Public Goods in Crises

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March 26, 2026

Abstract

We introduce nonrival public goods into global games of regime change and rationalize investor behavior in the Euro crisis, the collapse of Terra, and the 2023 bank runs. Each investor in a large project is vanishingly unlikely to be pivotal for its survival. She also benefits from the project's enormous public goods. In equilibrium, this large benefit precisely counterbalances her vanishing pivotal likelihood, such that even an atomistic and selfish investor internalizes her marginal impact on project survival. In an economy of firms, any divestment yields financial gains whenever it positively assorts projects' public goods with investors' sensitivities to those goods. Yet such divestments can harm the social surplus.

JEL Classification: G21, G28, D62, M14

Keywords: Global games, nonrival public goods, Euro crisis, Terra, 2023 bank runs, voting

*Lee is at the Central European University. Wang is at the Wharton School, University of Pennsylvania. We thank Toni Ahnert, Itamar Drechsler, Darrell Duffie, Daniel Garrett, Vincent Glode, Itay Goldstein, Marc Kaufmann, Leonid Kogan, Zihao Li, Dan Luo, Andrey Malenko, Simon Mayer, Tímea Molnár, David Musto, Sean Myers, Christian Opp, Marcus Opp, Nick Roussanov, Michael Sockin, Rob Stambaugh, Adam Szeidl, Luke Taylor, Paul Voss, Ming Yang, and Adam Zawadowski for helpful comments. Jiaqi Zou provided excellent copyediting. This paper was previously titled "Running Responsibly." Emails: leeso@ceu.edu; wangchj@wharton.upenn.edu.

1 Introduction

Investors seem willing to bear private financial risk for collective outcomes. We focus on three examples:

1. Domestic creditors were more likely to roll over the sovereign debt of peripheral countries during the 2008-2013 Euro crisis (Ongena, Popov, and Van Horen, 2019), further deepening exposure to their home economies. In practice, those creditors experienced high unemployment alongside large losses on their domestic debt holdings (Gourinchas, Philippon, and Vayanos, 2017).

2. The heaviest users of Terra clung to the stablecoin as it failed in 2022, suffering especially large losses (Liu, Makarov, and Schoar, 2023), though they would likely have been among the first to learn about the run.

3. The oldest "socially responsible" bank in the US, Amalgamated Bank, avoided major deposit outflows during the 2023 bank runs. Its various fundamentals were near those of the banks that ultimately failed, worse than those of the two surviving banks that suffered the largest outflows, and far worse than the industry average.

Each case presents a threat of regime change—sovereign default or failure of a currency or a bank. At stake are salient public goods: public infrastructure and regulatory capacity, an ecosystem of numerous users and apps, and socially responsible investments. Because a typical investor is vanishingly unlikely to be pivotal for regime change, the investor may well ignore her marginal impact on the regime's chance of survival. If so, the investor would refuse to risk her financial payoffs for the regime.

This argument neglects that public goods are often *nonrival*. Consider a creditor who may roll over bonds issued by her government. Its public services benefit the creditor beyond any financial payoff. Under a well-funded government, the creditor derives an enormous benefit from food and drug safety, disease surveillance, and much else, which a default may jeopardize. This large benefit counterbalances the vanishing likelihood that any investor is pivotal for default. If, however, the benefit and the vanishing likelihood fail to exactly

balance each other out, the investor's decision-making would degenerate into ignoring either her financial payoff or the public goods at stake.

We introduce nonrival public goods into a standard global game of regime change (Angeletos, Hellwig, and Pavan, 2007). Investors are atomistic and selfish. In any such global game, we show that each investor's likelihood of being pivotal and the size of public goods (or public bads) at stake *precisely* counterbalance each other. In equilibrium, every investor trades off her financial payoff against her marginal impact on the likelihood of project survival.

We bring our highly tractable framework to one normative and three empirical applications. First, we analyze the financial and social impacts of divestments by firms and of sorting investors across firms. There are financial gains from any divestment or sorting that positively assorts the firms' public goods with the investors' sensitivity to those goods. In contrast, while the social surplus always improves upon the sorting of investors, it can decline from the divestments by firms. Second, our framework explains investor behavior in the 2008–2013 European sovereign debt crisis, the failure of the Terra stablecoin, and a case study of a prominent socially responsible bank during the 2023 bank runs.

Section 2 explains our key mechanism using a two-stage global game. Each of a number I of *ex-ante* identical investors may fund a large project in distress. First, each investor observes a noisy signal about the project's funding need, then chooses whether to fund it. If the sum of new funds and existing project capital is sufficiently large, the project continues intact; otherwise, it is partly destroyed. Second, the project yields a financial payoff and some public goods or bads per unit of its size. Every investor is risk-neutral and obtains a nonpecuniary payoff that depends on the aggregate public good net of public bads scaled by a factor λ.[1] We call λ "social sensitivity" for brevity.

When the number I of investors is large, each investor has an infinitesimal probability of being the pivotal one who determines whether the project continues. Meanwhile, the net public good that hinges on the large project is on the same order as I. We show that, in

[1]The net public good is, for example, the amount of particulate pollution (measured by parts per million in affected areas). An investor's social sensitivity λ translates the net public good into her dollar willingness-to-pay (WTP) for the public good. An investor's WTP to abate localized air pollution would depend on her location and vulnerability to airborne particulate matter. We allow for heterogeneous λ from Section 3.

any global game of regime change, the pivotal probability is on the order of $1/I$, precisely offsetting the project's net public good.

Upon observing a signal, an investor updates her expectation about the project's funding need. She further deduces that other investors likely observed similar signals. The signal, however, is uninformative about where it ranks among those signals. Each investor thus expects her signal's ranking to be uniformly random. Applied to the marginal investor, the number of other investors choosing to fund is also uniformly random (the Laplacian Property), because exactly those with better ranked signals than hers choose to fund. As a result, the marginal investor believes that the probability of the project being one investor away from survival, making herself pivotal, is on the order of $1/I$. In equilibrium, investors are more likely to fund if the project generates public goods, less likely if it imposes public bads, and both effects are stronger when the investors are more socially sensitive. This mechanism is in line with the survey evidence of Kaufmann, Andre, and Kőszegi (2024) that retail consumers understand how their individual purchases can prompt a nonvanishing response in aggregate demand from other consumers.

Financial payoffs, being rivalrous, fundamentally differ from nonrival public goods. The project's total financial payoff is on the order of I. This payoff is split across its investors, leaving each of the I investors a financial claim on the order of one. Combined with the pivotal probability, the change in an investor's expected financial payoff through her marginal impact on project survival is on the order of $1/I$. This change is virtually zero. Therefore, investors ignore their marginal impacts on the aggregate financial outcome, whereas they internalize those on the aggregate nonrival public good.

Section 3 generalizes our game to study the financial and social impacts of divestments. We partition heterogeneous investors into heterogeneous firms in distress. The financial surplus is the total expected financial payoff and the social surplus is the total expected net public good. A "divestment" is a reallocation of projects between firms that positively assorts the projects' net public good with the investors' social sensitivity. A "sorting of investors" is any such positive-assortative redistribution of investors.

We show that *any* divestment or sorting of investors strictly raises the financial surplus. The sorting of investors strictly increases the social surplus as well. By contrast, the di-

vestment can strictly reduce the social surplus when investors have low social sensitivity. In sum, firms can earn financial gains by selectively trading their projects, which can harm the social surplus, or by attracting the more aligned investors, which always improves the social surplus.

Underlying the financial gains is a complementarity between public goods and social sensitivity: investors are more likely to fund a firm that would generate a larger net public good, especially if they are more sensitive to public goods. Nonetheless, the firms' divestments can harm the social surplus if investors have low social sensitivity. Under natural conditions, the divestment shifts the net public good towards the firms whose financial payoffs decline. Low social sensitivity implies that those firms become more likely to fail. Taken together, the divestment concentrates the net public goods exactly where failure risk increases, reducing the social surplus.

We apply our results to the textbook use cases of global games: debt rollover, currency attacks, and bank runs.

Section 4 rationalizes four stylized facts on peripheral countries in the 2008-2012 Euro crisis. *(i)* Domestic creditors were more likely to roll over risky peripheral-country debts than foreign creditors. *(ii)* Peripheral countries with the highest domestically held shares of sovereign debt avoided default and large bailouts, while others did not. *(iii)* The domestically held shares steadily increased throughout the crisis, and yet *(iv)* were flat prior to the crisis. We parsimoniously explain the four facts under a standard global game of debt rollover extended to multiple countries. At stake are noncongestible services, including key infrastructure and oversight of public health. Our model is the first to provide an endogenous explanation for the "moral suasion" hypothesis.

Section 5 maps the Terra failure to a classic currency attack game augmented with network effects as public goods. Doing so rationalizes how the most frequent users of Terra—who would likely have been among the first to learn of the run—were among the last to liquidate their holdings, incurring large losses (Liu et al., 2023).

Section 6 considers Amalgamated Bank, a publicly traded bank in New York that has been a leading proponent of progressive causes for more than a century. As of the 2023 bank runs, Amalgamated Bank had uninsured deposits and unrealized loss ratios near those of

the banks that would fail, worse than the surviving banks that suffered the largest runs, and far worse than the industry average. Yet, Amalgamated Bank did not experience deposit outflows. Our main mechanism rationalizes this fact in an otherwise standard global game of bank runs in which the bank specializes in socially responsible investments.

Warm-glow preferences cannot explain these facts. A warm-glow investor receives a "glow" while holding assets tied to public goods. Facing a financial incentive to abandon this asset, she can shift funds to a substitute asset. Or, she can cash her funds and wait until the uncertainty resolves or another investment opportunity arrives, at the cost of losing the glow in the interim. Any interim loss of the glow is likely to be small relative to the financial risks during debt crises, currency attacks, or bank runs. Section A analyzes a setting in which default would mean a permanent loss of the glow. Even here, each warm-glow investor ignores her marginal impact on project survival in her decision-making.

Section 7 elaborates on our contributions. (i) We develop the first, and highly tractable, global game in which agents internalize the marginal impact of one's action on the aggregate outcome, despite the agents being atomistic and selfish. Applying our framework to reallocations of investors and projects adds two results. (ii) Any positive assorting between projects' public goods and investors' social sensitivity raises the financial surplus. (iii) How this positive assorting occurs matters for society: sorting investors across projects always benefits the social surplus, whereas reallocating the projects among investors can harm the social surplus when the investors have low social sensitivity.

We proceed as follows. Section 2 develops a global game of regime change in the presence of nonrival public goods. Section 3 generalizes the game to derive the impacts of divestment and sorting on the financial and the social surplus. The next sections present three classic global-games settings where our results apply: debt rollover during the 2008–2013 Euro crisis (Section 4); a currency attack on the Terra stablecoin (Section 5); and the 2023 bank runs (Section 6). Section 7 details our contributions. Section 8 concludes with a discussion of potential ways to apply our mechanism to voting.

2 Main Mechanism

This section introduces nonrival public goods to an otherwise standard global game of regime change, in which a temporarily distressed project seeks funds. It delivers two messages. (i) Each investor internalizes her marginal impact on the risk of project failure, despite being atomistic and selfish. (ii) The project is less prone to failure if it produces greater public goods or lesser public bads, especially when investors are more sensitive to the net public good. Section 2.1 presents the global game. Section 2.2 derives the equilibrium and explains its key characteristics. Section 2.3 discusses our assumptions.

2.1 Global Game with Nonrival Public Goods

An infinitely large number I of risk-neutral investors, each holding one unit of wealth, may fund a large project in distress.[2] The project's total size is $mI > 0$. The project continues if it receives sufficient funding to cover its liquidity need and, if so, the project will yield financial payoffs and public goods or bads at the end of the game.

We introduce nonrival public goods to a generic global game of regime change (Angeletos et al., 2007). Each investor observes a signal about the project's funding need, then chooses to *fund* or *exit*. Conditional on continuation, the project generates a gross financial payoff R and a net public good $E \in \mathbb{R}$ per unit of project size mI. Each funding investor receives $mR > 1$, and unmodeled equity holders take the remaining financial payoffs. Conditional on failure, a share $\alpha > 0$ of the project is destroyed. The remainder is liquidated at a low value, which we set to zero for simplicity. Funding investors receive nothing. Exiting investors keep their wealth.

Every investor receives a nonpecuniary payoff representing her personal enjoyment of the realized net public good. More precisely, the *ex-post* utility U_i of investor i equals the sum of any financial payment she receives and the realized net public good scaled by her

[2] We work directly with an infinitely large hyperreal $I \in {}^*\mathbb{R}$, rather than taking limits. Hyperreal numbers, ${}^*\mathbb{R}$, are an extension of real numbers that contain infinite and infinitesimal numbers (Anderson, 2008).

sensitivity $\lambda > 0$ to public goods (social sensitivity):

$$U_i = \begin{cases} mR + \lambda mIE, & \text{if } i \text{ funds and project continues,} \\ 1 + \lambda mIE, & \text{if } i \text{ exits and project continues,} \\ (1-\alpha)\lambda mIE, & \text{if } i \text{ funds and project fails,} \\ 1 + (1-\alpha)\lambda mIE, & \text{if } i \text{ exits and project fails.}^{3} \end{cases}$$

Each investor i funds or exits in period 1 based on the difference between her expected utilities from funding and from exiting, conditional on her signal s_i about the funds needed for the project to continue. We call this difference her "willingness to fund":

$$\begin{aligned} \pi(s_i) = {} & \mathbb{P}\left(\text{project continues} \,|\, i \text{ funds}, s_i\right) mR - 1 \\ & + \Big[\underbrace{\mathbb{P}\left(\text{project continues} \,|\, i \text{ funds}, s_i\right) - \mathbb{P}\left(\text{project continues} \,|\, i \text{ exits}, s_i\right)}_{\text{Probability } \Delta P(s_i) \text{ that investor is pivotal}} \Big] \\ & \times \alpha\lambda mIE. \end{aligned} \tag{1}$$

If investor i funds, she receives her promised payment mR and a nonpecuniary payoff λmIE whenever the project continues, which occurs with probability $\mathbb{P}(\text{project continues} \,|\, i \text{ funds}, s_i)$. If she exits, she keeps her one unit of wealth, and her probability of receiving the nonpecuniary payoff falls to $\mathbb{P}\left(\text{project continues} \,|\, i \text{ exits}, s_i\right)$.

What remains is a generic global game of regime change. The project requires funds worth $\theta mI > 0$ to continue, where the funding-need ratio θ is drawn from a uniform distribution,

[3] We make two notes. First, U_i ignores public goods and bads produced outside the project. Incorporating them would add a constant term to U_i that cannot affect the investors' decision-making. Second, the nonpecuniary terms in U_i are far larger than the pecuniary terms if the project produces appreciable net public good, $E \neq 0$, that its investors care about, $\lambda > 0$. For example, if local residents are the investors and a local factory is the project, then a resident's suffering due to the factory's air pollution may well far exceed her financial payoff from her investment in the factory. Nonetheless, the financial payoffs are relevant for decision-making, which depends on the difference in payoff (1) between funding and exiting.

$\theta \sim \mathbb{U}[\underline{\theta}, \bar{\theta}]$, $\underline{\theta} < \bar{\theta}$. The ratio θ corresponds to the amount of maturing debt net of free cash flow, as a share of project size, in a debt rollover game. Its complement, $1-\theta$, corresponds to the fundamental, representing the foreign-exchange reserve ratio in a currency-attack setting or the liquid-assets ratio in a bank-run game. Investors do not observe the true θ and instead receive private signals $s_i = \theta + \sigma\varepsilon_i$, where noise $\sigma\varepsilon_i \overset{\text{iid}}{\sim} \mathbb{U}(-\sigma/2, \sigma/2)$, $\sigma > 0$. Let nI be the number of investors who fund. The project continues if it raises enough funds to meet its funding need, $nI \geq \theta mI$. Otherwise, the project fails.

Two parametric assumptions focus our analysis on nondegenerate cases.

Assumption 1. The funding need is sufficiently uncertain; $\underline{\theta} \leq -\sigma$ and $\bar{\theta} \geq 1 + \sigma$.

Assumption 2. Investors are not too socially sensitive:

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

Assumption 1 is standard. Assumption 2 is new and states that each investor's social sensitivity is not so strong as to render the financial payoff irrelevant for her funding choice. Section 2.3 explains our assumptions.

2.2 Equilibrium

We look for a switching equilibrium, following Kashyap, Tsomocos, and Vardoulakis (2024). Section 2.3 discusses this choice.

Definition 1. A switching equilibrium consists of cutoffs s_i^* and consistent beliefs such that each investor i optimally funds whenever her signal indicates a low funding need $s_i < s_i^*$ and optimally exits 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* $\psi := \left(1 - \frac{\alpha\lambda mE}{m\sigma+1}\right)(mR)^{-1} \in (0, 1)$. *There exists a unique switching equilibrium, wherein:*

1. *An investor funds if and only if her signal s_i is strictly below a common cutoff $s_i^* = s^*$, where*

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

2. *The project continues if and only if its funding need θmI is strictly below a threshold $\theta^* mI$, where*

$$\theta^* = \frac{1-\psi}{m}. \tag{3}$$

Proposition 1 states that the likelihood of project continuation is increasing in net public good E per project size, and more so when the investors have a higher social sensitivity λ. 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 Section B.

Our central mechanism is that each investor internalizes her marginal impact on the likelihood of project continuation, despite being vanishingly unlikely to be pivotal. More precisely, the probability ΔP of an investor being pivotal is on the order of $1/I$ while her impact conditional on being pivotal is on the order of I—the pivotal probability is as small as the conditional impact is large. These two quantities scale each other to a positive constant which, for the marginal investor whose signal is at the cutoff $s_i = s^*$, yields the following willingness to fund:

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

The Laplacian Property of global games (Morris and Shin, 2003) leads us to (4). Investor i is pivotal when just enough other investors fund such that one additional unit of funds is

necessary to continue the project,

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

The funding need $\theta m I$ determines the number nI of investors who fund through the exact law of large numbers. It happens that, whenever n is interior,

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

and thus the amount nI of funding obtained increases with an elasticity of $1/m\sigma$ as funding need $\theta m I$ decreases. Hence, the gap $\theta m I - nI$ between the funding need and the funds obtained equals one when there is $1/(m\sigma + 1)$ less funding than the amount of funding at which this gap would be zero. Letting n^* be the threshold for n above which the project continues, an investor is pivotal whenever nI lies above $n^* I - 1/(m\sigma + 1)$ and below $n^* I$:

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

An investor funds if and only if she observes a signal below s^*. The marginal investor observes $s_i = s^*$, and is thus pivotal if and only if her signal's rank among all signals is in $[n^* - 1/((m\sigma + 1)I), n^*]$. Because the rank of an investor's signal s_i is uniformly distributed over $[0, 1]$ (Morris and Shin, 2003, Laplacian Property), the marginal investor's signal has a rank in $[n^* - 1/((m\sigma + 1)I), n^*]$ with probability $1/((m\sigma + 1)I)$. The pivotal probability ΔP for deriving s^* is then

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

which exactly offsets the scale of the project's net public good IE, and yields the willingness to fund (4).

Two further equations characterize the equilibrium. First, the project's funding need

θmI and its funding nI must be equal at the threshold $n = n^*$,

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

Second, the marginal investor must be indifferent between funding and exiting, $\pi(s^*) = 0$:

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

Equations (6) and (7) together yield s^* and θ^* as given by (2) and (3).

2.3 Discussion of Assumptions

Absent the nonpecuniary payoff, $\lambda E = 0$, our game is a generic static global game of regime change (Angeletos et al., 2007) that is identical to the baseline bank-run game of Shen and Zou (2024) and the homogeneous-players case in the generic investment game of Sákovics and Steiner (2012). More broadly, when $\lambda E = 0$, our agents' utility U_i and willingness to fund (4) are identical to those in the global games of currency attacks (Hellwig, Mukherji, and Tsyvinski, 2006; Angeletos and Werning, 2006) and debt rollover (Morris and Shin, 2004; Ahnert and Kakhbod, 2017).

Technology. In equilibrium, an investor willingly trades off financial risk for public goods and bads as long as the average net public good per unit of project size is nonzero,

$$E = \frac{\text{project's total net public good}}{\text{project size}} \neq 0.$$

This condition allows for any project that has constant or increasing returns to scale in

public goods.[4] It also allows for any project with decreasing returns to scale, provided that the project's marginal net public good is nonzero. However, it does not allow for projects that have decreasing returns to scale with zero marginal net public good, such as a project whose net public good has the form I^β, where $\beta < 1$.

Signals. We draw noise $\sigma\varepsilon_i$ in the investors' signals from a uniform distribution, which is a standard way to obtain equilibrium uniqueness in the presence of one-sided strategic complementarity (Goldstein and Pauzner, 2005; Kashyap et al., 2024). More specifically, in our setup, an investor's willingness to fund is not monotonically increasing in the share n of others who fund, because she internalizes her marginal impact on the risk of project failure.[5] Her willingness to fund is instead increasing either in the range where it is positive *or* in the range where it is negative, not in both ranges simultaneously (i.e., "one-sided").

We let the noise be strictly positive to emphasize that each investor could be 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 to obtain a unique equilibrium in a standard way for global games with nonvanishing noise (Morris and Shin, 2003).[6] Global games often assume an arbitrary prior on θ and let the noise in signals s_i vanish, $\sigma \to 0$, which together are an alternative condition that obtains a unique equilibrium in global games. Our mechanism is robust to this alternative.

Equilibrium concept. We focus on switching equilibria, because the willingness to fund may not be monotonic with respect to the fundamental $1 - \theta$ in our setup (i.e., not

[4] Public goods can have increasing returns to scale if there are fixed costs, scale economies, or cutoff effects. For example, coral reefs bleach and die once the ambient water temperature exceeds a critical threshold, below which their health gradually improves as the temperature falls (Dalton and Carroll, 2011). Any water-cooling investment would yield minimal benefits to the reef until it becomes sufficient to maintain water temperatures below the threshold. Similarly, while a marginal human-caused death in a species with an abundant population may have little ecological consequence, a marginal death once the species has become endangered threatens irreversible ecological harm. The first example is a plausible case of increasing returns to scale for public goods, and the second example is such a case for public bads.

[5] It may decrease locally as n crosses from $nI < \theta mI - 1$ (where the project never continues) to $nI \in [\theta mI - 1, \theta mI)$ (the project continues if and only if investor i funds it), then again when crossing up to $nI \geq \theta mI$ (the project always continues).

[6] Otherwise, the posterior $\frac{1}{\sigma} f(\frac{s_i - \theta}{\sigma})$ of θ depends on its prior's parameters, which would require additional parametric conditions for equilibrium uniqueness.

"state monotonic").[7] Global games typically rely on state monotonicity to prove that every perfect Bayesian equilibrium is a switching equilibrium and that it is unique (Morris and Shin, 2003). Kashyap et al. (2024) limit their attention to symmetric switching equilibria and introduce a novel proof of uniqueness to address their own lack of state monotonicity. We allow for asymmetric switching equilibria and add a new proof of uniqueness in a setting where each atomistic agent internalizes her marginal impact on the likelihood of regime change.

Parametric assumptions. Assumption 1 is standard.[8] Assumption 2 is equivalent to $\frac{\alpha}{m\sigma+1}\lambda mE < 1 < mR + \frac{\alpha}{m\sigma+1}\lambda mE$. If instead $\frac{\alpha}{m\sigma+1}\lambda mE \geq 1$, then the unique equilibrium is degenerate in that every investor i funds unless she is certain that the project will fail ($s_i \geq 1 + \frac{\sigma}{2}$). If $1 \geq mR + \frac{\alpha}{m\sigma+1}\lambda mE$, then every investor i exits unless she is certain that the project will continue ($s_i \leq -\frac{\sigma}{2}$).

3 Divestment

We examine the financial and social impacts of reallocating projects and investors across firms. 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 investors on the financial surplus. Section 3.4 does so for the social surplus.

3.1 Generalized Global Game

We introduce multiple *firms* with arbitrary projects and differing investor bases to the global game of Section 2.1. There are $I = \infty$ investors who are partitioned into $K \geq 2$

[7] We may lack state monotonicity, because each investor's willingness to fund may locally decrease as θ crosses from $\theta mI \leq nI$ (where the project always continues) to $\theta mI \in (nI, nI + 1]$ (the project continues if and only if investor i funds), then again as θ crosses up to $\theta mI > nI + 1$ (the project never continues).

[8] It is needed for equilibrium uniqueness. Under Assumption 1, it is a dominant strategy for investor i to exit upon observing a signal of high need $s_i \geq 1 + \frac{\sigma}{2}$ (when the project fails even if everyone funds) and to fund if $s_i \leq -\frac{\sigma}{2}$ (it would continue even if no one funds). In the intermediate region $s_i \in (-\frac{\sigma}{2}, 1 + \frac{\sigma}{2})$, Assumption 1 ensures that the investor's posterior about θ is not truncated by its upper and lower boundaries, $\underline{\theta}$ and $\bar{\theta}$.

firms, whose portfolios are split across $N \geq 2$ projects. The investors are heterogeneous in their social sensitivity $\lambda_i \geq 0$. The firms are heterogeneous in their investors' average social sensitivity $\bar{\lambda}_k$, in each firm's share ω_k of the I investors, and in the proportion $\tau_{k,n}$ of the firm's funds allocated to project n, leaving each firm k with size $\omega_k mI$ and $\tau_{k,n}\omega_k mI$ allocated to project n. Per unit size, the average financial payoff of firm k is $\bar{R}_k \coloneqq \sum_{n=1}^{N} \tau_{k,n} R_n > 0$ and its average net public good is $\bar{E}_k \coloneqq \sum_{n=1}^{N} \tau_{k,n} E_n > 0$. Each firm independently draws its funding-need ratio $\theta_k \overset{iid}{\sim} \mathbb{U}[\underline{\theta}, \bar{\theta}]$.

All other assumptions and the equilibrium definition are identical to the game in Section 2.1. We make four clarifications. Firm failure destroys a uniform share α across the failing firm's projects. Regarding timing, each investor simultaneously receives her signal s_i about her firm's funding need in period $t = 0$ and simultaneously chooses whether to fund or exit in $t = 1$. Regarding parametric assumptions, we update Assumption 2 to ensure that each investor's social sensitivity is not too high given her firm's projects. The updated Assumption 2 imposes that, for every project n and investor i,

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

Regarding the equilibrium definition, the cutoffs s_i^* of a switching equilibrium are firm-specific, $s_{i,k}^*$.

This generalized global game has a unique switching equilibrium (Proposition 2).

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

1. *Investor i at firm k funds if and only if her signal $s_i < s_{i,k}^*$, where*

$$s_{i,k}^* = \frac{1 - \psi_k\left(\bar{\lambda}_k\right)}{m} - \frac{\sigma}{2} + \sigma\left[1 - \psi_k(\lambda_i)\right]. \tag{8}$$

2. Firm k fails if and only if its funding need $\theta_k m\omega_k I < \theta_k^* m\omega_k I$, where

$$\theta_k^* = \frac{1 - \psi_k\left(\bar{\lambda}_k\right)}{m}. \tag{9}$$

Proposition 2 departs from standard global games in that investors at the same firm have heterogeneous switching cutoffs $s_{i,k}^*$. Each investor's cutoff depends on her own social sensitivity λ_i and her firm's average sensitivity $\bar{\lambda}_k$, leading firms to have heterogeneous continuation thresholds θ_k^*.

3.2 Definitions

Divestment is any reallocation in the firms' portfolios that maintains the size of each firm and the aggregate size of each project. We write τ and τ' to denote vectors of the firms' initial and new portfolio weights $\tau_{k,n}$. A divestment is a change in portfolios from τ to τ' such that

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

Divestment is *positive assortative* whenever the projects with higher public goods are reallocated towards the firms with the more socially sensitive investors. More precisely, we order the firms by their average social sensitivity, such that $\bar{\lambda}_1 > \bar{\lambda}_2 > \ldots > \bar{\lambda}_K$. A positive-assortative divestment reallocates the firms' portfolios from τ to τ' such that the average public good $\bar{E}'_k$ across firms under τ' first-order stochastically dominates the initial $\bar{E}_k$,

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

Sorting of investors is a reallocation of the more socially sensitive investors towards the firms with higher average public goods. A sorting of investors keeps each firm's number $\omega_k I$ of investors constant. We order the firms such that $\bar{E}_1 > \ldots > \bar{E}_K$, and write $\bar{\mathbf{\Lambda}}$ and $\bar{\mathbf{\Lambda}}'$ to denote vectors of the firms' initial and new average social sensitivities. Sorting of investors

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

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

Financial surplus is the expected value of all financial payoffs generated in the economy:

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

Social surplus is the total expected net public good in the economy:

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

3.3 Financial Impact

Proposition 3. *Any positive-assortative divestment by firms or positive-assortative sorting of investors strictly raises the financial surplus in the unique switching equilibrium.*

Proposition 3 says that any reallocation that positively assorts the average public good $\bar{E}_k$ and the average social sensitivity $\bar{\lambda}_k$ yields financial gains from trade. As a result, any two firms can nearly always exchange projects or investors for financial gains.

The financial surplus generated by firm k is proportional to

$$\left[\mathbb{P}\left(\text{bank } k \text{ survives}\right) + (1-\alpha)\mathbb{P}\left(\text{bank } k \text{ fails}\right)\right] \bar{R}_k = c_1 \bar{R}_k - c_2 + c_3\, \bar{\lambda}_k \bar{E}_k,$$

where $c_1, c_2, c_3 > 0$ are common across all firms.

The nonpecuniary component $\bar{\lambda}_k \bar{E}_k$ introduces complementarity between a firm's net public good $\bar{E}_k$ and its investors' average social sensitivity $\bar{\lambda}_k$. Any positive-assortative divestment increases the net public good $\bar{E}_k$ of the firms with the more socially sensitive investors (higher $\bar{\lambda}_k$) while decreasing $\bar{E}_k$ at the other firms in a mean-preserving way. A

positive-assortative sorting of investors increases $\bar{\lambda}_k$ at the firms with higher $\bar{E}_k$, and decreases $\bar{\lambda}_k$ elsewhere. Either case strictly increases the financial surplus, because $\bar{E}_k$ and $\bar{\lambda}_k$ reinforce each other's impact on each firm's financial surplus.

The pecuniary component $c_1\bar{R}_k - c_2$ washes out in the aggregate, as it is linear and divestment and sorting are mean-preserving reallocations across firms. In particular, neither divestment nor sorting would affect the financial surplus in the absence of nonpecuniary payoffs (that is, if $\lambda_i E_n = 0$, $\forall i, n$).

3.4 Social Impact

Sorting investors always increases the social surplus. In contrast, the divestment harms the social surplus if the average social sensitivity $\bar{\lambda}_k$ is low at all firms and projects, and if the firms' initial investments satisfy a natural condition.

Proposition 4.

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

We assume that firms are jointly ordered by their initial average social sensitivities, $\bar{\lambda}_1 > \bar{\lambda}_2 > \ldots > \bar{\lambda}_K$*, and their initial average net public goods,* $\bar{E}_1 > \bar{E}_2 > \ldots > \bar{E}_K$*. We also assume that the projects' financial payoffs are strictly decreasing in their net public goods,* $R_n < R_m$ *whenever* $E_n > E_m$ *for all* n *and* m*.*

2. *For a given positive-assortative divestment, there exists a cutoff* $\Lambda_\ell > 0$ *such that the divestment strictly reduces the social surplus if average social sensitivity is sufficiently low everywhere,* $\bar{\lambda}_1 < \Lambda_\ell$*.*

Proposition 4 specifies that positive-assortative divestment harms the social surplus when investors are sufficiently insensitive to public goods under natural conditions: more financially profitable projects generate fewer public goods (e.g., polluting factories have lower production costs) and firms with less public goods have less socially sensitive investors. In this case, upon divestment, the total net public good becomes further concentrated in those firms that already have high net public goods, while their financial payoffs decline. Their

investors become less likely to fund, because they are insensitive to the public goods yet still care about the financial payoffs. The social surplus decreases as the public goods become more concentrated at the firms that are now less likely to survive, reducing the total net public good in expectation.

More precisely, the contribution of firm k to the social surplus is proportional to

$$\begin{aligned}&\left[\mathbb{P}\left(\text{firm } k \text{ survives}\right) + (1-\alpha)\mathbb{P}\left(\text{firm } k \text{ fails}\right)\right]\bar{E}_k \\ &\qquad = \; d_1\bar{E}_k - d_2\,\frac{\bar{E}_k}{\bar{R}_k} + d_3\,\frac{\bar{\lambda}_k\bar{E}_k^2}{\bar{R}_k},\end{aligned}$$

where $d_1, d_2, d_3 > 0$ are common to all firms. The first component $d_1\bar{E}_k$ of a firm's social surplus washes out across all firms, as it is linear and the divestment is mean-preserving. The sorting of investors does not change $\bar{R}_k$ or $\bar{E}_k$, and affects the social surplus solely through positively assorting $\bar{\lambda}_k$ and $\bar{E}_k$ in the complementarity component $d_3\frac{\bar{\lambda}_k\bar{E}_k^2}{\bar{R}_k}$. Accordingly, sorting investors always strictly raises the social surplus.

The last two components have opposing effects on the social surplus. The divestment causes the firms with higher average net public good $\bar{E}_k$ (and higher average social sensitivity $\bar{\lambda}_k$) to replace the projects with lower net public goods E_n and higher financial payoffs R_n. On the one hand, the "replacement" component $-d_2\bar{E}_k/\bar{R}_k$ reduces the social surplus. Because socially insensitive investors care little about public goods relative to financial payoffs, they become less likely to fund the divesting firms, increasing the risk of failure exactly where it is most damaging to public goods. On the other hand, the complementarity component $d_3\frac{\bar{\lambda}_k\bar{E}_k^2}{\bar{R}_k}$ increases the social surplus. This component is small when the average social sensitivity $\bar{\lambda}_k$ is low across all firms. Taken together, the replacement component dominates when investors are socially insensitive, in which case positive-assortative divestments strictly reduce the social surplus.

4 Debt Rollover

Our framework applied to a standard global game of debt rollover rationalizes four stylized facts during the 2008-2013 European sovereign debt crisis (Euro crisis). We make three plausible assumptions in this application:

1. German sovereign debt is risk-free during the Euro crisis.

2. Sovereign default reduces public services in the defaulting country.

3. Residents benefit more from the country's public services than nonresidents.

Section 4.1 presents the stylized facts and the broader empirical context. Section 4.2 maps this context to a global game of debt rollover. Section 4.3 rationalizes the stylized facts. Section 4.4 discusses alternative explanations and the existing literature.

4.1 Context

We explain the following four facts on peripheral countries (Cyprus, Greece, Italy, Ireland, Portugal, and Spain) during the Euro crisis:

(i) Domestic creditors were more likely to roll over peripheral sovereign debt than foreign creditors (Ongena et al., 2019).

(ii) Peripheral countries with the highest shares of domestically held sovereign debt avoided default and large bailout-to-GDP ratios (Broner, Erce, Martin, and Ventura, 2014).

(iii) Domestically held shares of sovereign debt increased throughout the crisis (Andritzky, 2012; Becker and Ivashina, 2018).

(iv) The domestic shares were flat or decreasing before 2008 (Andritzky, 2012; Becker and Ivashina, 2018).

Bailouts and default. Between 2010 and 2013, Greece, Ireland, Portugal, and Cyprus in turn secured large bailouts from the International Monetary Fund (IMF) and the EU,

each exceeding 40 percent of the country's contemporaneous GDP (Gourinchas, Martin, and Messer, 2025). In 2012, Greece agreed to default under IMF and EU supervision, imposing a haircut on privately held sovereign debts equal to about half of their total face value (Zettelmeyer, Trebesch, and Gulati, 2013; Gourinchas et al., 2017). Among the other peripheral countries, Spain secured a far smaller bailout in 2012, worth 10 percent of its GDP, while Italy neither defaulted nor requested a bailout.

The bailouts and default had two proximate causes. First, around 2008 onward, every peripheral country experienced rapidly slowing growth alongside large fiscal deficits and sovereign debt-to-GDP ratios (Broner et al., 2014). The resulting inability to service sovereign debt pushed Greece and Portugal to seek bailouts (Gennaioli, Martin, and Rossi, 2014). Second, banking crises, and the resulting need to recapitalize banks, prompted Cyprus, Ireland, and Spain to request bailouts (Acharya, Drechsler, and Schnabl, 2014; Gortsos, 2021). Italy avoided a banking crisis, yet maintained low growth and high debt and deficit.

Timeline. Until 2008, yields on the sovereign debts of peripheral countries were equal to the yields on German sovereign debt. Foreign shares of the peripheral debts were gradually increasing. EU-level institutions, and reasonably effective local courts, protected foreign creditors across all peripheral countries (Laprévote and Frisch, 2017; Chamon, Schumacher, and Trebesch, 2018). Their deficit-to-GDP ratios and debt-maturity structures were also similar (Broner et al., 2014). In contrast, the majority of Italian and Spanish debt were held domestically, while the other peripheral debts were mostly foreign-held (Merler and Pisani-Ferry, 2012; Broner et al., 2014).

From 2008, the peripheral yields diverged from the German ones and the domestically held shares of peripheral debt began to steadily increase (Broner et al., 2014). Facing higher yields and lower growth, the peripheral governments frequently issued "patriot bonds" and cited a "patriotic duty" for domestic firms and households to purchase those bonds.[9] Domestic creditors were more likely than foreign creditors to roll over peripheral sovereign debt

[9]Examples include Greece (Smith, 2011), Italy (Dinmore and Segreti, 2011), and Spain (Olivares, 2011). Nonperipheral countries, such as Belgium (Inman, 2011), also appealed to the patriotism of domestic creditors.

during months when large volumes of this debt were maturing (Ongena et al., 2019) and generally increased their purchases of peripheral sovereign debt (Andritzky, 2012; Becker and Ivashina, 2018).

By the end of 2013, domestic creditors held the majority of sovereign debt in Europe, with especially large domestic shares in the peripheral countries (Koijen, Koulischer, Nguyen, and Yogo, 2021). The Euro crisis ended as the European Central Bank purchased large amounts of EU sovereign debts following its commitment to "do whatever it takes" to defend the Euro.

4.2 Mapping to Theory

We capture the creditor's problem at the start of the Euro crisis in a standard global game of debt rollover extended to multiple debtor countries, each facing numerous domestic and foreign creditors. Below, all distributions are the same as in the model of Section 3.1 unless noted otherwise.

A large number I of creditors each holds one Euro in maturing sovereign debt issued by either one periphery country or Germany, $k \in \{IT, ES, GR, CY, IE, PT, DE\}$. Each creditor may either roll over her debt holding or exit. A proportion $\omega_k \in (0,1)$ of creditors own country k's debt, among whom a share $D_k \in (0,1)$ are domestic and the remainder are foreign. A "resident" of country k is a domestic creditor if she holds country k's debt and a foreign creditor if she holds another country's debt.

Sovereign debt helps fund services for the country's residents. Using its maturing debt, country k spends $\omega_k mI > 0$ Euros towards noncongestible services, generating a nonrival public good of E per Euro. Noncongestible services include key infrastructure, regulatory

capacity, digitization, defense and diplomacy, and the quality of courts and lawmaking.[10]

Country k's funding need is $\theta_k \omega_k mI$, which represents its maturing debts net of uncertain tax revenues (Greece's case), plus recapitalization needed by its banking sector (Ireland's case). Country k repays if at least $\theta_k \omega_k mI$ among its creditors roll over their debt holdings, and defaults otherwise. Each creditor i who holds country k's debt observes a signal s_i about θ_k based on macroeconomic news. A creditor who exits keeps her one Euro. A creditor rolling over her debt earns $mR > 1$ Euros if the debtor country repays, and nothing if it defaults.

Default destroys a share $\alpha \in (0, 1]$ of noncongestible services $\omega_k mIE$ in the defaulting country k, as it loses access to international capital markets (Cruces and Trebesch, 2013; Schumacher, Trebesch, and Enderlein, 2021). Resident i of country k obtains a nonpecuniary payoff $\lambda_i \omega_k mIE > 0$ if k repays and $\lambda_i (1 - \alpha) \omega_k mIE$ if k defaults, where her social sensitivity λ_i is not too high, as per Assumption 2.

A domestic creditor's willingness to roll over debt is

$$\mathbb{P}(\text{Country } k \text{ repays} \,|\, s_i) \cdot €mR - €1 + \Delta P(s_i) \lambda_i \alpha \omega_k mIE,$$

which is analogous to the willingness to fund (1) with $\lambda = \lambda_i$. A foreign creditor's willingness to roll over debt is

$$\mathbb{P}(\text{Country } k \text{ repays} \,|\, s_i) \cdot €mR - €1,$$

analogous to (1) with $\lambda = 0$.

Two states govern the funding-need ratio θ_k of peripheral countries. In the *safe* state, θ_k lies below zero with probability one, in which case all countries' debts are successfully rolled over. In the *risky* state, θ_k is uniformly drawn from $[\underline{\theta}, \bar{\theta}]$, whose parameters satisfy

[10] Congestible government services, such as roads and primary healthcare, provide less benefits per user as more users join. Our results do not extend to congestible services. Many other services are noncongestible. Dams and public lighting prevent flooding or darkness in the area no matter how many residents live there. Likewise noncongestible services are digital systems tracking vaccination status, weapons, suspicious income, credit scores, and much else. A country's national defense, diplomatic corps, leverage in multinational bargaining, and regulatory and judicial precedents protect the entire country, no matter its population. All these services depend on the overall size of its economy and spending as, for example, worse-funded regulators and courts would more often impose mistaken decisions or be corruptible. Some other examples are air-traffic control, weather and disaster forecasting, emergency information systems, and funding for basic research.

Assumption 1. In either state, the funding-need ratio θ_{DE} of Germany is below zero with probability one.

4.3 Results

Corollary 1 translates Propositions 2 and 3 into this setting.

Corollary 1. *Consider the risky state in the model of Section 4.2.*

(i) Domestic creditors of any given peripheral country are strictly more likely to roll over its debts than its foreign creditors.

(ii) A peripheral country with a higher share D_k of domestic creditors is strictly less likely to default.

Consider either state and suppose that the foreign creditors of countries k and ℓ are residents of each other's country, $k, \ell \in \{IT, ES, GR, CY, IE, PT, DE\}$.

(iii) In the risky state, any sorting of foreign creditors between k and ℓ strictly increases the financial and the social surplus.

(iv) In the safe state, any sorting of creditors across countries cannot affect the financial or the social surplus.

Corollary 1 ties together the four stylized facts on the Euro crisis. A domestic creditor who refuses to roll over her debt could tip her country into default, greatly reducing its government services. While the creditor is vanishingly unlikely to be pivotal, she would impose enormous nonpecuniary harm on herself if she does not roll it over and happens to be pivotal. As a result, the domestic creditors are more likely to roll over the debt, and strictly so under the risky state (Fact (i)).

This complementarity between residents and domestic sovereign debt lowers a country's risk of default, as more of the country's residents hold its debt (Fact (ii)). For peripheral countries in the risky state, creditors generate financial gains and increase the total expected government services whenever they sort into their resident-country debts, rationalizing the

increase in domestically held shares of peripheral debt after 2008 (Fact (iii)).[11] In the safe state, because no country faces default, there are neither financial gains nor increases in government services from such sorting of creditors, consistent with nonincreasing domestic shares before 2008, when investors priced peripheral debts as risk-free (Fact (iv)). Any diversification benefit would yield financial gains upon sorting residents towards foreign debt, which can explain the decreasing domestic debt shares seen in some peripheral countries before 2008.

4.4 Alternative Explanations

Many theories of sovereign default cannot explain these facts. The "original sin" from a mismatch between domestic and debt currencies (e.g. Eichengreen and Hausmann, 1999; Du and Schreger, 2022) does not apply to the Euro crisis, because the peripheral debts were denominated in the Euro. Discretionary strategic default (e.g., Eaton and Gersovitz, 1981; Guembel and Sussman, 2009) is unlikely to have been a driver of the Euro crisis, given that the losses on domestic debt holdings severely deepened recessions in the peripheral countries (Bocola, 2016; Altavilla, Pagano, and Simonelli, 2017; Gennaioli, Martin, and Rossi, 2018; De Marco, 2019).

Neither favor-exchange with domestic creditors nor discriminatory treatment of foreigners (e.g., Arellano, 2008; Broner et al., 2014) can account for the increasing domestic shares of peripheral debt.[12] The peripheral governments lacked the fiscal capacity for significant monetary favors during the Euro crisis. Moreover, discrimination against foreign creditors was restricted under EU rules (Laprévote and Frisch, 2017), and in fact the bailout terms tightly constrained policy and sought to protect foreign creditors (see, e.g., Zettelmeyer et al., 2013; Gortsos, 2021). Even if such discrimination were possible, domestic shares would not

[11] We omit a microstructure through which creditors may sort into different countries' debts. Rather, we view creditor sorting as a reallocation that financial markets can easily implement if it would yield financial gains and net public goods.

[12] Another alternative is home bias due to the information advantage of domestic creditors. This home bias cannot explain the case of Greece, where the domestic share began increasing in 2008 and continued increasing up to its 2012 default (Broner et al., 2014), which imposed large losses on all its creditors (Zettelmeyer et al., 2013).

necessarily increase, because foreign and domestic creditors can trade in secondary markets (Broner, Martin, and Ventura, 2010).

Recent evidence on creditor behavior during the Euro crisis (Altavilla et al., 2017; Becker and Ivashina, 2018; Ongena et al., 2019) instead supports the "moral suasion" hypothesis, under which creditors are more inclined to hold domestic debts due to patriotism or government pressure. Chari, Dovis, and Kehoe (2020) assume that residents can be coerced into holding domestic debt, capturing one form of moral suasion.[13] Among peripheral countries, explicit coercion was rare and the few policies pressuring residents to hold domestic debt (financial repression) began well after the domestic debt shares had started to increase (Reinhart and Sbrancia, 2015, Table 3). The evidence is mixed on whether financial repression affected rollover decisions; for instance, state-affiliated domestic banks were no more likely to roll over peripheral debts than other domestic banks (Ongena et al., 2019).

More broadly, favor-exchange and financial repression require that the incumbent government can credibly promise favors or apply pressure on investors. However, every incumbent leader in the peripheral countries was voted out sometime during the Euro crisis, and were often replaced by ideologically distant or insurgent opponents.[14] Domestic debt shares were rising as these incumbents were heading toward historic defeats. We endogenize creditor behavior that is consistent with "patriotic" moral suasion. Doing so, we rationalize the increasing domestic debt shares without assuming any ability of short-lived governments to credibly promise favors or apply pressure on investors.

[13] Other theories motivated by the Euro crisis ask different questions than ours. They investigate optimal policy responses (Schmitt-Grohé and Uribe, 2016; Faria-e Castro, Martinez, and Philippon, 2017; Gourinchas et al., 2025), roles of monetary independence (Bianchi and Mondragon, 2022) and political economy (Fernández-Villaverde, Garicano, and Santos, 2013), relative contributions of fiscal policy and sudden stops (Gourinchas et al., 2017; Martin and Philippon, 2017), and the feedback between sovereign risk and the private sector (Corsetti, Kuester, Meier, and Müller, 2013; Acharya et al., 2014; Gennaioli et al., 2014; Bocola, 2016; Farhi and Tirole, 2018).

[14] In Greece, the governing party's vote share fell from 44 to 13 percent between two elections while a far-left coalition rose to 27 percent. In Ireland, the incumbent party lost three quarters of its seats. Italy elected three different governing parties in two years. Portugal and Spain each replaced a center-left government with a center-right one. Cyprus replaced a communist president with a conservative.

5 Currency Attacks

Terra was the third-most valuable cryptocurrency by market capitalization and the most valuable "stablecoin" that was pegged to the US dollar. Terra failed over a three-day period in May 2022. Liu et al. (2023) document that the more active users of Terra were slower to liquidate their holdings during the currency attack. We explain their finding by applying Proposition 1 with the microfoundation of Cong, Li, and Wang (2021) for nonpecuniary payoffs from network effects.

Context. Each unit of Terra was pegged to 1 USD through an arbitrage mechanism involving a second cryptocurrency, Luna. This mechanism was vulnerable to a self-defeating loop once enough Luna holders begin liquidating their holdings. Terra's parent company kept a reserve in order to halt such loops.[15]

On May 7th, 2022, large selling pressure on Terra pulled its price significantly below 1 USD, causing Terra-to-Luna exchanges to gradually accelerate. Between May 9th and 13th, Luna's supply increased 5,000-fold and its price approached 0 while Terra's price fell below 20 cents, despite large purchases by the parent company. Terra and Luna were terminated soon thereafter.

While Terra existed, a thriving ecosystem was built around the stablecoin, including applications for payments, games, borrowing and lending, and trading equities and derivatives. As all transactions on these applications were settled in Terra, they failed alongside Terra.

Liu et al. (2023, Table 3) find that Terra accounts with higher trading volume-to-balance ratios before May 7th suffered larger losses between May 7th and 13th. Liu et al. (2023, p. 31) interpret the losses as indicators of the slow speed by which those account holders ran during the attack on Terra.

Mapping to theory. The Terra holders faced a standard global game of currency attack

[15] A select few arbitrageurs were allowed to exchange 1 Terra for 1 USD-worth of Luna, and the reverse. If Terra's price were to fall below 1 USD, the arbitrageurs can exchange it for Luna, reducing Terra's supply and typically returning its price to 1 USD. However, the peg can come under attack, as each Terra-to-Luna exchange increases the supply of Luna, lowering Luna's price. When other Luna holders cannot bear the resulting unrealized losses, the initial fall in Luna's price would prompt them to sell and further reduce the price, triggering a loop that pulls Luna's price towards 0. As Luna's price free-falls during the loop, an arbitrageur can no longer sell her Luna for 1 USD per Terra she exchanged, breaking the arbitrage mechanism.

in the period just before Terra's unraveling from May 9th.

We consider a large number I of investors who each holds one Terra on May 8th, when Terra is trading at a d dollar discount. Each Terra holder could stay put or sell her Terra to the arbitrageurs. The payoff from selling is always $1-d$ USD. The payoff from staying is 0 if Terra fails, and 1 USD if Terra survives and its peg is restored. Terra fails if and only if at most a share θ of investors decide to stay, where the uncertain fundamental $1-\theta$ corresponds to the parent company's reserves and its liquidity. Every investor observes a signal s_i about θ, representing public news and disclosures about the reserves.

Terra's rich ecosystem generates a nonrival net public good IE, none of which is expected to survive Terra's failure, implying $\alpha = 1$. We adopt the utility function of a crypto-token investor in Cong et al. (2021) to microfound each investor's nonpecuniary payoff $\lambda_i IE$ from the net public good. Applying Cong et al. (2021, eqn. (3)) to our setting, each investor i receives a nonpecuniary payoff equal to

$$\underbrace{e^{u_i}}_{\lambda_i} \times \underbrace{\text{number of Terra holders}}_{I} \times \underbrace{\text{productivity of the Terra ecosystem}}_{E}$$

from the network effect in the Terra ecosystem.[16] This network effect is the number I of Terra holders scaled by how productively (E) the Terra ecosystem translates I into liquidity, variety, or quality of the applications built on Terra. The idiosyncratic term e^{u_i} is an investor's *transaction need* for Terra (Cong et al., 2021, p. 1111). As the investors with greater transaction need e^{u_i} would trade Terra more often, they would derive a larger benefit from Terra's network effect, and thus e^{u_i} is equivalent to an investor's social sensitivity λ_i. Higher e^{u_i} exactly maps to higher trading volume-to-balance ratio in Liu et al. (2023), which interprets this ratio as a measure of investor sophistication. Absent our mechanism, sophisticated investors would run early.

[16] We omit the exponent terms that Cong et al. (2021) include for analytical convenience.

An investor's willingness to stay $\pi(s_i)$ in this setup is

$$\pi(s_i) = \mathbb{P}(\text{Terra survives} \,|\, s_i) \cdot \$1 - \$(1-d) + \Delta P(s_i) \underbrace{e^{u_i}}_{\lambda_i} IE,$$

whose functional form is analogous to the willingness to fund (1) in Section 2.1. We can thus apply Proposition 1, which predicts that the investors with higher transaction need e^{u_i} are less likely to sell their Terra. These investors would have higher trading volume-to-balance ratios and be more likely to incur losses upon Terra's failure, rationalizing the positive correlation between the two documented in Liu et al. (2023).

6 Bank Runs

We explain a salient case study from the 2023 banking crisis using our framework mapped to a standard global game of bank runs.

Motivating anecdote. In the 1946 classic film, *It's a Wonderful Life*, George Bailey's bank funds high-quality housing for the working class. When panicking depositors mob Bailey's bank during the Depression, George recalls to them all the good that his bank does for their town, and warns of the looming monopoly by the less generous competing bank. This speech dissuades enough withdrawals to keep the Bailey bank afloat.

Context. Amalgamated Bank is a New York-based publicly traded bank that held about $7 billion in deposits. Despite its small size, Amalgamated is a leading lender to labor unions and progressive causes, serving as the primary bank of the Democratic National Committee and the Clinton and Biden presidential campaigns. Amalgamated has long adopted "socially responsible" practices, advocating for gun control and pledging net-zero emissions by 2045. Amalgamated's advocacy is often credited with effecting change, say, when it successfully pressured credit card companies into flagging gun-shop purchases (Weingarten, 2023).

In 2023, 22 banks faced panic runs triggered by large unrealized losses and high shares of uninsured deposits (Cipriani, Eisenbach, and Kovner, 2024; Acharya, Richardson, Schoenholtz, et al., 2023). Figure 1 plots the unrealized-loss-to-equity ratios and the uninsured

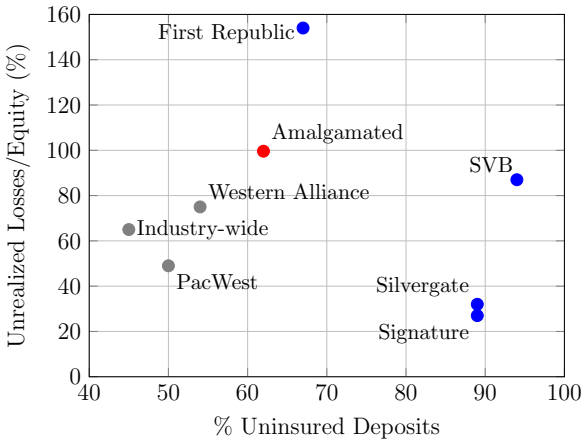


Figure 1: Unrealized Losses and Uninsured Deposit Shares in 2022Q4-2023Q1

Unrealized losses to equity value ratio and the share of deposits that were uninsured for Amalgamated Bank, the average across all US banks, four banks that failed in 2023Q1, and two banks (PacWest and Western Alliance) that had the largest deposit outflows in 2023Q1 among nonfailing banks. Source for Amalgamated Bank: as of 2023Q1 from The Wall Street Journal, July 15, 2023. Source for other banks: as of 2022Q4 from Kelly and Rose (2025).

deposit shares across US banks as of early 2023. Amalgamated Bank was near the four banks that ultimately failed and worse than the two nonfailing banks with the largest deposit withdrawals. Yet, Amalgamated's deposits slightly *increased*.

Recent arguments that private and non-coastal banks were protected from contagion effects (Cipriani et al., 2024; Kelly and Rose, 2025) do not apply to Amalgamated Bank. Amalgamated itself and the popular press (e.g., Weil, 2023) credit its commitment to socially responsible investments and the resulting "differentiated position [...] as a mission-based bank" for preventing a run (Amalgamated Financial Corp., 2023, p. 1).

Mapping to theory. The total net public good IE of Amalgamated Bank includes social impacts through its support for labor unions, progressive causes, and reducing the capital costs of socially responsible assets relative to pollution-intensive and firearms-related assets. Under our framework, Amalgamated's depositors internalize the potential for enormous harm to the environment and public safety if the bank were to fail. Amalgamated suffers fewer withdrawals as a result, and is more likely to survive than banks with similar liquidity ratios and financial payoffs.

A formal mapping to a standard bank-run game (e.g., Shen and Zou, 2024) only requires

setting $m = 1$ in the model of Section 2.1. A large number I of depositors each holds a unit deposit at a bank. Each depositor i either runs by withdrawing her deposit or stays. The bank would generate a net public good $IE > 0$ if it survives, through its investments in socially responsible projects. The net public good falls to $(1 - \alpha)IE$ if the bank fails, capturing the finding that a bank failure increases the bankruptcy risk of its borrowers by 40% (Schindler and Lambert, 2025). The net public good benefits depositor i at rate $\lambda_i > 0$, corresponding to lesser exposure to pollution or gun violence. The bank fails only if the number of runners exceeds the bank's liquid asset holdings $(1 - \theta)I$. The depositors observe noisy signals s_i about θ, as the bank's real-time asset holdings and liquidity are not public knowledge. In equilibrium, both the expected withdrawal amount and the failure risk of the bank are strictly decreasing in E.

7 Contributions

The closest prior work to ours is on global games, socially responsible consumers, and socially responsible investing. We make three contributions. (i) We develop the first, and highly tractable, global game in which agents internalize the marginal impact of one's action on the aggregate outcome, despite the agents being atomistic and selfish. Applying our framework to reallocations of investors and projects adds two results. (ii) Any positive assorting between projects' public goods and investors' social sensitivity raises the financial surplus. (iii) How this positive assorting occurs matters for society: sorting investors across projects always benefits the social surplus, whereas reallocating the projects among investors can harm the social surplus when the investors have low social sensitivity.

Global games obtain a unique equilibrium in spite of strategic complementarities. Prominent financial applications of global games include currency attacks (e.g., Morris and Shin, 1998; Corsetti, Dasgupta, Morris, and Shin, 2004), bank runs (e.g., Rochet and Vives, 2004; Goldstein and Pauzner, 2005; Shen and Zou, 2024; Kashyap et al., 2024), debt rollover (e.g., Morris and Shin, 2004; Ahnert and Kakhbod, 2017; He, Krishnamurthy, and Milbradt, 2019), short selling (Liu, 2015), stablecoin runs (Ma, Zeng, and Zhang, forthcoming), and generic

investment problems (e.g., Sákovics and Steiner, 2012; Morris and Yildiz, 2019). We introduce nonrival public goods to this literature. Doing so induces atomistic and selfish agents to internalize their marginal contributions to the aggregate outcome.

Global games naturally apply to political and cultural regime change (e.g., Edmond, 2013; Egorov and Sonin, 2021; McGee, 2025), where public goods are a dominant concern. In existing work, agents take the likelihood of regime change as exogenously given, because they abstract away the nonrivalry inherent to many public goods. In our framework, every agent endogenously internalizes her marginal impact on the likelihood of a regime change.

Kaufmann et al. (2024) develop a theory of *socially responsible consumers*. In their setting, atomistic and altruistic consumers care about other consumers' private costs from externalities. Each unit of foregone consumption slightly reduces the price, raising every other consumer's demand by a vanishingly small amount. These small amounts summed across a vast number of consumers have a strictly positive impact on aggregate demand, "dampening" the initial decrease in consumption. This dampening induces altruistic consumers to consume more and thus cause more social harm than they otherwise would. We do not assume altruism and analyze a setting with strategic complementarities. In our setting, no dampening occurs and purely selfish agents internalize their marginal impacts on the aggregate outcome, preserving more public goods than they otherwise would.

A large literature on *socially responsible investing* analyzes investor behavior in the presence of public goods. Heinkel, Kraus, and Zechner (2001), Pástor, Stambaugh, and Taylor (2021), Pedersen, Fitzgibbons, and Pomorski (2021), Piccolo, Schneemeier, and Bisceglia (2022), Wu and Zechner (2023), and Huang and Kopytov (2024) study warm-glow investors who obtain utility from holding green assets. Chowdhry, Davies, and Waters (2019), Oehmke and Opp (2024), Green and Roth (2025), and Gupta, Kopytov, and Starmans (2024) study large funds with mandates to increase the total public good. Broccardo, Hart, and Zingales (2022) and Dangl, Halling, Yu, and Zechner (2023) model agents who care about the total public good. Unlike this literature, we study selfish investors whose decisions endogenously depend on the public goods at stake when investment decisions feature strategic complementarities, with different applications and results.

More broadly, a rich literature examines public policies in the presence of nonpecuniary

externalities (Barnett, 1980; Laffont and Tirole, 1996; Hoffmann, Inderst, and Moslener, 2017; Hong, Wang, and Yang, 2023; Biais and Landier, 2022; Döttling and Rola-Janicka, 2024). This literature focuses on cap-and-trade, emission taxes, and mandates, which lie outside the scope of this paper.

8 Voting

As in our setting, voting can trigger a regime change involving nonrival public goods, and a typical voter is unlikely to be pivotal. However, most voting games assume that voters act as if they are pivotal to achieve equilibrium uniqueness, whereas our mechanism requires an endogenous pivotal probability.

The difficulty of applying our mechanism to voting arises from a difference in payoffs between global games and most voting games. In a global game, agents strictly prefer taking one action conditional on a regime change and another action conditional on the status quo. Voters in a typical voting game are indifferent between their potential actions conditional on a voting outcome. A class of voting games inserts the relative likelihood of different voting outcomes directly into voters' utilities to model voting as a global game (e.g., Myatt, 2007, 2017). Our mechanism applies to those voting games.

We view voting on corporate proposals with the trading of shares (Levit, Malenko, and Maug, 2024; Bond and Levit, 2024) or of voting rights (Blair, Golbe, and Gerard, 1989) as the most promising candidates for a voting game that can incorporate our mechanism without inserting likelihoods directly into voters' utilities. Trading introduces differences in payoffs among possible actions conditional on a vote outcome. It is then sufficient that different actions (say, selling one's share versus holding it and voting against) yield strictly maximal payoffs conditional on different vote outcomes. Strategic complementarity exists in some models where shareholders can sell their shares (e.g., Levit et al., 2024) or voting rights (e.g., Speit, Voss, and Danis, 2023). Formally incorporating share or vote trading into a global game is beyond the scope of this paper.

Appendix

A Warm-Glow Investors

We consider warm-glow investors who each receives a glow as long as she is funding a specific project and this project has yet to fail. The investor permanently loses the glow if the project fails.

Formally, we modify the game of Section 2 in exactly one way. The *ex-post* utility U_i of investor i equals the sum of any financial payment she receives and a warm glow $\lambda^{\text{WG}} mE$ if the project continues:

$$U_i^{\text{WG}} = \begin{cases} mR + \lambda^{\text{WG}} mE, & \text{if } i \text{ funds and project continues,} \\ 1 + \lambda^{\text{WG}} mE, & \text{if } i \text{ exits and project continues,} \\ 0, & \text{if } i \text{ funds and project fails,} \\ 1, & \text{if } i \text{ exits and project fails.} \end{cases}$$

In equilibrium, each investor ignores her marginal impact on the likelihood of project survival.

Proposition A.1. *There exists a unique switching equilibrium, wherein:*

1. *An investor funds if and only if her signal s_i is strictly below a common cutoff s^{WG}, where*
$$s^{WG} = (m\sigma + 1)\frac{mR - 1}{m^2 R} - \frac{\sigma}{2}.$$
2. *The project continues if and only if its funding need θmI is strictly below a threshold $\theta^{WG} mI$, where*
$$\theta^{WG} = \frac{mR - 1}{m^2 R}.$$

Proposition A.1 implies that neither the cutoff s^{WG} for an investor to fund nor the cutoff θ^{WG} for the project to continue depends on the glow $\lambda^{\text{WG}} mE$. Both cutoffs would remain

identical if the investors were purely financially motivated, $\lambda^{\mathrm{WG}} mE = 0$. The proof is given in Section B.

B Proofs

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

Given θ, the probability that each investor observes a signal below her cutoff s^* and therefore funds 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 investors choosing to fund is

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

The firm fails if and only if its funding need exceeds the amount of new funds raised from investors, $\theta mI > nI$, which is equivalent to $\theta > \theta^*$.

Upon observing a signal $s_i \geq \theta^* + \frac{\sigma}{2}$, an investor infers that $\theta > \theta^*$ and thus the firm fails with probability 1. Hence, $\pi(s_i) = -1 < 0$ and the investor optimally chooses to exit. Likewise, upon observing a signal $s_i \leq \theta^* - \frac{\sigma}{2}$, $\pi(s_i) = mR - 1 > 0$ and the investor optimally chooses to fund.

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 $s_i \in \left(\theta^* - \frac{\sigma}{2}, \theta^* + \frac{\sigma}{2}\right)$, an investor's perceived probability of being pivotal is

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

Then, the willingness to fund $\pi(s_i)$ becomes

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

Therefore, the investor optimally funds whenever her signal $s_i < s_i^*$ and optimally exits whenever $s_i > s_i^*$.

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

$$n = \int H\left(\frac{s_i^* - \theta}{\sigma}\right) \mathrm{d}i. \tag{B.1}$$

Let $\vec{s}^*$ denote the vector of funding thresholds $(s_i^*)_{i\in[0,1]}$. The firm fails if and only if the

value of its funding need is above a critical threshold $\theta^*(\vec{s}^*)mI$, where $\theta^*(\vec{s}^*)$ solves

$$m\theta^*(\vec{s}^*) = \int H\left(\frac{s_i^* - \theta^*(\vec{s}^*)}{\sigma}\right) \mathrm{d}i, \tag{B.2}$$

which says that at the critical threshold, $\theta = \theta^*(\vec{s}^*)$, just enough investors fund to meet the firm's funding needs.

Because a marginal investor i is indifferent between funding 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 θ of the marginal investor i,

$$\theta^*(\vec{s}^*) \in \left[s_i^* - \frac{\sigma}{2}, s_i^* + \frac{\sigma}{2}\right]. \tag{B.3}$$

Otherwise, the marginal investor i would believe that the firm survives with probability 1 or 0, $\mathbb{P}\left(\theta \leq \theta^*(\vec{s}^*) \,|\, s_i = s_i^*\right) = 1$ or 0, and that she is pivotal with probability 0, $\Delta P(s_i^*) = 0$, and thus i cannot be indifferent between funding and not under such beliefs: $\pi(s_i^*) = \mathbb{P}\left(\theta \leq \theta^*(\vec{s}^*) \,|\, s_i = s_i^*\right) mR - 1 + \Delta P(s_i^*)\alpha\lambda mIE \neq 0$.

It then follows from (B.3) 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 (B.1) with respect to θ at the threshold $\theta = \theta^*(\vec{s}^*)$ gives

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

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

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

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

$$\begin{aligned}\pi(s_i^*) &= \mathbb{P}\left(\theta \leq n \,|\, s_i = s_i^*\right) mR - 1 + \Delta P(s_i^*)\lambda mIE \\ &= \mathbb{P}\left(\theta \leq \theta^*(\vec{s}^*) \,|\, s_i = s_i^*\right) mR - 1 + \frac{1}{m\sigma+1}\frac{1}{I}\cdot\lambda mIE \\ &= \left[1 - H\left(\frac{s_i^* - \theta^*(\vec{s}^*)}{\sigma}\right)\right] mR - 1 + \frac{\alpha\lambda mE}{m\sigma+1}.\end{aligned}$$

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

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

Hence, (B.2) becomes

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

which yields

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

and thus (2).

□

Proof of Proposition 2. We generalize the proof of Proposition 1 to a firm whose in-

vestors are heterogeneous in λ_i.

First, we show that the candidate switching equilibrium $(s^*_{i,k})$ is indeed an equilibrium. The probability that each investor of firm k observes a signal below her cutoff $s^*_{i,k}$ and funds is $H\left(\frac{s^*_{i,k}-\theta_k}{\sigma}\right)$. The exact law of large numbers implies that the proportion n_k of investors funding firm 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

$$\begin{aligned} n_k &= \int \frac{s^*_{i,k} + \frac{\sigma}{2} - \theta^*_k}{\sigma} \mathrm{d}i \\ &= \frac{\theta^*_k + \sigma\,[1-\psi(\lambda_i)] - \theta^*_k}{\sigma} = m\theta^*_k. \end{aligned}$$

Hence, the firm fails if and only if its funding need exceeds the amount of new funds raised from investors, $\theta_k \omega_k m I > n_k \omega_k I$, which is equivalent to $\theta_k > \theta^*_k$.

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

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 $s_{i,k} \in \left(\theta^*_k - \frac{\sigma}{2}, \theta^*_k + \frac{\sigma}{2}\right)$, an investor's perceived probability

of being pivotal is

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

Then, the willingness to fund $\pi(s_{i,k})$ becomes

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

Therefore, the investor optimally funds whenever her signal $s_{i,k} < s_{i,k}^*$ and optimally exits whenever $s_{i,k} > s_{i,k}^*$.

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

$$n_k = \int H\left(\frac{\tilde{s}_{i,k}^* - \theta_k}{\sigma}\right)\mathrm{d}i. \tag{B.4}$$

Let $\tilde{s}_k^*$ denote the vector of funding thresholds $(\tilde{s}_{i,k}^*)_{i\in[0,1]}$. The firm fails if and only if the value of its funding need is above the critical threshold $\theta^*(\tilde{s}_k^*)\omega_k m I$. Because a marginal

investor i is indifferent between funding and exiting 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 θ_k of the marginal investor i,

$$\theta^*(\tilde{s}^*_k) \in \left[\tilde{s}^*_{i,k} - \frac{\sigma}{2}, \tilde{s}^*_{i,k} + \frac{\sigma}{2}\right]. \tag{B.5}$$

Otherwise, the marginal investor i would believe that the firm 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 funding and exiting under such beliefs: $\pi(\tilde{s}^*_{i,k}) = \mathbb{P}\left(\theta_k < \theta^*(\tilde{s}^*_k) \,|\, s_{i,k} = \tilde{s}^*_{i,k}\right) mR_k - 1 + \Delta P(\tilde{s}^*_{i,k})\alpha\lambda_i\omega_k mIE_k \neq 0$. It then follows from (B.5) 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 (B.4) with respect to θ_k at the 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 investor's perceived probability of being pivotal is

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

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

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

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

$$H\left(\frac{\tilde{s}^*_{i,k} - \theta^*(\tilde{s}^*_k)}{\sigma}\right) = 1 - \psi_k(\lambda_i). \tag{B.6}$$

Hence, (B.2) becomes

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

Therefore, (B.6) becomes

$$\tilde{s}^*_{i,k} = \frac{1 - \psi_k\left(\bar{\lambda}_k\right)}{m} + \sigma\left[1 - \psi_k(\lambda_i)\right] - \frac{\sigma}{2} = s^*_{i,k},$$

which yields (8) and (9).

□

Proof of Proposition 3. We let $\bar{R} = \sum_{k=1}^K \omega_k \bar{R}_k$ be the average financial payoff across

all projects.

$$\begin{aligned}
\text{Financial surplus} &= \sum_{k=1}^{K} \big(\mathbb{P}\left(\text{firm } k \text{ survives}\right) + (1-\alpha)\mathbb{P}\left(\text{firm } k \text{ fails}\right)\big)\bar{R}_k\omega_k mI \\
&= \sum_{k=1}^{K} \left[1 - \alpha\,\frac{\bar{\theta} - \theta_k^*}{\bar{\theta} - \underline{\theta}}\right]\bar{R}_k\omega_k mI \\
&= \bar{R}mI + \frac{\alpha}{\bar{\theta} - \underline{\theta}} \sum_{k=1}^{K} \frac{1 - \frac{1-\frac{\alpha\bar{\lambda}_k m\bar{E}_k}{m\sigma+1}}{m\bar{R}_k}}{m}\, m\bar{R}_k\omega_k I - \frac{\alpha\bar{\theta}}{\bar{\theta} - \underline{\theta}}\,\bar{R}mI \\
&= \frac{\alpha^2}{(\bar{\theta} - \underline{\theta})(m\sigma+1)} \sum_{k=1}^{K} \omega_k\bar{\lambda}_k\bar{E}_k I \\
&\qquad + \bar{R}mI + \frac{\alpha}{\bar{\theta} - \underline{\theta}}\,\bar{R}I - \frac{\alpha}{(\bar{\theta} - \underline{\theta})m}\,I - \frac{\alpha\bar{\theta}}{\bar{\theta} - \underline{\theta}}\,\bar{R}mI.
\end{aligned}$$

We consider the impact of a positive-assortative divestment from τ to τ'. We order the firms by their investors' average social sensitivity, $\bar{\lambda}_1 > \ldots > \bar{\lambda}_K$, and let $\bar{E}'_k = \sum_{n=1}^{N} \tau'_{k,n} E_n$ be the average net public good of the firms' projects after the divestment.

We apply the Abel transform 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 net public good of all firms,

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

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 investors with a symmetric argument.

□

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

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

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 firm k, and let $\bar{E}'_k = \sum_{n=1}^{N} \tau'_{k,n} E_n$ be its average net public good after the divestment. Then, it follows from two Abel transformations that

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

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

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

and thus the divestment strictly reduces social surplus.

Part 3: The sorting of investors strictly raises the term $\sum_{k=1}^{K} \omega_k \bar{\lambda}_k \bar{E}_k \frac{\bar{E}_k}{\bar{R}_k}$ without affecting the other terms in the social surplus. Therefore, the sorting of investors always strictly raises the social surplus. □

Proof of Proposition A.1. The proof of Proposition 1 shows that the marginal investor's perceived probability of being pivotal is

$$\Delta P\left(s^{\mathrm{WG}}\right) = \frac{1}{m\sigma + 1} \frac{1}{I}.$$

Then, her willlingness to fund $\pi^{\mathrm{WG}}\left(s_i^{\mathrm{WG}}\right)$ becomes

$$\pi^{\mathrm{WG}}\left(s_i^{\mathrm{WG}}\right) = \mathbb{P}\left(\theta \leq n \,|\, s_i = s_i^*\right) mR - 1 + \underbrace{\Delta P\left(s_i^{\mathrm{WG}}\right) \lambda m E}_{=0}.$$

Proposition A.1 follows. □

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