecuniary externalities, and thus there can be no distinction between financial and social surplus.

gain from divestment until externalities and depositors are maximally positively assorted, which obtains the maximum financial surplus.

Our results can reconcile the conflicting empirical evidence on whether and to what degree banks and other institutions divest (Pastor, Stambaugh, and Taylor, 2024b). We predict that banks with socially responsible depositors would divest brown assets to those with less responsible depositors. The more responsible the depositors, the more their bank would divest brown assets, whereas the banks with the least responsible depositors would divest green assets. Controlling for financial payoffs, banks with green holdings would have lower risk of failure, and depositors who are more socially responsible would be less likely to run on green banks and more likely run on brown banks. We are unaware of any empirical work that tests these predictions, neither for banks nor other financial institutions that are susceptible to runs, including firms reliant on short-term debt (He and Xiong, 2012), money market funds (Parlatore, 2016), and open-end mutual funds (Chen, Goldstein, and Jiang, 2010).[3]

Section 5 elaborates on our contributions. (i) We develop the first and highly tractable global game in the presence of socially responsible agents. Our game adds two results. (ii) Any positive assorting between externalities and social preferences strictly raises the financial surplus. (iii) How the positive assorting occurs matters for society: Reallocating externalities harms the social surplus when social responsibility is weak, whereas reallocating preferences always benefits the social surplus.

Our results have two key implications. First, we reconcile the gulf between ESG investing in practice and socially optimal investment strategies. Extant theory has two messages. Investments maximize social impact when directed into assets that are neither particularly green nor brown (Landier and Lovo, 2023; Green and Roth, 2025). More broadly, contracting or exercising control rights to induce cleaner production has greater impact than passive investments (Broccardo et al., 2022; Oehmke and Opp, 2024). Yet, the prevalent ESG investing strategies involve excluding or tilting portfolios away from brown assets, with social impact that is often undetectable (Berk and van Binsbergen, 2021; Kacperczyk and

[3]Swing pricing can mitigate the risk of damaging runs on open-end mutual funds (Jin, Kacperczyk, Kahraman, and Suntheim, 2022). In practice, there has been limited adoption of swing pricing in the US due to institutional frictions (Capponi, Glasserman, and Weber, 2023).

Peydró, 2022) or counterproductive (Hartzmark and Shue, 2022). In our framework, even the counterproductive divestments have a clear purpose: financial gains from trade.

Second, we can resolve the apparent conflict between ESG investing and fiduciary duty (McGowan, 2022). Traditional fiduciary duty demands that portfolio managers maximize the financial well-being of their clients. Many of those portfolio managers have adopted ESG investing policies while claiming a strong commitment to fiduciary duty in surveys (Edmans, Gosling, and Jenter, 2024). We show that fiduciary duty does not conflict with ESG investing—in fact, fulfilling fiduciary duty may *require* divestment.

Two salient alternative motives might explain the widespread adoption of ESG investment policies. First, they may serve a marketing or "greenwashing" purpose. However, financial institutions that commit to ESG policies do tilt their holdings away from brown assets compared to other institutions (e.g., Kacperczyk and Peydró, 2022). Second, the ESG policies may attract deposits or investments, making the financial cost of distorting holdings worthwhile. Yet, imposing costs on current depositors and investors in order to attract new funds would fragrantly violate fiduciary duty, threatening litigation and prosecution. Our explanation does not require financial institutions to be persistently fooling prospective clients nor be in breach of their fiduciary duties. Rather, we only require, holding financial payoffs constant, that clients be more willing to withdraw from more socially harmful institutions.

The remainder of the paper is organized as follows. Section 2 presents a global game of runs with consequentialist depositors. Section 3 generalizes the game to derive the impacts of divestment and depositor sorting on the financial and social surplus. Section 4 maps our counterfactuals to ESG investing in practice and provides empirical evidence. Section 5 details our contributions. Section 6 discusses key omitted features and then concludes.

2 Bank Runs with Consequentialist Depositors

This section delivers two messages through a simple global game. (i) Socially responsible depositors internalize their impact on the risk of bank failure, even when they are vanishingly small. (ii) Externalities and social responsibility are complementary in expanding the financial surplus. Section 2.1 presents the model, Section 2.2 derives the equilibrium and

explains its key characteristics, and Section 2.3 explains our modeling assumptions.

2.1 Global Game

Numerous risk-neutral and consequentialist depositors may run on a bank in a three-period global game. Each of I depositors holds a unit of demand deposit at the bank. We analyze this economy when I is infinitely large.[4] The bank has invested the deposits into a production technology that will yield a financial payoff R and an externality E per each unit of initial deposit if the bank survives until the end of the game.

In period 0, the bank gains liquid assets worth θI, where the ratio θ of liquid assets to deposits is drawn from a uniform distribution, $\theta \sim \mathbb{U}[\underline{\theta}, \bar{\theta}]$, $\underline{\theta} < \bar{\theta}$. A depositor does not know the true liquidity ratio θ, and instead privately observes a noisy signal $s_i = \theta + \sigma\varepsilon_i$, where noise $\sigma\varepsilon_i \overset{iid}{\sim} \mathbb{U}(-\sigma/2, \sigma/2)$, $\sigma > 0$.

In period 1, each depositor may choose to *run* or *stay*. A depositor who runs receives her unit deposit. Let nI be the number of depositors who run ("runners"). The bank survives if it has sufficient liquid assets to meet all demands for early withdrawal from runners, $nI \leq \theta I$. Otherwise, the bank fails: share $\alpha > 0$ of the technology is destroyed, staying depositors receive nothing, and unmodeled outside investors absorb any net losses.

In period 2, conditional on survival, the bank's technology generates gross financial payoff $R > 1$ and externality $E \in \mathbb{R}$ per unit of initial deposit. In this case, the bank transfers R to each staying depositor, and distributes the remaining financial payoffs to the outside investors. Figure 1 summarizes the timing of the model.

All depositors are consequentialists, as in Kaufmann et al. (2024). Precisely, the *ex-post* utility U_i of depositor i equals the sum of any financial payment she receives and the

[4] Precisely, I belongs to the set of hyperreal numbers, ${}^*\mathbb{R}$, which are an extension of real numbers that contain infinite and infinitesimal numbers (Anderson, 2008). An infinitely large hyperreal $I \in {}^*\mathbb{R}$ is a real number such that $I > r$, $\forall r \in \mathbb{R}^+$.

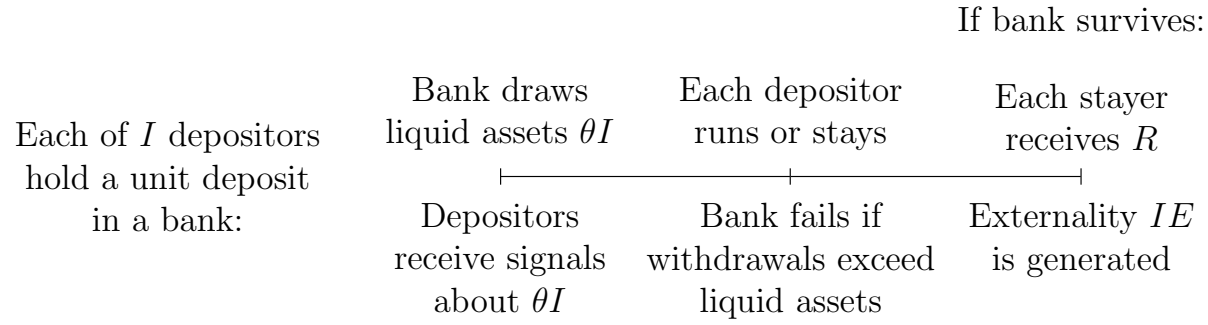


Figure 1: Model Timeline

aggregate externality weighted by a social responsibility factor λ:[5]

$$U_i(\theta, n) = \begin{cases} R + \lambda IE, & \text{if } i \text{ stays and } \theta I \geq nI, \\ 1 + \lambda IE, & \text{if } i \text{ runs and } \theta I \geq nI, \\ 1 + (1-\alpha)\lambda IE, & \text{if } i \text{ runs and } \theta I < nI, \\ (1-\alpha)\lambda IE, & \text{otherwise.} \end{cases}$$

Therefore, her expected utility gain from staying over running in period 1 is:

$$\begin{aligned} \pi(s_i) &= \mathbb{P}\left(\theta \geq n \,|\, s_i\right) R - 1 \\ &\quad + \Big[\underbrace{\mathbb{P}\left(\theta \geq n \,|\, i \text{ stays}, s_i\right) - \mathbb{P}\left(\theta \geq n \,|\, i \text{ runs}, s_i\right)}_{\text{Probability } \Delta P(s_i) \text{ that depositor is pivotal}} \Big] \alpha\lambda IE. \end{aligned} \tag{1}$$

We impose two parametric assumptions that focus our analyses on nondegenerate cases.

Assumption 1. The range of fundamental is sufficiently large; $\underline{\theta} \leq -\sigma$ and $\bar{\theta} \geq 1 + \sigma$.

[5] We make two notes. First, U_i ignores externalities generated outside the production technologies held by the bank. Incorporating such "outside-bank" externalities would add a constant term to U_i, which cannot affect depositors' decision making. Second, the externality terms in U_i are far larger than its other terms, which captures the idea that nonpecuniary externalities (e.g., air and water quality, available technologies, functioning of legal institutions) determine much of an agent's level of utility. But a rational agent's decision making depends purely on the portion of her utility that she can control, as the utility gain (1) from staying reflects.

Assumption 2. Depositors are not too socially responsible:

$$\lambda < \begin{cases} \dfrac{\sigma+1}{\alpha E}, & \text{if } E > 0, \\ (1-R)\dfrac{\sigma+1}{\alpha E}, & \text{if } E < 0. \end{cases}$$

Assumption 1 is standard and ensures equilibrium uniqueness (Morris and Shin, 2003; Goldstein and Pauzner, 2005). Assumption 2 is new and states that each depositor's social preference is not too strong to entirely overshadow her financial concern and dictates her run choice, ensuring that depositor behavior is nondegenerate. Section 2.3 explains our assumptions.

2.2 Equilibrium

We look for a switching equilibrium, following Kashyap et al. (2024).[6]

Definition 1. A switching equilibrium consists of cutoffs s_i^* and consistent beliefs such that each depositor i optimally runs whenever her signal $s_i < s_i^*$ and optimally stays whenever $s_i > s_i^*$: $\pi(s_i) < 0$ if $s_i < s_i^*$, and $\pi(s_i) > 0$ if $s_i > s_i^*$.

Proposition 1. *Let* $\psi := \left(1 - \frac{\alpha\lambda E}{\sigma+1}\right) R^{-1} \in (0,1)$. *There exists a unique switching equilibrium, wherein:*

1. *Every depositor runs if and only if her signal* s_i *is strictly below a common cutoff* $s_i^* = s^*$, *where*

$$s^* = (\sigma+1)\psi - \frac{\sigma}{2}. \tag{2}$$

2. *The bank fails if and only if its liquid assets* θI *are strictly below a threshold* $\theta^* I$, *where*

$$\theta^* = \psi. \tag{3}$$

[6] As Section 2.3 explains, focusing on switching equilibria addresses the absence of "state monotonicity" in the payoff function that global games typically require.

Proposition 1 states that the risk of bank failure is decreasing in social responsibility λ and in externality E, and the two complement each other in reducing the failure risk. We explain Proposition 1 assuming a symmetric switching equilibrium with a common signal cutoff s^*. The complete proof establishes the uniqueness with arbitrary signal cutoffs s_i^*. All proofs are in Appendix A.

Our departure from existing models of runs is that each depositor internalizes her marginal impact on the risk of a run, despite being vanishingly unlikely to be pivotal. Precisely, the probability ΔP that a depositor is pivotal is on the order of $1/I$ while the aggregate externality that hinges on the bank's survival is IE. The two terms scale each other up to a strictly positive expected impact which, for the marginal depositor whose signal is at the cutoff $s_i = s^*$, yields the following utility gain from staying:

$$\pi(s^*) = \mathbb{P}\left(\theta \geq n \,|\, s_i = s^*\right) R - 1 + \frac{\alpha}{1+\sigma} \cdot \lambda E. \tag{4}$$

The Laplacian Property of global games (Morris and Shin, 2003) leads us to (4). Depositor i is pivotal when just enough other depositors run such that one additional runner would trigger bank failure,

$$\Delta P(s_i) = \mathbb{P}\left(\theta I - nI \in [0,1] \,\middle|\, s_i\right).$$

The bank's liquid assets θI determine the amount nI of withdrawals through the exact law of large numbers, because the number of depositors is infinitely large. Assuming that n is interior,

$$n = \frac{s^* - \theta}{\sigma} + \frac{1}{2},$$

and thus the withdrawals decrease at a constant rate of $1/\sigma$ as the liquid assets increase. Hence, the gap $\theta I - nI$ between liquid assets and withdrawals is 1 when there are $1/(\sigma+1)$ fewer withdrawals than the amount of withdrawals that would close this gap. Letting n^* be the threshold for n below which the bank survives, a depositor is pivotal whenever nI lies above $n^*I - 1/(\sigma+1)$ and below n^*:

$$\Delta P(s_i) = \mathbb{P}\left(nI \in \left[n^*I - \frac{1}{\sigma+1}, n^*I\right] \,\middle|\, s_i\right) = \mathbb{P}\left(n \in \left[n^* - \frac{1}{\sigma+1}\frac{1}{I}, n^*\right] \,\middle|\, s_i\right).$$

While this probability is complex to compute for a generic depositor, it is simple to calculate for the marginal depositor who determines the equilibrium cutoff s^*. The marginal depositor's signal is at the cutoff $s_i = s^*$, keeping her indifferent between staying and running. From her perspective, n is uniformly distributed over $[0, 1]$ under the Laplacian Property. The pivotal probability ΔP for deriving s^* is then

$$\Delta P(s^*) = \frac{1}{\sigma + 1} \frac{1}{I}. \tag{5}$$

Therefore, $\Delta P(s^*)$ is on the order of $1/I$ that exactly offsets the scale of the technology's aggregate externality IE, which yields the marginal depositor's utility gain (4) from staying.

Two further equations characterize the equilibrium. First, the bank's liquid assets θI and withdrawals nI must be equal at the survival threshold $n = n^*$,

$$n^* = \theta^* = \frac{s^* - \theta^*}{\sigma} + \frac{1}{2}. \tag{6}$$

Second, the marginal depositor must be indifferent between running and staying, $\pi(s^*) = 0$. Combining (1) and (5) yields the utility differential (4) and the indifference condition:

$$\underbrace{\mathbb{P}\left(\theta \geq n \,|\, s_i = s^*\right)}_{=\mathbb{P}(n \leq n^* \,|\, s_i = s^*) = n^*} R - 1 + \frac{\alpha}{\sigma + 1} \cdot \lambda E = 0. \tag{7}$$

Equations (6) and (7) together yield (2) and (3).

2.3 Discussion

Preferences. "Warm glow" preferences are a common alternative to consequentialist preferences (e.g., Heinkel et al., 2001; Pástor, Stambaugh, and Taylor, 2021). Applied to bank runs, warm-glow depositors would receive exogenously higher "glow" payoffs if their bank has greener holdings. Utility gain (4) microfounds and disciplines warm-glow utilities in a rational setting. A generic warm-glow utility allows considerable flexibility in its functional form: The glow may be increasing in the aggregate externality, that of the bank, or simply

one's own deposit. Whether a depositor receives the glow could depend on her actions (i.e., whether she stays or runs) or the real output of her technology holdings (i.e., whether she stays *and* her bank survives). It would be unclear if its results are robust insights under warm-glow preferences or driven by its particular specification. By contrast, consequentialist depositors rationally internalize their marginal impact on the externality, drastically narrowing down a researcher's flexibility through (4)—which is precisely the utility gain from staying for a warm-glow depositor whose glow is (i) increasing in the externality E of her own deposit and (ii) tied to the real output. Empirically, a substantial portion of consumers are indeed consequentialists (Kaufmann et al., 2024).

Consequence of failure. Bank failure destroys a positive proportion of the bank's technology holdings. This assumption is consistent with the stylized fact that firms whose relationship bank experiences a liquidity shock suffer lower profits, revenues, employment, and other measures of firm size (e.g., Khwaja and Mian, 2008; Chodorow-Reich, 2014; Schwert, 2018). Partly destroying the bank's technology holdings upon its failure is our simple way of capturing the loss in the benefits of relationship banking to firms operating those technologies, causing a reduction in their operations.

Technology. We assume constant returns-to-scale for externalities and financial payoffs. Our results are robust to increasing returns-to-scale in either or both externalities and financial payoffs.[7] They are robust to decreasing returns-to-scale in externalities as long as the marginal externality per unit deposit converges to a strictly positive or negative number as $I \to \infty$. Likewise, our results are robust to decreasing returns-to-scale in financial payoffs as long as the marginal financial payoff per unit deposit converges to any number greater than 1. We choose constant returns-to-scale for expositional simplicity.

Liquid assets. The bank's liquidity ratio θ is the fundamental that coordinates de-

[7]Financial payoffs can exhibit increasing returns-to-scale with fixed costs or economies of scale. Externalities could have increasing returns-to-scale due to economies of scale in green technologies, as is seemingly the case for solar power, or if environmental impacts have cutoff effects. For example, coral reefs bleach and die once the temperature of surrounding water exceeds a cutoff, below which their health improves gradually as the temperature falls (Dalton and Carroll, 2011). The reefs would see little benefit from any water-cooling investment until it is sufficient to keep water temperature below the cutoff. Similarly, a marginal human-caused death may be of little ecological consequence in a plentiful species, while a marginal death once the species has become endangered would impose far larger costs. The first example is a plausible case of increasing returns-to-scale for positive externalities, and the second example is such a case for negative externalities.

positors in our model.[8] A common alternative specification adopts uncertain payoffs of the bank's assets as the coordinating fundamental. If we were to adopt the same, the bank's expected loss from a run would be decreasing in the number of technologies it holds due to diversification of assets. Asset diversification is orthogonal to the social responsibility channel that generates our results in the following sections. Because a literature already studies the impact of diversification on runs (e.g., Gennaioli, Shleifer, and Vishny, 2013), we turn off the diversification effect to focus on our contribution—the impact of social responsibility on runs.

Signals. We draw noise $\sigma\varepsilon_i$ in the depositors' signals from a uniform distribution (as do, e.g., Goldstein and Pauzner (2005) and Kashyap et al. (2024)), rather than a generic distribution (e.g., Shen and Zou (2024)). Uniform noise is a standard way to establish uniqueness in the absence of global strategic complementarity in the payoff function, as is the case here. In our setup, because depositor i internalizes her marginal impact on the risk of bank failure, her utility gain from staying is not always increasing in the share of others who stay, $1-n$: It may decrease locally as $1-n$ crosses from $(1-n)I < (1-\theta)I$ (where the bank never survives) to $(1-n)I \in [(1-\theta)I, (1-\theta)I+1)$ (the bank survives if and only if depositor i stays), then again when crossing up to $(1-n)I \geq (1-\theta)I+1$ (the bank always survives). We instead have one-sided strategic complementarity in that the utility gain is increasing either in the range where it is positive or in the range where it is negative. The uniform noise ensures equilibrium uniqueness with one-sided complementarity (Goldstein and Pauzner, 2005; Kashyap et al., 2024).

Global games often focus on the limit where the noise vanishes, $\sigma \to 0$, allowing for a general distribution for the fundamental θ without compromising tractability. We let the noise be away from the limit, $\sigma > 0$, to emphasize that each depositor is pivotal when her signal is in a nondegenerate interval, $\left[\theta^* - \frac{\sigma}{2}, \theta^* + \frac{\sigma}{2}\right]$. We assume a uniform prior on θ, the alternative to assuming $\sigma \to 0$ in global games. Doing so ensures that the posterior $\frac{1}{\sigma} f(\frac{s_i-\theta}{\sigma})$ does not depend on the parameters of the prior, as global games require for tractability

[8] Our choice of fundamental follows He and Manela (2016) and Shen and Zou (2024) in the bank run literature. This choice is standard in other literatures that use global games, including currency attacks (Hellwig, Mukherji, and Tsyvinski, 2006; Angeletos and Werning, 2006), investment (Sákovics and Steiner, 2012), and debt rollover (Ahnert and Kakhbod, 2017). Prominent examples using the alternative specification include Rochet and Vives (2004), Goldstein and Pauzner (2005), and Kashyap et al. (2024).

(Morris and Shin, 2003).

Equilibrium Definition. We focus on the switching equilibrium, because "state monotonicity" may not hold in our payoff function. State monotonicity means that the utility gain from taking an action is monotonic with respect to the fundamental (Morris and Shin, 2003; Kashyap et al., 2024). Canonical global games rely on state monotonicity to prove that every perfect Bayesian equilibrium is a switching equilibrium and that it is unique (Morris and Shin, 2003). Our setup may not satisfy state monotonicity, because each depositor i internalizes her marginal impact on the risk of bank failure. Although her utility gain from staying is generally increasing in the fundamental θ, it may locally decrease as θ crosses from $\theta I < nI$ (where the bank never survives) to $\theta I \in [nI, nI+1)$ (the bank survives if and only if depositor i stays), then again as θ crosses up to $\theta I \geq nI + 1$ (the bank always survives). To prove uniqueness while lacking state monotonicity, Kashyap et al. (2024) limits attention to symmetric switching equilibria and introduces a novel proof of uniqueness. We allow for any switching equilibrium that is not necessarily symmetric and, in so doing, add a new proof of uniqueness for the switching equilibrium in a setting where depositors internalize their marginal impacts.

Parametric assumptions. Assumption 1 is standard in the literature, and pins down a unique equilibrium that allows for sharp normative analysis. Precisely, under Assumption 1, it is a dominant strategy for depositor i to run upon observing a low signal $s_i < -\frac{\sigma}{2}$ and to stay if $s_i > 1 + \frac{\sigma}{2}$.[9] In the intermediate region $s_i \in [-\frac{\sigma}{2}, 1 + \frac{\sigma}{2}]$, Assumption 1 ensures that the depositor's posterior about θ is sufficiently far away from its upper and lower boundaries, $\underline{\theta}$ and $\bar{\theta}$, such that the posterior is not contaminated by θ being too close to the boundaries and remains uniform $\mathbb{U}[s_i - \frac{\sigma}{2}, s_i + \frac{\sigma}{2}]$.

Assumption 2 is equivalent to $\frac{\alpha}{\sigma+1}\lambda E < 1 < R + \frac{\alpha}{\sigma+1}\lambda E$. If instead $\frac{\alpha}{\sigma+1}\lambda E \geq 1$, then a depositor stays as long as she believes that the bank survives with any positive probability. Therefore, in any switching equilibrium, each depositor runs only if her signal is sufficiently low, $s_i < -\frac{\sigma}{2}$, that the bank is certain to fail (i.e., even if no one runs). If $1 \geq R + \frac{\alpha}{\sigma+1}\lambda E$, then any switching equilibrium is such that each depositor stays only if her signal is sufficiently high, $s_i > 1 + \frac{\sigma}{2}$, that the bank is certain to survive (i.e., even if everyone runs).

[9] A low signal $s_i < -\frac{\sigma}{2}$ implies the fundamental must be negative, $\theta < 0$, thus the bank would fail even if all depositors stayed. A high signal $s_i > 1 + \frac{\sigma}{2}$ implies the opposite.

3 Divestment

We examine the impact of divestment on financial and social surplus. Section 3.1 sets up the generalized global game. Section 3.2 defines key terms. Section 3.3 explains the impact of divestment and sorting of depositors on the financial surplus. Section 3.4 does so for the social surplus.

3.1 Generalized Global Game

We introduce multiple banks with arbitrary technology holdings and differing depositor bases to the global game in Section 2.1. There are $I = \infty$ depositors who are partitioned into $K \geq 2$ banks, whose deposits are split across $N \geq 2$ technologies. The depositors are heterogeneous in their social responsibility factors $\lambda_i \geq 0$. The banks are heterogeneous in their depositors' average social responsibility $\bar{\lambda}_k$. Moreover, the banks differ in their proportion ω_k of deposits and in the proportion $\tau_{k,n}$ of its deposits invested in technology n. Thus, bank k has deposits worth $\tau_{k,n}\omega_k I$ invested into technology n. The net financial payoff from holding any technology until the end of the game is strictly positive, $R_n > 1$. Each bank independently draws its liquidity ratio $\theta_k \overset{iid}{\sim} \mathbb{U}[\underline{\theta}, \bar{\theta}]$.

The timing, all other assumptions, and the equilibrium definition are identical to the game in Section 2.1. We make four clarifications. Bank failure destroys a uniform share α across the failing bank's technology holdings. Regarding the timing of actions, depositors across all banks simultaneously receive their individual signal s_i in period $t = 0$ and simultaneously choose whether to run or stay in $t = 1$. Regarding parametric assumptions, we update Assumption 2 to ensure that each depositor's social responsibility is not too high given her bank's holdings. Precisely, the updated Assumption 2 imposes that, for every technology n and depositor i,

$$\lambda_i < \begin{cases} \dfrac{\sigma + 1}{\alpha E_n}, & \text{if } E_n > 0, \\ (1 - R_n)\dfrac{\sigma + 1}{\alpha E_n}, & \text{if } E_n < 0. \end{cases}$$

Regarding the equilibrium definition, the cutoffs s_i^* of a switching equilibrium are bank-specific, $s_{i,k}^*$, in the presence of K banks.

This generalized global game has a unique switching equilibrium (Proposition 2). In what follows, we denote bank k's average gross financial payoff by $\bar{R}_k \coloneqq \sum_{n=1}^{N} \tau_{k,n} R_n$ and its average externality by $\bar{E}_k \coloneqq \sum_{n=1}^{N} \tau_{k,n} E_n$.

Proposition 2. *Let* $\psi_k(\lambda) \coloneqq \left(1 - \frac{\alpha\lambda\bar{E}_k}{\sigma+1}\right)\bar{R}_k^{-1}$. *The generalized global game has a unique switching equilibrium, wherein:*

1. *Depositor i at bank k runs if and only if her signal $s_i < s^*_{i,k}$, where*

$$s^*_{i,k} = \psi_k\left(\bar{\lambda}_k\right) + \sigma\psi_k(\lambda_i) - \frac{\sigma}{2}. \tag{8}$$

2. *Bank k fails if and only if its liquid assets $\theta_k I_k < \theta^*_k I_k$, where*

$$\theta^*_k = \psi_k\left(\bar{\lambda}_k\right). \tag{9}$$

Proposition 2 departs from the equilibria of extant bank-run models (and Proposition 1) in that the depositors at the same bank have heterogeneous signal cutoffs $s^*_{i,k}$ below which they run, due to the heterogeneity in their social responsibility λ_i. These cutoffs lead each bank to have its own failure threshold θ^*_k that depends on the distribution of λ_i among its depositors.

3.2 Definitions

Divestment is any reallocation of technology holdings across banks. Specifically, a divestment is a change in banks' technology holdings that maintains the same level of deposits at each bank and neither creates nor destroys existing technology holdings, *ex ante*. We write τ and τ' to denote vectors of the banks' old and new technology holdings $\tau_{k,n}$. A divestment changes the banks' technology holdings from τ to τ' such that total investment into each technology remains constant,

$$\sum_{k=1}^{K} \tau_{k,n}\omega_k = \sum_{k=1}^{K} \tau'_{k,n}\omega_k \text{ for all } n.$$

Divestment is *positive assortative* whenever the greener technologies are reallocated towards banks with the more socially responsible depositors. Precisely, we order the banks by their responsibility, such that $\bar{\lambda}_1 > \bar{\lambda}_2 > \ldots > \bar{\lambda}_K$. A positive-assortative divestment is a divestment from holdings τ to τ' such that the average externalities $\bar{E}'_k$ across banks under τ' first-order stochastically dominate the old $\bar{E}_k$,

$$\sum_{k=1}^{\kappa} \omega_k \bar{E}'_k \geq \sum_{k=1}^{\kappa} \omega_k \bar{E}_k \text{ for all } \kappa < K \text{ with the inequality being strict for some } \kappa.$$

Each panel of Figure 2 depicts an example of positive-assortative divestment. Bank 1 has depositors who are the most socially responsible, followed by Banks 2 and 3. Red arrows within each panel illustrate a reallocation of technology holdings.

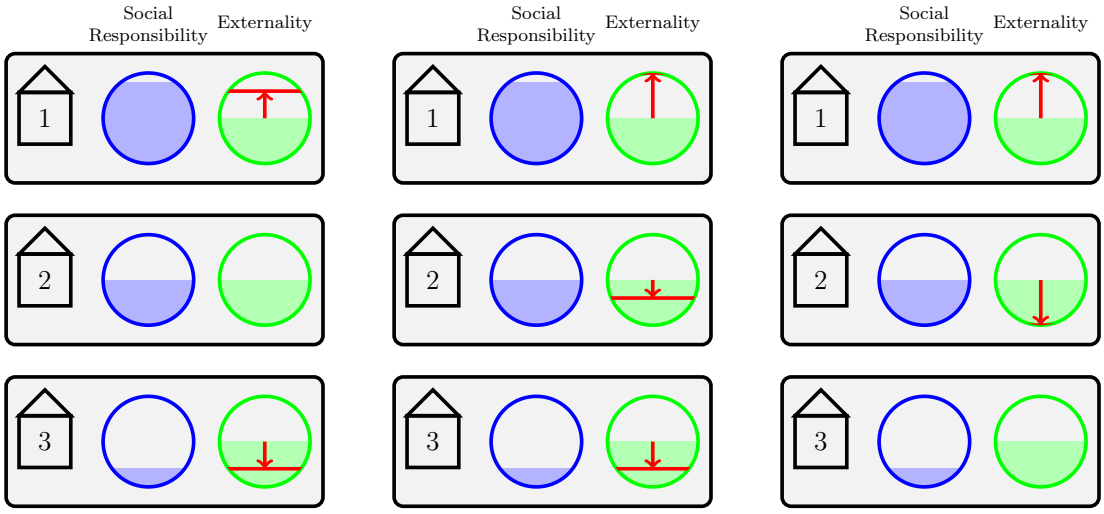


Figure 2: Examples of Positive Assortative Divestment

Sorting of depositors is a reallocation of depositors across banks that allocates the more responsible depositors towards banks with the greener technologies. Precisely, we order the banks by their "greenness," such that $\bar{E}_1 > \ldots > \bar{E}_K$. We write $\bar{\mathbf{\Lambda}}'$ and $\bar{\mathbf{\Lambda}}$ to denote vectors of the banks' new and old average depositor social responsibility. Depositor sorting occurs

when $\bar{\mathbf{\Lambda}}'$ first-order stochastically dominates $\bar{\mathbf{\Lambda}}$:

$$\sum_{k=1}^{\kappa} \omega_k \bar{\lambda}'_k \geq \sum_{k=1}^{\kappa} \omega_k \bar{\lambda}_k \text{ for all } \kappa < K \text{ with the inequality being strict for some } \kappa.$$

Financial surplus is the expected value of all financial payoffs generated in the economy net of financial costs. The financial surplus is equivalent to the expected net financial payoff aggregated across all banks:

$$\text{Financial surplus} \equiv \sum_{k=1}^{K} \Big[\big(\mathbb{P}\left(\text{bank } k \text{ survives}\right) + (1-\alpha)\mathbb{P}\left(\text{bank } k \text{ fails}\right) \big) \bar{R}_k - 1 \Big] \omega_k I.$$

Social surplus is the sum of the financial surplus and the aggregate externality generated in the economy. The social surplus is equivalent to the expected financial payoff aggregated across all banks net of externalities and costs:

$$\text{Social surplus} \equiv \sum_{k=1}^{K} \Big[\big(\mathbb{P}\left(\text{bank } k \text{ survives}\right) + (1-\alpha)\mathbb{P}\left(\text{bank } k \text{ fails}\right) \big) \left(\bar{R}_k + \bar{E}_k \right) - 1 \Big] \omega_k I.$$

We sometimes write financial or social surplus *of a bank* to denote the bank's contribution to the surplus. Likewise, surplus *across a subset of banks* refers to the surplus computed within this subset, rather than the aggregate of all banks.

3.3 Financial Impact

Any positive-assortative divestment or sorting of depositors strictly increases the financial surplus in the unique switching equilibrium.

Proposition 3.

1. *Any positive-assortative divestment strictly raises the financial surplus.*

2. *Any positive-assortative sorting of depositors strictly raises the financial surplus.*

If $\mathcal{K}$ denotes any subset of banks:

3. *Any divestment or sorting of depositors that positively assorts the banks in $\mathcal{K}$ always strictly raises the financial surplus across those banks, and the aggregate financial surplus (across all banks) if the divestment or depositor sorting does not involve the other banks.*

Proposition 3 says any reallocation that positively assorts average externality $\bar{E}_k$ and average social responsibility $\bar{\lambda}_k$ yields financial gains from trade. Part 3 generalizes this result to the positive assorting of *any subset* of banks. Thus, any number of banks (including just two) can exchange technology holdings to achieve financial gains, regardless of whether other banks participate.

We outline the proof as follows. Bank k's contribution to the financial surplus is proportional (up to a constant) to:

$$\mathbb{P}\left(\text{bank } k \text{ survives}\right)\bar{R}_k = \mathbb{P}\left(\theta_k \geq \theta_k^*\right)\bar{R}_k - 1 = c_1\bar{R}_k - c_2 + c_3\,\frac{\bar{\lambda}_k\bar{E}_k}{\sigma+1},$$

in which constants $c_1, c_2, c_3 > 0$ are the same across all banks and comprise parameters $\bar{\theta}$ and $\underline{\theta}$ governing the prior distribution of the liquidity ratio θ_k. Therefore, we can separate the effect of divestment or depositor sorting on the financial surplus into a financial payoffs component $c_1\bar{R}_k$ and a social component $\bar{\lambda}_k\bar{E}_k/(\sigma+1)$. The financial payoffs component directly enters in the definition of the financial surplus. The social component appears indirectly because consequentialist depositors internalize their impact on the risk of bank failure (despite being vanishingly small, Section 2.2). Thus, the equilibrium run cutoff θ_k^* varies across the bank's average externality $\bar{E}_k$ and average social responsibility $\bar{\lambda}_k$.

Neither this divestment nor the sorting of depositors imposes any condition on the financial payoffs R_n of the technologies being exchanged, because the financial component $c_1\bar{R}_k$ does not affect financial surplus. As we transfer technologies between banks, some banks' $\bar{R}$ increase and other banks' $\bar{R}$ decline in a mean-preserving way. The changes in the financial component across banks exactly offset each other, as $\bar{R}$ enters linearly, because all depositors value financial payoffs equally regardless of their social responsibility. Therefore, only the social component determines the effect on the financial surplus.

The complementarity between externalities and social responsibility in the social compo-

nent $\bar{\lambda}_k \bar{E}_k/(\sigma+1)$ generates gains from trade. In contrast to financial payoffs, depositors have heterogeneous preferences for externalities. A bank with more socially responsible depositors is more sensitive to the greenness of its technology holdings than a bank with less responsible depositors. Any positive-assortative divestment shifts technology holdings to raise the externality $\bar{E}$ of banks with greater social responsibility $\bar{\lambda}$ while lowering $\bar{E}$ at banks with lesser $\bar{\lambda}$ in a mean-preserving way. Symmetrically, a sorting of depositors increases $\bar{\lambda}$ at banks with higher $\bar{E}$, and reduces $\bar{\lambda}$ where $\bar{E}$ is lower. Either case strictly increases the social component of the financial surplus, because $\bar{E}$ and $\bar{\lambda}$ reinforce each other's impact on the financial surplus.

3.4 Social Impact

In contrast, the social impact of divestment or depositor sorting hinges on (i) the social responsibility of the depositors in the economy and (ii) the trade-off between externalities and financial payoffs across available technologies.

Proposition 4.

1. *Any positive-assortative sorting of depositors strictly raises social surplus.*

Suppose banks are ordered by their average social responsibility, $\bar{\lambda}_1 > \bar{\lambda}_2 > \ldots > \bar{\lambda}_K$*, and financial payoffs of technologies are strictly decreasing in their externalities,* $R_n < R_{n+1}$ *whenever* $E_n > E_{n+1}$*. For a given positive-assortative divestment, there exist cutoffs* Λ_ℓ *and* Λ_h*,* $0 < \Lambda_\ell < \Lambda_h < \infty$*, such that:*

2. *The divestment strictly raises social surplus if depositors are sufficiently responsible,* $\bar{\lambda}_K > \Lambda_h$*.*

3. *The divestment strictly reduces social surplus if (i) depositors are insufficiently responsible,* $\bar{\lambda}_1 < \Lambda_\ell$*, and (ii) the banks' average externalities initially align with their average social responsibilities,* $\bar{E}_1 > \bar{E}_2 \ldots > \bar{E}_K$*.*

Positive-assortative sorting of depositors always improves social surplus. Corresponding divestment harms social surplus if the average responsibility λ_k is sufficiently low across all

banks, and improves social surplus if λ_k is sufficiently high. We see why in the contribution of bank k to the social surplus, which is proportional (up to a constant) to:

$$\mathbb{P}\left(\text{bank } k \text{ survives}\right)\left(\bar{R}_k + \bar{E}_k\right) = d_1\left(\bar{R}_k + \bar{E}_k\right) - d_2 - d_3\,\frac{\bar{E}_k}{\bar{R}_k} + d_4\,\frac{\bar{\lambda}_k \bar{E}_k}{\sigma+1}\left(1 + \frac{\bar{E}_k}{\bar{R}_k}\right),$$

in which $d_1, d_2, d_3, d_4 > 0$ are constants common to all banks.

Upon any divestment, changes in the linear terms $d_1(\bar{R}_k + \bar{E}_k) - d_2$ exactly offset each other across the affected banks. The remaining terms have opposing effects on the social surplus. On the one hand, in the natural case where higher financial payoffs imply worse externalities, a positive-assortative divestment raises the externality-to-payoffs ratio $\bar{E}_k/\bar{R}_k$ at the divesting banks (higher $\bar{\lambda}_k$ banks whose $\bar{E}_k$ increase), and reduces $\bar{E}_k/\bar{R}_k$ at some other banks. For the divesting banks, the numerator of $\bar{E}_k/\bar{R}_k$ increases and its denominator decreases, whereas the reverse is true for the other banks. Thus, the increase in $\bar{E}_k/\bar{R}_k$ at the divesting banks exceed the decrease in $\bar{E}_k/\bar{R}_k$ at the other banks. Overall, the second term $-d_3\bar{E}_k/\bar{R}_k$ reduces the social surplus. On the other hand, the complementarity term $d_4\frac{\bar{\lambda}_k\bar{E}_k}{\sigma+1}\left(1+\frac{\bar{E}_k}{\bar{R}_k}\right)$ raises the social surplus upon a positive-assortative divestment for aforementioned reasons. The complementarity term disappears as $\bar{\lambda}_k$ becomes small. Therefore, divestment strictly reduces the social surplus if all banks have sufficiently small λ_k and, symmetrically, strictly raises the social surplus if λ_k are sufficiently high.

The economic intuition behind the $-d_3\bar{E}_k/\bar{R}_k$ term is that divestment reallocates lower financial payoffs, alongside higher externalities, towards the divesting banks. Unless the depositors at the divesting bank heavily weight the externalities, the lower payoffs increase the bank's failure risk. Therefore, the divestment reallocates "green" technologies to exactly the banks that become more likely to fail. This effect leans against the rise in the social surplus due to the complementarity between externalities and social responsibility generated by divestment and sorting. Only the complementarity effect affects the financial surplus, which excludes the positive externalities that are lost as banks fail.

Depositor sorting does not change $\bar{R}_k$ or $\bar{E}_k$, and as such affects social surplus solely through the complementarity term. Accordingly, depositor sorting always strictly increases social surplus.

3.5 Illustration

We numerically illustrate Propositions 3 and 4 in two examples in which there are five banks, $K = 5$. Example 1 positively assorts the holdings across all banks. This counterfactual represents widespread adoption of exclusionary divestment or tilting policies by the banks with the more socially responsible depositors. Example 2 positively assorts three banks while leaving the other banks unchanged. This counterfactual represents, for example, two banks divesting from assets that do not align with their depositors' preferences through a shared intermediating bank. Our examples use two functions, $d(k, x)$ and $D(k, x)$:

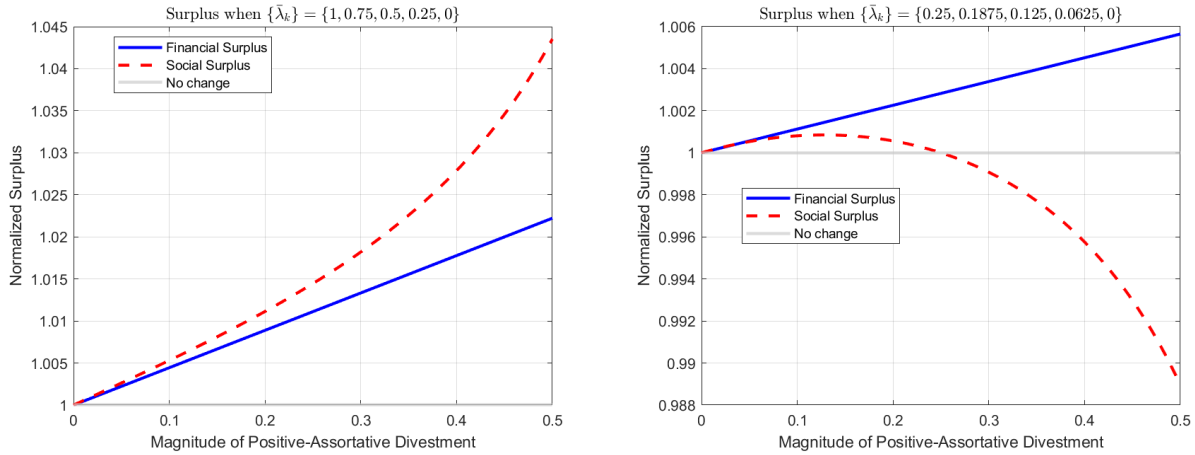
$$d(k,x) \coloneqq \begin{cases} x & , \quad \text{if } k = 1 \\ x/2 & , \quad \text{if } k = 2 \\ 0 & , \quad \text{if } k = 3 \\ -x/2 & , \quad \text{if } k = 4 \\ -x & , \quad \text{if } k = 5 \end{cases} \quad \text{and} \quad D(k,x) \coloneqq \begin{cases} 0.6x & , \quad \text{if } k = 1 \\ 0.4x & , \quad \text{if } k = 2 \\ -x & , \quad \text{if } k = 3 \end{cases}.$$

Example 1. There are $K = 5$ banks of equal size, $\omega_k = 1/5$ for $k = 1, \ldots, 5$, and two technologies, with externalities and payoffs $(E_1, R_1) = (3, 1)$ and $(E_2, R_2) = (-1, 3)$. (Technology 1 is "green" and technology 2 is "brown.") We set $\alpha = 0.5$, $\sigma = 1$, and $[\underline{\theta}, \bar{\theta}] = [-2, 3]$. The banks initially hold equal shares of the technologies, $\tau^0_{k,1} = \tau^0_{k,2} = 0.5$ for all k. We consider two economies, one where (a) the average depositor is highly responsible and another where (b) she is not. The economies correspond to the average social responsibilities of banks that follow (a) $\mathbf{\Lambda_h} = (\bar{\lambda}_1, \ldots, \bar{\lambda}_5) = (1, 0.75, 0.5, 0.25, 0)$ or (b) $\mathbf{\Lambda}_\ell = 0.25\mathbf{\Lambda_h}$. All example setups and their counterfactuals satisfy Assumptions 1 and 2.

We compute the financial and the social surpluses upon a range of positive-assortative divestments. Precisely, we vary $\tau_{k,1} = 0.5 + d(k, x)$ and $\tau_{k,2} = 0.5 - d(k, x)$ over $x \in [0, 0.5]$.

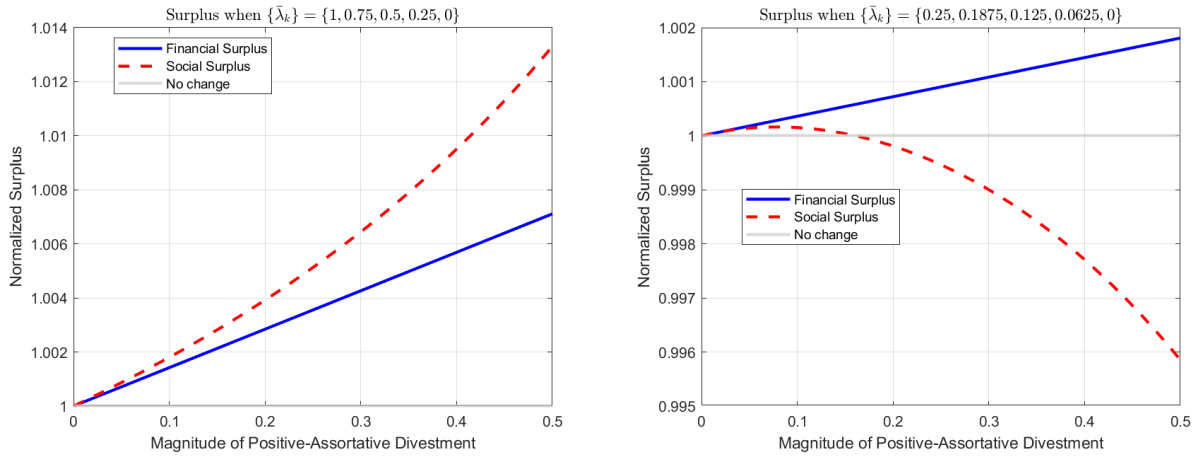
Example 2. We keep the setup of Example 1, then consider positive assortative exchanges between the three more responsible banks. Precisely, for $k \in \{1, 2, 3\}$, we vary $\tau_{k,1} = 0.5 + D(k, x)$ and $\tau_{k,2} = 0.5 - D(k, x)$ over $x \in [0, 0.5]$.

Figure 3 plots the impacts of the divestment in Example 1, which positively assorts all banks, normalizing the financial and the social surpluses by their initial values. Figure 4 plots the same for the divestment in Example 2, which positively assorts a subset of banks. In both examples, the financial surplus is always strictly increasing, whereas the social surplus strictly decreases when the depositors have low social responsibility.



(a) High Social Responsibility (b) Low Social Responsibility

Figure 3: Financial and Social Surplus Upon Divestment Across All Banks



(a) High Social Responsibility (b) Low Social Responsibility

Figure 4: Financial and Social Surplus Upon Divestment Across a Subset of Banks

4 Empirical Relevance

The pursuit of financial gains can explain the widespread adoption of divestment by financial institutions. We support this claim through three messages: First, our positive-assortative divestment encompasses a wide range of ESG-investing strategies, including exclusionary divestment, tilting, and spinoffs (Section 4.1). Second, recent evidence finds positive assorting between bank holdings and the social preferences of depositors (Section 4.2). Third, depositor selection into banks is likely to strengthen our results (Section 4.3).

4.1 ESG-Investing Practices

Exclusion and Tilting

Financial institutions engaged in ESG investing mainly practice exclusionary divestment or tilting (Bolton and Kacperczyk, 2021a,b; Pastor, Stambaugh, and Taylor, 2024a). Prior theory specifies the types of institutions that would adopt these strategies. In Heinkel et al. (2001), Broccardo et al. (2022), and Piccolo, Schneemeier, and Bisceglia (2022), socially responsible institutions exclude sufficiently brown assets from their portfolios in favor of green assets. In Pástor et al. (2021), Pedersen, Fitzgibbons, and Pomorski (2021), and Edmans, Levit, and Schneemeier (2022), the optimal portfolio of a socially responsible institution devotes a lesser weight to brown assets relative to the financially optimal portfolio, and thus tilts away from brown assets.

It is natural to map the social responsibility of institutions in this literature to the average responsibility $\bar{\lambda}_k$ of a bank's depositors in our model. A bank's social responsibility would stem from regulation and the preferences of its stakeholders, and both would be correlated with the preferences of the bank's depositors. Under this mapping, exclusion is a reallocation that shifts all technologies with sufficiently bad externalities (low E_n) from the banks with sufficiently responsible depositors (high $\bar{\lambda}_k$) to the banks with low $\bar{\lambda}_k$. Tilting is a reallocation that reduces the holdings of low E_n technologies from the high $\bar{\lambda}_k$ banks in exchange for high E_n technologies. Our definition of positive-assortative divestment encompasses such exclusion and tilting.

Spinoffs

Spinoffs of subsidiaries with social objectives have been common among banks. Examples include the DWS Group, an ESG-focused asset manager spun off from Deutsche Bank, and the Microfinance Foundation, which was the social lending arm of BBVA. In our framework, pure financial interests can rationalize ESG-focused spinoffs (Proposition 5).

Proposition 5. *Suppose some bank k "spins off" a subsidiary—splitting into two banks k' and k'', such that $\bar{E}_{k'} > \bar{E}_{k''}$ and $\bar{\lambda}_{k'} > \bar{\lambda}_{k''}$, while their combined average externality and social responsibility remain $\bar{E}_k$ and $\bar{\lambda}_k$. We split the liquid assets $\theta_k I$ proportionally between k' and k''. The sum of the financial surpluses at the new banks k' and k'' strictly exceeds the financial surplus of the original bank k.*

Any spinoff that positively assorts bank holdings and depositor preferences between the parent and the new subsidiary strictly increases their combined financial surplus. Thus, a banking group can always increase its financial payoffs by spinning off its greener technology holdings and more socially responsible depositors into a new subsidiary. Going beyond our model, transaction costs and loss in economies of scale would limit the spinoffs among banks to the reasonable numbers we actually observe.

4.2 Empirical Evidence

A nascent empirical literature finds that when banks divest, they do so positive assortatively, and stakeholder preferences drive these divestments. The banks that commit to reducing emissions indeed decrease lending and underwriting for highly polluting firms after the commitment (Kacperczyk and Peydró, 2022; Green and Vallee, forthcoming). Risk, expected returns, or time horizon do not explain the reduction in lending, consistent with the preferences of banks' stakeholders driving divestments. Similarly, banks that are members of a United Nations ESG initiative (UNEP FI) offer lower rates and fewer covenants on loans to firms that voluntarily disclose their emissions (Degryse, Goncharenko, Theunisz, and Vadasz, 2023). European institutions and signatories to a later UN ESG initiative (UN-PRI) more heavily tilt their equity holdings towards stocks with higher ESG ratings (Pastor et al., 2024a).

There is strong evidence that depositors are aware of the assets held by their banks, and prefer banks whose holdings are aligned with one's preferences. For example, bank branches in high-trust counties face larger withdrawals upon a downgrade in their community ratings (Chen, Hung, and Wang, 2023). Banks funding a controversial pipeline suffer lower deposit growth in states with greater opposition to the pipeline (Homanen, 2022). The same is true of banks lending to the gun industry in more Democrat-leaning counties around a mass shooting (Jeung, 2024). On the whole, more socially responsible depositors are more likely to withdraw from banks imposing worse externalities, consistent with the mechanism underlying our results.

4.3 Depositor Selection into Banks

Would our results persist if the depositors could choose their banks? Explicitly modeling this choice is an intractable problem in global games. We instead examine a broad class of reallocations that *jointly* shift externalities and social responsibilities across banks. To infer the impact of endogenous bank choice on the financial gains from divestment, we assume that the greener banks attract the more responsible depositors, as intuition and empirical evidence suggest.[10] Corollary 1 considers any joint reallocations that "simulate" the movement of the more responsible depositors towards the greener banks before or in response to a divestment.

Corollary 1. *We consider any given joint reallocation from the vectors of average externalities* $\bar{\mathbf{E}}$ *and social responsibilities* $\bar{\mathbf{\Lambda}}$ *to* $\bar{\mathbf{E}}'$ *and* $\bar{\mathbf{\Lambda}}'$ *such that either*

$$\bar{\mathbf{\Lambda}} \text{ to } \bar{\mathbf{\Lambda}}' \text{ is positive assortative w.r.t. } \bar{\mathbf{E}}, \text{ and } \bar{\mathbf{E}} \text{ to } \bar{\mathbf{E}}' \text{ is positive assortative w.r.t. } \bar{\mathbf{\Lambda}}';$$

$$\text{or } \bar{\mathbf{E}} \text{ to } \bar{\mathbf{E}}' \text{ is positive assortative w.r.t. } \bar{\mathbf{\Lambda}}, \text{ and } \bar{\mathbf{\Lambda}} \text{ to } \bar{\mathbf{\Lambda}}' \text{ is positive assortative w.r.t. } \bar{\mathbf{E}}'.$$

The joint reallocation strictly raises the financial surplus, and by a strictly larger magnitude than the positive-assortative divestment from $\bar{\mathbf{E}}$ *to* $\bar{\mathbf{E}}'$ *alone.*

As the more socially responsible depositors select into the greener banks, there is greater

[10] Piatti, Shapiro, and Wang (2023) shows that consequentialist investors would tilt their portfolios towards green assets, echoing our assumption.

potential complementarity between externalities and the average responsibility at a bank, expanding the financial gains from divestment. All financial gains are exhausted only when depositors and technology holdings cannot be further positively assorted.

An allocation $(\bar{\mathbf{E}}, \bar{\mathbf{\Lambda}})$ is *maximally positively assorted* if there is no positive-assortative divestment from $\bar{\mathbf{E}}$ with respect to $\bar{\mathbf{\Lambda}}$ nor depositor sorting from $\bar{\mathbf{\Lambda}}$ with respect to $\bar{\mathbf{E}}$. Given any permutation ϕ of banks $1, \ldots, K$, we let $\big(\bar{\mathbf{E}}(\phi), \bar{\mathbf{\Lambda}}(\phi)\big)$ allocate technologies and depositors to banks $\phi(1), \ldots, \phi(K)$ according to the pecking order of technology holdings by externality E_n and depositors by social responsibility λ_i.

Proposition 6. *We let* $\mathbf{M}$ *be the set of maximally positively assorted allocations.*

1. *The set* $\mathbf{M}$ *has* $K!$ *allocations,*

$$\mathbf{M} = \{\big(\bar{\mathbf{E}}(\phi), \bar{\mathbf{\Lambda}}(\phi)\big) : \phi \text{ is a permutation of } 1, \ldots, K\}. \tag{10}$$

2. *The allocation that maximizes the financial surplus is in* $\mathbf{M}$.

While the assorting will never be maximal in practice, the mechanism of Corollary 1 would push banks towards attracting more aligned depositors and retaining fewer non-aligned depositors.[11]

5 Contributions

We make three main contributions. (i) We develop the first and highly tractable global game in the presence of socially responsible agents. Our game adds two results. (ii) Any positive assorting between externalities and social preferences strictly raises the financial surplus. (iii) How the positive assorting occurs matters for society: Reallocating externalities harms the social surplus when social responsibility is weak, whereas reallocating preferences always benefits the social surplus.

[11] Depositors' stickiness to their current bank and the banks' strong market power would hamper sorting, despite the financial gains. First, depositors rarely switch banks, even when forgone interest income and savings on fees are large (Adams, Hunt, Palmer, and Zaliauskas, 2021). Second, banks extract substantial rents from their current depositors (Drechsler, Savov, and Schnabl, 2017, 2021), which may incentivize banks to retain non-aligned depositors.

The closest prior work to ours are on socially responsible investing (Section 5.1) and heterogeneity among intermediaries (Section 5.2).

5.1 Socially Responsible Investing

One literature analyzes the investing behavior of warm-glow investors who derive utility from holding green assets. Heinkel et al. (2001), Pástor et al. (2021), Pedersen et al. (2021), Piccolo et al. (2022), Wu and Zechner (2023), and Huang and Kopytov (2024) show that warm-glow investors construct portfolios consisting solely of or tilted towards green assets relative to portfolios that would maximize financial payoffs. The financial surplus is necessarily smaller with warm-glow investors than without in this literature.

An adjacent literature considers large funds with consequentialist mandates. Chowdhry, Davies, and Waters (2019) studies contracting between a socially responsible investor and a profit-seeking firm. Oehmke and Opp (2024) derives the optimal investment strategy of a large fund whose mandate is to maximize the social surplus. In both, the investor or fund subsidizes public goods provision at the expense of greater production costs. Green and Roth (2025) examines funds with varying degrees of social mandates. Each fund directs capital towards firms that would generate positive externalities yet would not be funded by profit-seeking investors. Gupta, Kopytov, and Starmans (2024) features socially responsible funds that encounter green or brown firms through search. The funds buy the brown firms, then incur a cost to turn them green. In each of these models, the presence of a socially responsible fund can only reduce the financial surplus.

Broccardo et al. (2022) assumes atomistic and consequentialist investors who can publicly commit to divesting from brown firms.[12] Firms incur costs to abate to avoid lower valuations if the investors are sufficiently responsible. Dangl, Halling, Yu, and Zechner (2023) shows, rather, that consequentialist investors do not affect firms' decisions if the share of externalities they consider in their utilities diminishes to zero as the economy grows.

We combine the strategies in the warm-glow literature and the preferences in the consequentialist literature. We substitute the risk of runs for the cost-of-capital channel. The

[12] Kaufmann et al. (2024) analyzes the behavior of consequentialist consumers who face an upward-sloping supply curve. Dewatripont and Tirole (2024) studies the impact of competition among consequentialist suppliers.

resulting framework features atomistic agents who internalize their marginal impacts, introducing the tractability and (in many settings) the realism of small agents to the consequentialist literature without endowing investors with commitment power. Its key implication starkly departs from both literatures—exclusionary divestment, tilting, or other positive assorting of assets and preferences strictly raises the financial surplus. Thus, financial institutions can cater to socially responsible clients without breaching fiduciary duty. More broadly, we show that divestment by institutions can have sharply different societal impact than sorting by their clients. While doing so, we separate the objectives of institutions from the preferences of their clients, opening the door to the study of profit-maximizing institutions whose clients are socially responsible.

5.2 Heterogeneous Intermediaries

We examine the impact of heterogeneity across bank holdings and social preferences of depositors on the expected financial loss from runs. A recent literature studies runs in settings with endogenous competition between heterogeneous banks. Boissay, Collard, and Smets (2016) models an economy with banks that differ in their per-unit cost of lending, may borrow or lend in the interbank market, and can fail. A decline in aggregate productivity induces the high-cost banks to borrow more in the interbank market, raising adverse selection risk. Sufficiently high risk triggers interbank trading to cease, driving up the expected loss from runs. Begenau and Landvoigt (2022) and Coimbra and Rey (2023) feature more and less risk-taking banks. Lower capital requirements (Begenau and Landvoigt, 2022) or interest rates (Coimbra and Rey, 2023) increase the market share of the more risk-taking banks, and thus raise the expected loss from runs. In this literature, increasing bank heterogeneity adds higher cost or more risk-taking banks into the economy, which naturally raises the expected loss from runs. We keep bank holdings exogenous, introduce nonpecuniary externalities, and show that the joint distribution of bank holdings and depositor preferences drives the expected loss from runs.

Two papers show that bank heterogeneity can reduce the expected loss from runs, as we do. Gennaioli et al. (2013) and Goldstein, Kopytov, Shen, and Xiang (2024) model banks whose asset holdings have idiosyncratic risk and a market where banks can liquidate assets to

stave off failure. Diversification (Gennaioli et al., 2013) or homogenization of balance sheets (Goldstein et al., 2024) increases the banks' exposure to systemic risk. Doing so makes simultaneous declines in the values of bank holdings more likely. Asset prices would sharply fall upon such declines, as many banks seek to liquidate their holdings at once. Thus, the expected loss from runs is smaller where the banks are more heterogeneous. We replace the fire-sale externality with nonpecuniary ones and consider social preferences. Our framework adds the insight that the impact of heterogeneity in bank holdings hinge around preferences: Positive assorting of bank holdings and depositor preferences strictly decreases the expected loss from runs, whereas negative assorting strictly increases the loss.

6 Conclusion

We abstract away several features important for bank runs and socially responsible investing, including deposit insurance, government policies, decision-making within firms, and financial contagion. The 2023 runs on Silicon Valley Bank and others demonstrate the continuing relevance of bank failure risk for depositors. They reveal that the cap on deposit insurance is binding for many depositors, especially the top decile which own the vast majority of deposits (Argyle, Iverson, Kotter, Nadauld, and Palmer, 2025). More importantly, deposit insurance induces moral hazard, and the resulting deadweight loss is increasing in the underlying cost of runs that deposit insurance is meant to mitigate. If divestment reduces this underlying cost, then it would also shrink the deadweight loss induced by deposit insurance.

A long-standing literature derives optimal policies in the presence of nonpecuniary externalities, typically pollution taxes or cap-and-trade (Barnett, 1980; Laffont and Tirole, 1996; Hoffmann, Inderst, and Moslener, 2017). Its recent contributions add socially responsible agents into the optimal policy problem (Hong, Wang, and Yang, 2023; Biais and Landier, 2022; Döttling and Rola-Janicka, 2024). The resulting policies would affect the joint distribution of externalities and financial payoffs among technologies in our model. We show that, no matter this joint distribution, financial institutions have a financial incentive to positively assort their holdings to the social responsibilities of their clients.

Our framework does not incorporate the exercise of shareholder voice (Morgan and Tumlinson, 2019; Huang and Kopytov, 2024; Döttling, Levit, Malenko, and Rola-Janicka, 2024) or inside stakeholders (Chang and Hong, 2023; Geelen, Hajda, and Starmans, 2025). We instead focus on withdrawals as the voice of outside clients. Unlike selling competitively priced assets, which puts downward pressure on prices and thereby invites replacement capital, withdrawals of deposits increase the risk of bank failure without a countervailing effect through prices. In this sense, withdrawals allow depositors to voice their wish to shrink brown banks, the key mechanism underlying our results.

We identify financial gains from connections among banks whose depositors differ in their social responsibility. We do not consider its impact on financial contagion, since a rich literature following Allen and Gale (2000) and Freixas, Parigi, and Rochet (2000) already provides them. Specifically, Acemoglu, Ozdaglar, and Tahbaz-Salehi (2015) predicts that a densely connected financial network minimizes systemic risk when banks are subject to small shocks, whereas a sparse network is safer when shocks are large. If the financial gains induce banks to form new connections, our mechanism would create denser networks and protection from small shocks. If the gains cause banks to focus their connections on a few banks with quite disparate depositors, they could protect against large shocks.

Appendix

A Proofs

Proof of Proposition 1. First, we show that the candidate switching equilibrium s^* is indeed an equilibrium.

Given fundamental θ, the probability that each depositor observes a signal below her cutoff s^* and runs is

$$H\left(\frac{s^*-\theta}{\sigma}\right)=\begin{cases}\dfrac{s^*-\theta}{\sigma}+\dfrac{1}{2} & \text{if } \theta\in\left[s^*-\dfrac{\sigma}{2},s^*+\dfrac{\sigma}{2}\right]\\ 0 & \text{if } \theta>s^*+\dfrac{\sigma}{2}\\ 1 & \text{if } \theta<s^*-\dfrac{\sigma}{2}.\end{cases}$$

The exact law of large numbers implies that the proportion n of depositors choosing to run is

$$n=H\left(\frac{s^*-\theta}{\sigma}\right).$$

The bank fails if and only if it has insufficient liquid assets to meet all demands for early withdrawal, $\theta I<nI$, which is equivalent to $\theta<\theta^*$.

Upon observing a signal $s_i\leq\theta^*-\frac{\sigma}{2}$, a depositor infers that $\theta<\theta^*$, and thus the bank fails with probability 1. Hence, $\pi(s_i)=-1<0$ and the depositor optimally chooses to run. Likewise, upon observing a signal $s_i\geq\theta^*+\frac{\sigma}{2}$, $\pi(s_i)=R-1>0$ and the depositor optimally chooses to stay.

Next, we consider the case $s_i\in\left(\theta^*-\frac{\sigma}{2},\theta^*+\frac{\sigma}{2}\right)$. For all $\theta\in\left[s^*-\frac{\sigma}{2},s^*+\frac{\sigma}{2}\right]$,

$$\frac{\mathrm{d}n}{\mathrm{d}\theta}=\frac{\mathrm{d}}{\mathrm{d}\theta}H\left(\frac{s^*-\theta}{\sigma}\right)=-\frac{1}{\sigma}.$$

Thus, upon observing any signal $s_i\in\left(\theta^*-\frac{\sigma}{2},\theta^*+\frac{\sigma}{2}\right)$, a depositor's perceived probability of

being pivotal is

$$\Delta P(s_i) = \mathbb{P}\left(\theta - n \in \left[0, \frac{1}{I}\right] \,\middle|\, s_i\right) = \mathbb{P}\left(\theta \in \left[\theta^*, \theta^* + \frac{1}{1+\frac{1}{\sigma}}\frac{1}{I}\right] \,\middle|\, s_i\right)$$
$$= \frac{1}{\sigma}\frac{1}{1+\frac{1}{\sigma}}\frac{1}{I} = \frac{1}{\sigma+1}\frac{1}{I}.$$

Then, the utility gain $\pi(s_i)$ from staying over running becomes

$$\begin{aligned}
\pi(s_i) &= \mathbb{P}\left(\theta \geq n \,|\, s_i\right) R - 1 + \Delta P(s_i)\alpha\lambda IE \\
&= \mathbb{P}\left(\theta \geq \theta^* \,|\, s_i\right) R - 1 + \frac{\alpha}{\sigma+1}\frac{1}{I} \cdot \lambda IE \\
&= H\left(\frac{s_i - \theta^*}{\sigma}\right) R - 1 + \frac{\alpha}{\sigma+1}\lambda E \\
&= \left(\frac{s_i - \theta^*}{\sigma} + \frac{1}{2}\right) R - 1 + \frac{\alpha}{\sigma+1}\lambda E \\
&= \left(s_i - \left[\theta_i^* + \sigma\left(\psi - \frac{1}{2}\right)\right]\right)\frac{R}{\sigma} \\
&= \left(s_i - s_i^*\right)\frac{R}{\sigma}.
\end{aligned}$$

Therefore, the depositor optimally runs whenever her signal $s_i < s_i^*$ and optimally stays whenever $s_i > s_i^*$.

Next, we show that s^* is the unique switching equilibrium. When every depositor i follows some switching strategy s_i^*, the probability that i observes a signal below her cutoff s_i^* and runs is $H\left(\frac{s_i^* - \theta}{\sigma}\right)$. The exact law of large numbers implies that the proportion n of depositors running is

$$n = \int H\left(\frac{s_i^* - \theta}{\sigma}\right) \mathrm{d}i. \tag{11}$$

Let $\vec{s^*}$ denote the vector of run thresholds $(s_i^*)_{i\in[0,1]}$. The bank fails if and only if the value of its liquid assets is below a critical threshold $\theta^*(\vec{s^*})I$, where $\theta^*(\vec{s^*})$ solves

$$\theta^*(\vec{s^*}) = \int H\left(\frac{s_i^* - \theta^*(\vec{s^*})}{\sigma}\right) \mathrm{d}i, \tag{12}$$

which says that at the critical threshold, $\theta = \theta^*(\vec{s}^*)$, the bank has just enough liquid assets to meet all demands for early withdrawal.

Because a marginal depositor i is indifferent between running or not upon observing the cutoff signal s_i^*, $\pi(s_i^*) = 0$, the critical threshold $\theta^*(\vec{s}^*)$ must fall within the support of the posterior belief on the fundamental θ of the marginal depositor i,

$$\theta^*(\vec{s}^*) \in \left[s_i^* - \frac{\sigma}{2}, s_i^* + \frac{\sigma}{2}\right]. \tag{13}$$

Otherwise, the marginal depositor i would believe that the bank survives with probability 1 or 0, $\mathbb{P}\left(\theta > \theta^*(\vec{s}^*) \,|\, s_i = s_i^*\right) = 1$ or 0, and that she is pivotal with probability 0, $\Delta P(s_i^*) = 0$, and thus i cannot be indifferent between running and staying under such beliefs: $\pi(s_i^*) = \mathbb{P}\left(\theta > \theta^*(\vec{s}^*) \,|\, s_i = s_i^*\right) R - 1 + \Delta P(s_i^*)\lambda I E \neq 0$.

It then follows from (13) that

$$\frac{\mathrm{d}}{\mathrm{d}\theta}_{|\theta=\theta^*(\vec{s}^*)} H\left(\frac{s_i^* - \theta}{\sigma}\right) = -\frac{1}{\sigma} \qquad \forall i.$$

Differentiating (11) with respect to θ at the fundamental threshold $\theta = \theta^*(\vec{s}^*)$ gives

$$\frac{\mathrm{d}n}{\mathrm{d}\theta}_{|\theta=\theta^*(\vec{s}^*)} = -\frac{1}{\sigma}.$$

Thus, the marginal depositor's perceived probability of being pivotal is

$$\begin{aligned}
\Delta P(s_i^*) &= \mathbb{P}\left(\theta - n \in \left[0, \frac{1}{I}\right] \,\middle|\, s_i = s_i^*\right) \\
&= \mathbb{P}\left(\theta \in \left[\theta^*, \theta^* + \frac{1}{1+\frac{1}{\sigma}}\frac{1}{I}\right] \,\middle|\, s_i = s_i^*\right) \\
&= \frac{1}{\sigma}\frac{1}{1+\frac{1}{\sigma}}\frac{1}{I} = \frac{1}{\sigma+1}\frac{1}{I}.
\end{aligned}$$

Then, $\pi(s_i^*)$ becomes

$$\begin{aligned}\pi(s_i^*) &= \mathbb{P}\left(\theta \geq n \,|\, s_i = s_i^*\right) R - 1 + \Delta P(s_i^*)\lambda IE \\ &= \mathbb{P}\left(\theta \geq \theta^*(\vec{s}^*) \,|\, s_i = s_i^*\right) R - 1 + \frac{1}{\sigma+1}\frac{1}{I} \cdot \lambda IE \\ &= H\left(\frac{s_i^* - \theta^*(\vec{s}^*)}{\sigma}\right) R - 1 + \frac{\alpha}{\sigma+1}\lambda E.\end{aligned}$$

Thus, the indifference condition $\pi(s_i^*) = 0$ is equivalent to

$$H\left(\frac{s_i^* - \theta^*(\vec{s}^*)}{\sigma}\right) = \psi.$$

Hence, (12) becomes

$$\theta^*(\vec{s}^*) = H\left(\frac{s_i^* - \theta^*(\vec{s}^*)}{\sigma}\right) = \frac{s_i^* - \theta^*(\vec{s}^*)}{\sigma} + \frac{1}{2} = \psi,$$

which yields

$$s_i^* = (\sigma+1)\psi - \frac{\sigma}{2}$$

and thus (2).

□

Proof of Proposition 2. We generalize the proof of Proposition 1 to a bank with heterogeneous depositors λ_i.

First, we show that the candidate switching equilibrium $(s_{i,k}^*)$ is indeed an equilibrium. The probability that each depositor of bank k observes a signal below her cutoff $s_{i,k}^*$ and runs is $H\left(\frac{s_{i,k}^* - \theta_k}{\sigma}\right)$. The exact law of large numbers implies that the proportion n_k of depositors running from bank k is

$$n_k = \int H\left(\frac{s_{i,k}^* - \theta_k}{\sigma}\right) \mathrm{d}i.$$

When $\theta_k = \theta_k^*$,

$$\frac{s_{i,k}^* - \theta_k}{\sigma} \in \left(-\frac{1}{2}, \frac{1}{2}\right) \qquad \forall i,$$

and thus

$$\begin{aligned} n_k &= \int \frac{s^*_{i,k} + \frac{\sigma}{2} - \theta^*_k}{\sigma} \, \mathrm{d}i \\ &= \frac{\theta^*_k + \sigma \, \frac{1 - \frac{\int \lambda_i \mathrm{d}i}{\sigma+1} \bar{E}_k}{\bar{R}_k} - \theta^*_k}{\sigma} = \theta^*_k. \end{aligned}$$

Hence, the bank fails if and only if it has insufficient liquid assets to meet all demands for early withdrawal, $\theta_k \omega_k I < n_k \omega_k I$, which is equivalent to $\theta_k < \theta^*_k$.

Upon observing a signal $s_{i,k} \leq \theta^*_k - \frac{\sigma}{2}$, a depositor infers that $\theta_k < \theta^*_k$, and thus the bank fails with probability 1. Hence, $\pi(s_{i,k}) = -1 < 0$ and the depositor optimally runs. Likewise, upon observing a signal $s_{i,k} \geq \theta^*_k + \frac{\sigma}{2}$, $\pi(s_{i,k}) = R - 1 > 0$ and the depositor optimally stays.

Next, we consider the case $s_{i,k} \in \left(\theta^*_k - \frac{\sigma}{2}, \theta^*_k + \frac{\sigma}{2}\right)$. It follows from $\theta^*_k \in \left[s^*_{i,k} - \frac{\sigma}{2}, s^*_{i,k} + \frac{\sigma}{2}\right]$ that

$$\frac{\mathrm{d}n}{\mathrm{d}\theta_k}_{|\theta_k = \theta^*_k} = \int \frac{\mathrm{d}}{\mathrm{d}\theta_k}_{|\theta_k = \theta^*_k} H\left(\frac{s^*_{i,k} - \theta_k}{\sigma}\right) \mathrm{d}i = -\frac{1}{\sigma}.$$

Thus, upon observing any signal $s_{i,k} \in \left(\theta^*_k - \frac{\sigma}{2}, \theta^*_k + \frac{\sigma}{2}\right)$, a depositor's perceived probability of being pivotal is

$$\begin{aligned} \Delta P(s_{i,k}) &= \mathbb{P}\left(\theta_k - n_k \in \left[0, \frac{1}{\omega_k I}\right] \,\middle|\, s_{i,k}\right) \\ &= \mathbb{P}\left(\theta_k \in \left[\theta^*_k, \theta^*_k + \frac{1}{1 + \frac{1}{\sigma}} \frac{1}{\omega_k I}\right] \,\middle|\, s_{i,k}\right) \\ &= \frac{1}{\sigma} \frac{1}{1 + \frac{1}{\sigma}} \frac{1}{\omega_k I} \\ &= \frac{1}{\sigma + 1} \frac{1}{\omega_k I}. \end{aligned}$$

Then, the utility gain $\pi(s_{i,k})$ from staying over running becomes

$$\begin{aligned}
\pi(s_{i,k}) &= \mathbb{P}\left(\theta_K \geq n_k \,|\, s_{i,k}\right) \bar{R}_k - 1 + \Delta P(s_{i,k}) \alpha \lambda_i \omega_k I \bar{E}_k \\
&= \mathbb{P}\left(\theta_k \geq \theta_k^* \,|\, s_{i,k}\right) \bar{R}_k - 1 + \frac{\alpha}{\sigma + 1} \frac{1}{\omega_k I} \cdot \lambda_i \omega_k I \bar{E}_k \\
&= H\left(\frac{s_{i,k} - \theta_k^*}{\sigma}\right) \bar{R}_k - 1 + \frac{\alpha}{\sigma + 1} \lambda_i \bar{E}_k \\
&= \left(\frac{s_{i,k} - \theta_k^*}{\sigma} + \frac{1}{2}\right) \bar{R}_k - 1 + \frac{\alpha}{\sigma + 1} \lambda_i \bar{E}_k \\
&= \left(s_{i,k} - s_{i,k}^*\right) \frac{\bar{R}_k}{\sigma}.
\end{aligned}$$

Therefore, the depositor optimally runs whenever her signal $s_{i,k} < s_{i,k}^*$ and optimally stays whenever $s_{i,k} > s_{i,k}^*$.

Next, we show that $\left(s_{i,k}^*\right)$ is the unique switching equilibrium. When every depositor i follows some switching strategy $\tilde{s}_{i,k}^*$, the probability that i observes a signal below her cutoff $\tilde{s}_{i,k}^*$ and runs is $H\left(\frac{\tilde{s}_{i,k}^* - \theta_k}{\sigma}\right)$. The exact law of large numbers implies that the proportion n of depositors running is

$$n_k = \int H\left(\frac{\tilde{s}_{i,k}^* - \theta_k}{\sigma}\right) \mathrm{d}i. \tag{14}$$

Let $\tilde{s}_k^*$ denote the vector of run thresholds $(\tilde{s}_{i,k}^*)_{i \in [0,1]}$. The bank fails if and only if the value of its liquid assets is below the critical threshold $\theta^*(\tilde{s}_k^*)\omega_k I$. Because a marginal depositor i is indifferent between running and staying upon observing the cutoff signal $\tilde{s}_{i,k}^*$, $\pi(\tilde{s}_{i,k}^*) = 0$, the critical threshold $\theta^*(\tilde{s}_k^*)$ must fall within the support of the posterior belief on the fundamental θ_k of the marginal depositor i,

$$\theta^*(\tilde{s}_k^*) \in \left[\tilde{s}_{i,k}^* - \frac{\sigma}{2}, \tilde{s}_{i,k}^* + \frac{\sigma}{2}\right]. \tag{15}$$

Otherwise, the marginal depositor i would believe that the bank survives with probability 1 or 0, $\mathbb{P}\left(\theta_k > \theta^*(\tilde{s}_k^*) \,|\, s_{i,k} = \tilde{s}_{i,k}^*\right) = 1$ or 0, and thus i is pivotal with probability 0, $\Delta P(\tilde{s}_{i,k}^*) = 0$, then i cannot be indifferent between running and staying under such beliefs: $\pi(\tilde{s}_{i,k}^*) =$

$\mathbb{P}\left(\theta_k > \theta^*(\tilde{s}_k^*) \,|\, s_{i,k} = \tilde{s}_{i,k}^*\right) R_k - 1 + \Delta P(\tilde{s}_{i,k}^*)\lambda_i \omega_k I E_k \neq 0$. It then follows from (15) that

$$\frac{\mathrm{d}}{\mathrm{d}\theta_k}_{|\theta_k = \theta^*(\tilde{s}_k^*)} H\left(\frac{\tilde{s}_{i,k}^* - \theta_k}{\sigma}\right) = -\frac{1}{\sigma} \qquad \forall i.$$

Differentiating (14) with respect to θ_k at the fundamental threshold $\theta_k = \theta^*(\tilde{s}_k^*)$ gives

$$\frac{\mathrm{d}n}{\mathrm{d}\theta_k}_{|\theta_k = \theta^*(\tilde{s}_k^*)} = -\frac{1}{\sigma}.$$

Thus, the marginal depositor's perceived probability of being pivotal is

$$\begin{aligned}
\Delta P(\tilde{s}_{i,k}^*) &= \mathbb{P}\left(\theta_k - n_k \in \left[0, \frac{1}{\omega_k I}\right] \,\middle|\, s_{i,k} = \tilde{s}_{i,k}^*\right) \\
&= \mathbb{P}\left(\theta \in \left[\theta_k^*, \theta_k^* + \frac{1}{1+\frac{1}{\sigma}} \frac{1}{\omega_k I}\right] \,\middle|\, s_{i,k} = \tilde{s}_{i,k}^*\right) \\
&= \frac{1}{\sigma} \frac{1}{1+\frac{1}{\sigma}} \frac{1}{\omega_k I} = \frac{1}{\sigma+1} \frac{1}{\omega_k I}.
\end{aligned}$$

Then, $\pi(\tilde{s}_{i,k}^*)$ becomes

$$\begin{aligned}
&\mathbb{P}\left(\theta_k \geq n_k \,|\, s_{i,k} = \tilde{s}_{i,k}^*\right) \bar{R}_k - 1 + \Delta P(\tilde{s}_{i,k}^*)\alpha\lambda_i \omega_k I \bar{E}_k \\
&= \mathbb{P}\left(\theta \geq \theta^*(\tilde{s}_k^*) \,|\, s_{i,k} = \tilde{s}_{i,k}^*\right) \bar{R}_k - 1 + \frac{\alpha}{\sigma+1} \frac{1}{\omega_k I} \cdot \lambda_i \omega_k I \bar{E}_k \\
&= H\left(\frac{\tilde{s}_{i,k}^* - \theta^*(\tilde{s}_k^*)}{\sigma}\right) \bar{R}_k - 1 + \frac{\alpha}{\sigma+1} \lambda_i \bar{E}_k.
\end{aligned}$$

Thus, the indifference condition $\pi(\tilde{s}_{i,k}^*) = 0$ is equivalent to

$$H\left(\frac{\tilde{s}_{i,k}^* - \theta^*(\tilde{s}_k^*)}{\sigma}\right) = \psi_k(\lambda_i). \tag{16}$$

Hence, (12) becomes

$$\theta^*(\tilde{s}_k^*) = \int H\left(\frac{\tilde{s}_{i,k}^* - \theta^*(\tilde{s}_k^*)}{\sigma}\right) \mathrm{d}i = \frac{\int s_{i,k}^* \mathrm{d}i - \theta^*(\tilde{s}_k^*)}{\sigma} + \frac{1}{2} = \int \psi_k(\lambda_i)\mathrm{d}i = \psi_k(\bar{\lambda}_k).$$

Therefore, (16) becomes

$$\tilde{s}_{i,k}^* = \psi_k\left(\bar{\lambda}_k\right) + \sigma\psi_k(\lambda_i) - \frac{\sigma}{2} = s_{i,k}^*,$$

which yields (8) and (9).

□

Proof of Proposition 3. *Parts 1 and 2:*

We let $\bar{R} = \sum_{k=1}^K \omega_k \bar{R}_k$ be the average financial payoff across all technologies.

$$\begin{aligned}
\text{Financial surplus} &= \sum_{k=1}^K \Big[\big(\mathbb{P}\left(\text{bank } k \text{ survives}\right) + \alpha\mathbb{P}\left(\text{bank } k \text{ fails}\right)\big)\bar{R}_k - 1\Big]\omega_k I \\
&= \sum_{k=1}^K \left[\alpha\mathbb{P}\left(\text{bank } k \text{ fails}\right)\right]\bar{R}_k\omega_k I - I \\
&= \sum_{k=1}^K \left[\alpha\frac{\theta_k^* - \underline{\theta}}{\bar{\theta} - \underline{\theta}}\right]\bar{R}_k\omega_k I - I \\
&= \bar{R}I - \frac{\alpha}{\bar{\theta} - \underline{\theta}}\sum_{k=1}^K \frac{1 - \bar{\lambda}_k\bar{E}_k}{\bar{R}_k}\bar{R}_k\omega_k I + \frac{\alpha\underline{\theta}}{\bar{\theta} - \underline{\theta}}\bar{R}I - I \\
&= \frac{\alpha}{\bar{\theta} - \underline{\theta}}\sum_{k=1}^K \omega_k\bar{\lambda}_k\bar{E}_k I \\
&\quad + \bar{R}I - \frac{\alpha}{\bar{\theta} - \underline{\theta}}I + \frac{\alpha\underline{\theta}}{\bar{\theta} - \underline{\theta}}\bar{R}I - I.
\end{aligned}$$

We consider the impact of a positive-assortative divestment from τ to τ'. We order the banks by their social responsibility, $\bar{\lambda}_1 > \ldots > \bar{\lambda}_K$, and let $\bar{E}'_k = \sum_{n=1}^N \tau_{k,n}E_n$ be the average externality of the banks' technology holdings after the divestment.

We apply Abel transformation to the term $\sum_{k=1}^{K} \omega_k \bar{\lambda}_k \bar{E}_k$ as follows:

$$\begin{aligned}
&\sum_{k=1}^{K} \omega_k \bar{\lambda}_k \bar{E}_k \\
=& \sum_{k=1}^{K} \left(\sum_{\kappa=1}^{k} \omega_\kappa \bar{E}_\kappa - \sum_{\kappa=1}^{k-1} \omega_\kappa \bar{E}_\kappa \right) \bar{\lambda}_k \\
=& \sum_{\kappa=1}^{K} \omega_\kappa \bar{E}_\kappa \bar{\lambda}_K + \sum_{k=1}^{K-1} \sum_{\kappa=1}^{k} \omega_\kappa \bar{E}_\kappa \left(\bar{\lambda}_k - \bar{\lambda}_{k+1} \right)
\end{aligned}$$

Given that a divestment keeps constant the average externality of all technologies,

$$\sum_{\kappa=1}^{K} \omega_\kappa \bar{E}_\kappa = \sum_{\kappa=1}^{K} \omega_\kappa \bar{E}'_\kappa,$$

then

$$\begin{aligned}
&\sum_{k=1}^{K} \omega_k \bar{\lambda}_k \bar{E}'_k - \sum_{k=1}^{K} \omega_k \bar{\lambda}_k \bar{E}_k \\
=& \sum_{k=1}^{K-1} \left(\sum_{\kappa=1}^{k} \omega_\kappa \bar{E}'_\kappa - \sum_{\kappa=1}^{k} \omega_\kappa \bar{E}_\kappa \right) \left(\bar{\lambda}_k - \bar{\lambda}_{k+1} \right) > 0.
\end{aligned}$$

Therefore, the positive-assortative divestment strictly raises the financial surplus. So does any sorting of depositors with a symmetric argument.

Part 3: Applying the above argument to any divestment or sorting of depositors amongst a subset $\mathcal{K}$ of banks implies Part 3.

□

Proof of Proposition 4. We let $\bar{E} = \sum_{k=1}^{K} \omega_k \bar{E}_k$ be the average externalities of all technologies.

$$
\begin{aligned}
\text{Social surplus} &= \sum_{k=1}^{K} \Big[\big(\mathbb{P}\left(\text{bank } k \text{ survives}\right) + \alpha \mathbb{P}\left(\text{bank } k \text{ fails}\right) \big) (\bar{R}_k + \bar{E}_k) - 1 \Big] \omega_k I \\
&= \sum_{k=1}^{K} \left[1 - \alpha \mathbb{P}\left(\text{bank } k \text{ fails}\right) \right] \left(\bar{R}_k + \bar{E}_k \right) \omega_k I - I \\
&= \sum_{k=1}^{K} \left[1 - \alpha \frac{\theta_k^* - \underline{\theta}}{\bar{\theta} - \underline{\theta}} \right] \left(\bar{R}_k + \bar{E}_k \right) \omega_k I - I \\
&= \left(\bar{R} + \bar{E} \right) I - \frac{\alpha}{\bar{\theta} - \underline{\theta}} \sum_{k=1}^{K} \frac{1 - \bar{\lambda}_k \bar{E}_k}{\bar{R}_k} \left(\bar{R}_k + \bar{E}_k \right) \omega_k I + \frac{\alpha \underline{\theta}}{\bar{\theta} - \underline{\theta}} \bar{R} I - I \\
&= \frac{\alpha}{\bar{\theta} - \underline{\theta}} \left[\sum_{k=1}^{K} \omega_k \bar{\lambda}_k \bar{E}_k \left(1 + \frac{\bar{E}_k}{\bar{R}_k} \right) - \sum_{k=1}^{K} \frac{\bar{E}_k}{\bar{R}_k} \right] I \\
&\quad + \left(\bar{R} + \bar{E} \right) I - \frac{\alpha}{\bar{\theta} - \underline{\theta}} I + \frac{\alpha \underline{\theta}}{\bar{\theta} - \underline{\theta}} \left(\bar{R} + \bar{E} \right) I - I
\end{aligned}
$$

Parts 1 and 2: We consider the impact of a positive-assortative divestment from τ to τ'. Let $\bar{R}'_k = \sum_{n=1}^{N} \tau_{k,n} R_n$ be the average gross financial payoff of bank k, and let $\bar{E}'_k = \sum_{n=1}^{N} \tau_{k,n} E_n$ be its average externality after the divestment. Then, it follows from three Abel transformations that

$$
\sum_{k=1}^{K} \omega_k \bar{\lambda}_k \bar{E}'_k \left(1 + \frac{\bar{E}'_k}{\bar{R}'_k} \right) > \sum_{k=1}^{K} \omega_k \bar{\lambda}_k \bar{E}_k \left(1 + \frac{\bar{E}_k}{\bar{R}_k} \right)
$$

$$
\sum_{k=1}^{K} \frac{\bar{E}'_k}{\bar{R}'_k} > \sum_{k=1}^{K} \frac{\bar{E}_k}{\bar{R}_k}.
$$

If all the $\bar{\lambda}_k$ are sufficiently small, $\bar{\lambda}_1 < \Lambda_\ell$ for some $\Lambda_\ell > 0$, then

$$
\sum_{k=1}^{K} \omega_k \bar{\lambda}_k \bar{E}'_k \left(1 + \frac{\bar{E}'_k}{\bar{R}'_k} \right) - \sum_{k=1}^{K} \omega_k \bar{\lambda}_k \bar{E}_k \left(1 + \frac{\bar{E}_k}{\bar{R}_k} \right) < \sum_{k=1}^{K} \frac{\bar{E}'_k}{\bar{R}'_k} - \sum_{k=1}^{K} \frac{\bar{E}_k}{\bar{R}_k},
$$

and thus the divestment strictly reduces social surplus. The opposite holds if all the $\bar{\lambda}_k$ are sufficiently large, $\bar{\lambda}_K > \Lambda_h$ for some $\Lambda_h > \Lambda_\ell$.

Part 3: The sorting of depositors strictly raises the term $\sum_{k=1}^{K} \omega_k \bar{\lambda}_k \bar{E}_k \left(1 + \frac{\bar{E}_k}{\bar{R}_k} \right)$ without

affecting the other terms in the social surplus. Therefore, the sorting of depositors always strictly raises the social surplus.

□

Proof of Proposition 5. Before the spinoff, the financial surplus generated by bank k is

$$\Big[\big(\mathbb{P}\left(\text{bank } k \text{ survives}\right) + \alpha\mathbb{P}\left(\text{bank } k \text{ fails}\right)\big)\bar{R}_k - 1\Big]\omega_k I$$

$$= \frac{\alpha}{\bar{\theta}-\underline{\theta}}\omega_k\bar{\lambda}_k\bar{E}_k I + \bar{R}_k\omega_k I - \frac{\alpha}{\bar{\theta}-\underline{\theta}}\omega_k I + \frac{\alpha\underline{\theta}}{\bar{\theta}-\underline{\theta}}\bar{R}_k\omega_k I - \omega_k I.$$

After the spinoff, the combined financial surplus generated by banks k' and k'' is

$$\Big[\big(\mathbb{P}\left(\text{bank } k' \text{ survives}\right) + \alpha\mathbb{P}\left(\text{bank } k' \text{ fails}\right)\big)\bar{R}_{k'} - 1\Big]\omega_{k'} I + \Big[\big(\mathbb{P}\left(\text{bank } k'' \text{ survives}\right) + \alpha\mathbb{P}\left(\text{bank } k'' \text{ fails}\right)\big)\bar{R}_{k''} - 1\Big]\omega_{k''} I$$

$$= \frac{\alpha}{\bar{\theta}-\underline{\theta}}\omega_{k'}\bar{\lambda}_{k'}\bar{E}_{k'} I + \frac{\alpha}{\bar{\theta}-\underline{\theta}}\omega_{k''}\bar{\lambda}_{k''}\bar{E}_{k''} I + \bar{R}_{k'}\omega_{k'} I - \frac{\alpha}{\bar{\theta}-\underline{\theta}}\omega_{k'} I + \frac{\alpha\underline{\theta}}{\bar{\theta}-\underline{\theta}}\bar{R}_{k'}\omega_{k'} I - \omega_{k'} I + \bar{R}_{k''}\omega_{k''} I - \frac{\alpha}{\bar{\theta}-\underline{\theta}}\omega_{k''} I + \frac{\alpha\underline{\theta}}{\bar{\theta}-\underline{\theta}}\bar{R}_{k''}\omega_{k''} I - \omega_{k''} I$$

$$= \frac{\alpha}{\bar{\theta}-\underline{\theta}}\omega_{k'}\bar{\lambda}_{k'}\bar{E}_{k'} I + \frac{\alpha}{\bar{\theta}-\underline{\theta}}\omega_{k''}\bar{\lambda}_{k''}\bar{E}_{k''} I + \bar{R}_k\omega_k I - \frac{\alpha}{\bar{\theta}-\underline{\theta}}\omega_k I + \frac{\alpha\underline{\theta}}{\bar{\theta}-\underline{\theta}}\bar{R}_k\omega_k I - \omega_k I.$$

The spinoff strictly raises the financial surplus because

$$\omega_k\bar{\lambda}_k\bar{E}_k < \omega_{k'}\bar{\lambda}_{k'}\bar{E}_{k'} + \omega_{k''}\bar{\lambda}_{k''}\bar{E}_{k''}.$$

□

Proof of Corollary 1. Corollary 1 follows from Proposition 3.

□

Proof of Proposition 6. *Part 1:* We establish (10) through an induction in K.

When $K = 1$, (10) is trivial. We suppose that (10) holds for K. For $K+1$, we first show that any allocation $\left(\bar{\mathbf{E}}(\phi), \bar{\mathbf{\Lambda}}(\phi)\right)$, where ϕ is a permutation of $1, \ldots, K+1$, is maximally assorted. Under $\left(\bar{\mathbf{E}}(\phi), \bar{\mathbf{\Lambda}}(\phi)\right)$, Bank $\phi(1)$ has the greenest possible technology holding and the most responsible possible depositors, so $\bar{E}'_{\phi(1)} \leq \bar{E}_{\phi(1)}$, $\bar{\lambda}'_{\phi(1)} \leq \bar{\lambda}_{\phi(1)}$ for any allocation $\left(\bar{\mathbf{E}}', \bar{\mathbf{\Lambda}}'\right)$. Among the remaining K banks, the induction hypothesis implies that $\left(\bar{\mathbf{E}}(\phi)_{-\phi(1)}, \bar{\mathbf{\Lambda}}(\phi)_{-\phi(1)}\right)$ is maximally assorted. Therefore, $\left(\bar{\mathbf{E}}(\phi), \bar{\mathbf{\Lambda}}(\phi)\right)$ is maximally assorted.

We next show that any maximally assorted allocation $\left(\bar{\mathbf{E}}, \bar{\mathbf{\Lambda}}\right)$ must be $\left(\bar{\mathbf{E}}(\phi), \bar{\mathbf{\Lambda}}(\phi)\right)$ for some permutation ϕ of $1, \ldots, K+1$. Without loss of generality, suppose that Bank 1 has the greenest technologies of all the $K+1$ banks, $\bar{E}_1 = \max_{k=1,\ldots,K+1} \bar{E}_k$. Then, Bank 1 must have the $\omega_1 I$ most responsible depositors, as otherwise substituting some of these depositors for some less responsible depositors in Bank 1 would positively sort depositors. Likewise, Bank 1 must also have the greenest possible technology holdings, as otherwise divesting some browner technology holdings in favor of some of these green technologies would be positively assortative. Among the remaining K banks, the induction hypothesis implies that $\left(\bar{\mathbf{E}}_{-1}, \bar{\mathbf{\Lambda}}_{-1}\right) = \left(\bar{\mathbf{E}}(\phi)_{-1}, \bar{\mathbf{\Lambda}}(\phi)_{-1}\right)$ for some permutation ϕ of $2, \ldots, K+1$.

Part 2: The set of feasible $(\bar{\mathbf{E}}, \bar{\mathbf{\Lambda}})$ is a convex polygon, whose vertices are the $K!$ maximally assorted $(\bar{\mathbf{E}}(\phi), \bar{\mathbf{\Lambda}}(\phi))$. Set $\mathbf{M}$ consists of these vertices. As the function $(\bar{\mathbf{E}}, \bar{\mathbf{\Lambda}}) \mapsto \sum_{k=1}^{K} \omega_k \bar{E}_k \bar{\lambda}_k$ is convex, its maximum is attained at one of the K vertices.

□

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