# Working Paper Series

# Proving Approval: Bank Dividends, Regulation, and Runs

Previously circulated as "Proving Approval: Dividend Regulation and Capital Payout Incentives."

Levent Güntay
*Federal Deposit Insurance Corporation*

Stefan Jacewitz
*Federal Deposit Insurance Corporation*

Jonathan Pogach
*Federal Deposit Insurance Corporation*

Previous Version: November 2015
Current Version: August 2017

Forthcoming as "A Prudential Paradox: The Signal in (not) Restricting Bank Dividends" in *Journal of Money, Credit and Banking.*

FDIC CFR WP 2015-05

fdic.gov/cfr

# Proving Approval: Bank Dividends, Regulation, and Runs*

Levent Güntay[†] Stefan Jacewitz[†] Jonathan Pogach[†]

August 29, 2017

**Abstract**

Bank stability depends on information. Regulators can allow banks to release some information about their safety and soundness. This paper shows how dividend regulation and information interact to affect bank stability. In the model, wealth-expropriation, excess cash flow, and signaling incentives affect a bank's decision to pay dividends. The regulator aims to prevent wealth expropriation through dividend restrictions on undercapitalized banks. However, this action increases the banks' incentives to pay dividends for signaling. Signaling incentives are further exacerbated in the presence of bank runs. We show that the first best solution is achievable through dividend restrictions only if capital requirements are sufficiently high. Furthermore, a more restrictive dividend regulatory policy is optimal in stressed economic environments, when banks are more run-prone, allowing the weak banks to pool with strong.

**Keywords:** *Dividends, Banking, Capital Regulation, Wealth-Expropriation, Signaling, Bank runs*



*We thank Michal Kowalik, Celine Meslier, George Pennacchi, Manju Puri, Carlos Ramirez, Haluk Unal, and participants of seminars or workshops at American University, the FDIC, the FDIC-JFSR 13th Annual Banking Research Conference, the Federal Reserve Board of Governors, the Financial Intermediation Research Society (FIRS) Conference 2016, and the Financial Management Association.

[†]Güntay is at the MEF University, Turkey and Jacewitz and Pogach are at the Federal Deposit Insurance Corporation, US. The authors may be contacted at guntayl@mef.edu.tr, sjacewitz@fdic.gov, and jpogach@fdic.gov, respectively.

# 1 Introduction

Banks are inherently fragile. This fragility is based on what information is available to market participants. In banking systems worldwide, regulators play a key role in the dissemination of information about bank health to the market. One important way that the market learns about regulators' inside information is through observed dividend payments. Since regulators have the ability to restrict dividend payments, the market interprets these payments through the lens of privately informed regulators. Moreover, since regulators may deny dividend payment requests made by weaker banks, stronger banks have an incentive to pay out more dividends to signal to the market that they have earned the regulators' approval. In this paper, we study the role that dividend restrictions play in bank payout policy and financial stability through their effects on market information about bank health.

We show that the optimal regulatory dividend policy depends critically on the stability and capitalization of the banking system. A dividend policy that restricts only the most fragile institutions may be too informative, making weaker banks more susceptible to bank runs. Alternatively, an unrestrictive and uninformative policy risks allowing undercapitalized banks to expropriate wealth from the government by "cashing out" of their equity position. Additionally, when depositors are panicky, providing less information through a more restrictive dividend policy can be optimal, as it allows weaker banks to pool with stronger banks. In this way, the opaqueness created by the lack of information promotes stability by preventing costly bank runs. In all cases, we find that higher capital requirements mitigate the distortionary wealth expropriation and inefficient signaling effects of banks' payout policies.

Banks are more likely than firms in other industries to make dividend payments (see Figure 1) and those payments are more likely to fluctuate (see Figure 2). Prior to the 2008 financial crisis, banks paid dividends roughly four times more often than industrial firms and 33 percent more often than even non-bank financial firms. Similarly, over the 15 years

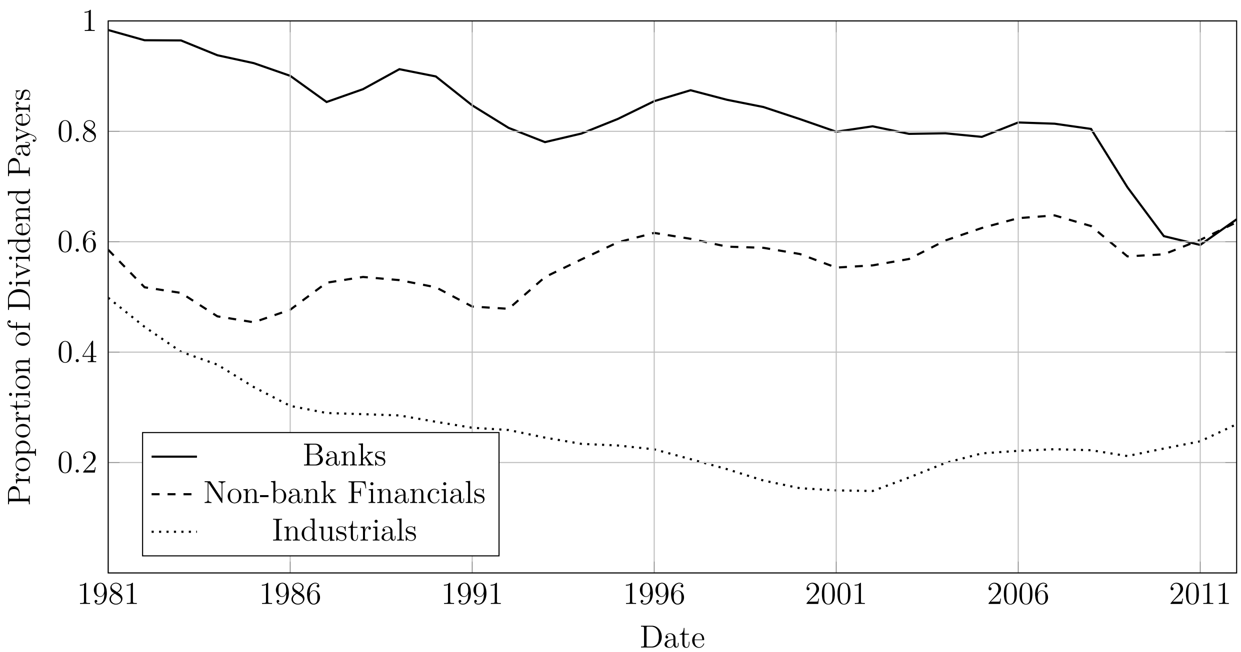


**Figure 1:** Fraction of firms paying a dividend.

prior to the 2008 financial crisis, bank dividends were less stable than in their industrial and non-bank financial counterparts. Banks were also more likely to both increase and decrease their annual dividends when compared to industrial and non-bank financials.

In the final build-up to the crisis, between 2007 and 2008, the largest twenty-one banks used dividends to shed \$130 billion of equity off of \$1.5 trillion of market capitalization (Acharya, Gujral, Kulkarni, and Shin (2011)). Not long thereafter, many of these same banks relied on public funds for their survival – if they survived at all. The sum paid out to shareholders accounts for more than half of the total Troubled Asset Relief Program (TARP) support received by US institutions through December 2008 (\$247 billion). Among non-bank firms associated with the financial crisis, AIG increased its dividend distributions year-on-year for every year between 2002 to 2008. It declared the largest dividend per share in its history on May 8, 2008, with a payment date of September 19, 2008, the same week as the Lehman failure.[1]

[1]http://www.nasdaq.com/symbol/aig/dividend-history

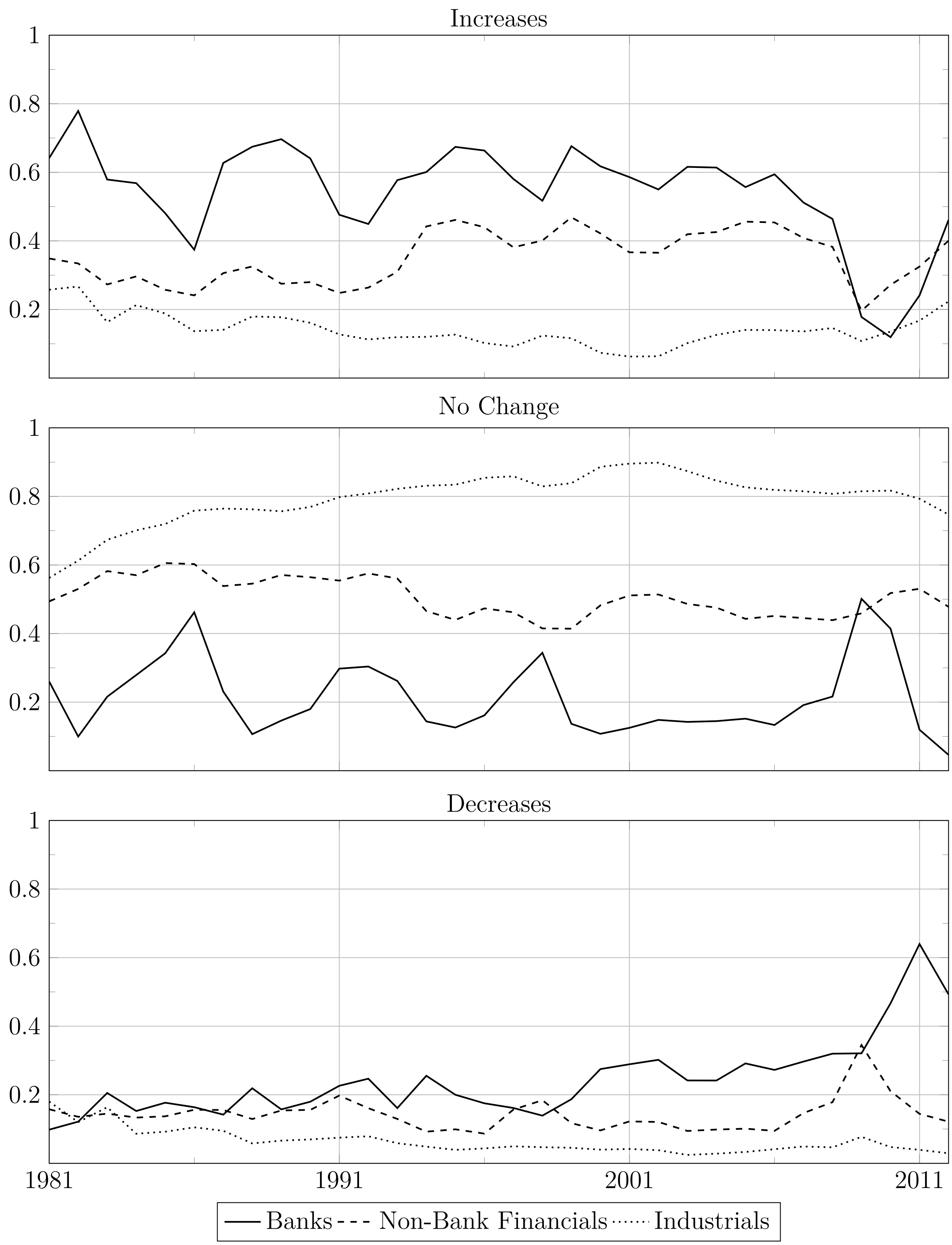


**Figure 2:** Proportion of firms with a year-on-year increase, decrease, and no change in dividends per share.

In this paper, we analyze the tradeoffs faced by policy makers in setting capital payout regulations. Traditionally, dividend restrictions are justified as a means to prevent wealth expropriation (including risk shifting) by equity holders from bank debt holders or government guarantors. Risk-shifting and wealth expropriation may also result in deadweight losses associated with increased failures or the misallocation of capital that results from mispricing of debt.[2] However, the publicly observable differences between individual banks' payout policies provide information about the otherwise opaque asset quality of banks. Therefore, a payout restriction on a bank will also create an incentive for other banks to pay socially inefficient dividends. This effect arises immediately from the information asymmetry between regulators and the market: When a bank's dividend payment must be approved by a relatively informed regulator, the market rationally interprets the dividend payment as a signal reflecting *both* the bank's fundamentals *and* the regulator's private information. A bank, eager to signal its health to the market, then has an additional incentive to pay a dividend to demonstrate to the market that the regulator has deemed it sufficiently healthy. As an outflow of funds from a bank, these regulator-induced dividend payments not only reduce the banks' capital levels, but also reduce the availability of loanable funds in the economy. Thus, while restricting dividends on potentially risky banks has the positive effect of reducing wealth expropriation among weaker banks, it also distorts the payout incentives of the entire industry—stronger and weaker banks alike. We show that these signaling distortions can be eliminated, or mitigated, through higher capital requirements.

While implied regulatory approval through observed dividend payments adds information to the market, regulators simultaneously maintain the confidentiality of some information to deter bank runs and promote the stability of the financial system.[3] Consequently, understanding the regulator's tradeoffs on dividend restriction policies requires an understanding of how

[2]See Akerlof, Romer, Hall, and Mankiw (1993).
[3]See the discussion in Section 2 on information and banking.

the informational environment affects bank runs. We model bank runs as costly withdrawals of funding that occur when the perceived probability that a bank is undercapitalized, given public information, exceeds an exogenous threshold. A lower threshold implies a more "run-prone" or "panicky" environment. For simplicity, we assume that bank runs are prohibitively expensive.[4] Therefore, the regulator's first objective is to avoid financial panics.

Within the model's framework, the policy of a broad-based (and, consequently, uninformative) dividend restriction has the advantage of both reducing runs and preventing inefficient dividends. Pooling a sufficient number of moderately capitalized banks with undercapitalized banks abates depositors' fears that a non-dividend paying bank is actually undercapitalized. Simultaneously, broad-based dividend restrictions prevent moderately capitalized banks from inefficiently signaling their strength to separate themselves from the more run-prone banks.

Following this logic, we show that the optimal level of regulatory strictness increases as depositors become more run-prone. That is, the more fragile the banking system, the more valuable it will be for regulators to withhold information about individual banks' health through non-informative, broad-based dividend restrictions. However, when applied too narrowly or too conservatively, dividend restrictions also have the capacity to both exacerbate runs at restricted banks and induce inefficient signaling incentives for unrestricted banks. For example, when only undercapitalized banks are restricted from paying dividends, there is an equilibrium in which all unrestricted banks pay a dividend – inefficiently for many – to separate themselves from the undercapitalized ones. Meanwhile, the separation of adequately capitalized banks implies that all restricted banks are immediately identified as being undercapitalized, given their failure to pay dividends, prompting self-fulfilling panics for all non-dividend paying, undercapitalized banks.

To our knowledge, this paper is the first to build a theoretical model of the payout

[4]Though outside our modeling framework, runs on short-term funding can result in a systemic fire sale problem. For instance, Hanson, Kashyap, and Stein (2011) argue that some of the most damaging aspects of the crisis arose precisely from the collapse of an entire market consequent to such runs on short-term funding.

incentives of banks, including endogenous bank responses, to capital and dividend regulation. Despite vast literature on the payout policies of both industrial firms and nonbank-financial firms, little theoretical work examines the unique and consequential circumstances under which banks and systemically important institutions pay dividends. This is particularly surprising, since the standard theory for non-bank firms does not translate well due to banks' (and systemic financial institutions') unique agency problems, capital structures, and overarching regulatory environment. Furthermore, understanding dividend policy is more consequential for banks when compared to both industrial and nonbank-financial firms, as indicated by the relatively high levels of leverage; the fraction of the institutions paying dividends; the frequency with which banks increase (and cut) dividends; and the total aggregate dollar amount transferred to shareholders through dividend payments.

The rest of the paper is organized as follows. Section 2 reviews the existing literature. Section 3 introduces the framework of the model and obtains the equilibrium dividend policies for various cases with and without a regulator. Bank runs are incorporated in Section 4. Section 5 discusses the policy implications and concludes the paper.

# 2 Literature Review

This paper contributes to the literature on banks and information and to the growing literature on payout policies at banks and systemically important financial institutions. In the information and banking literature, Dang, Gorton, Holmström, and Ordoñez (2017) show that opacity in bank assets can be optimal. For market participants to accept a financial instrument as money-like, the instrument must be information insensitive. Simultaneously, banks hold assets that tend to be highly information sensitive. To maintain the fluidity of the market, banks – and regulators – keep information hidden from the market. The history and development of this opacity can be found in Gorton (2014). Dang, Gorton, Holmström, and Ordoñez (2017) point out that regulators' bank examinations and other information are kept confidential, but some information, like "stress test" results, are disclosed. Our model explores the optimality of what information is released (e.g., dividend payments), when it is released (the prevailing economic environment), why it is released (to maintain stability), and how it is released (narrowly or broadly).

On the empirical side, Acharya, Gujral, Kulkarni, and Shin (2011) document the payout policies of large financial institutions in the period leading up to and during the 2008 financial crisis. The largest institutions decreased their collective common equity from 2000 to 2006 even as their nominal assets grew tremendously. Furthermore, payout policies persisted during the 2008 crisis, even for those institutions that ultimately failed or required government assistance. Meanwhile, Hirtle (2014) documents differential behavior of large and small bank holding companies with regard to dividends and repurchases. Kanas (2013) finds evidence of risk-shifting from 1992 to 2008, with high-risk banks being more likely to pay a dividend. Floyd, Li, and Skinner (2014) compare the payout policies of US banks to those of industrials and non-bank financial firms over a thirty-year period, including the 2008 financial crisis. Consistent with Figures 1 and 2, they document that banks have a higher and more stable *propensity* to pay dividends, even more so than non-bank financial firms. Furthermore, they find patterns similar to Acharya, Gujral, Kulkarni, and Shin (2011) with regard to large bank behavior during the crisis. Our paper provides a theoretical framework through which to view these empirical findings.

Despite the growing empirical literature, few papers examine the unique incentives for payouts in the banking industry. A recent exception is Acharya, Le, and Shin (2013) who study the negative externalities that arise when banks pay dividends. As a result, they argue that the private equilibrium can feature excess dividends and that minimum capital ratios can deter such excess. In contrast, we examine dividend behaviors that arise in the presence of capital regulation and focus on endogenous bank responses.

Although our study focuses on bank payout policy, we benefit from previous theoretical work on corporate dividend policy. Risk-shifting, or the expropriation of wealth by shareholders at the expense of debtholders, dates back at least to the works of Myers (1977) and Jensen and Meckling (1976). Similarly, Galai and Masulis (1976) (among others) demonstrate that stockholders may increase their equity value by increasing the riskiness of their assets to the detriment of debtholders. Meanwhile, free cash flow as an explanation for dividend policy also has roots in Jensen and Meckling (1976), as well as in Grossman and Hart (1980) and Easterbrook (1984).

Another thread in the dividend literature focuses on firms' signaling strength through capital payouts. We rely on one of these papers, Miller and Rock (1985), which models management as balancing the desires of both short- and long-term shareholders. This framework allows management to payout some level of dividends to benefit short-term shareholders at the expense of the long-term shareholders.

Finally, this paper ties into a larger literature on prompt corrective action (PCA). In particular, we consider the role that regulators play in stemming capital outflow from dividend payout policies. Empirical papers in this literature generally find reduced risk taking and increased capital ratios in response to PCA (e.g., Benston and Kaufman (1997) and Aggarwal and Jaques (2001)), while others report mixed results (e.g., Kanas (2013)). Furthermore, Admati, DeMarzo, Hellwig, and Pfleiderer (2011) advocate payout restrictions to promote a safer financial industry, as a whole. Our paper contributes to this discussion by highlighting that signaling incentives generated by the presence of PCA result in socially inefficient dividends at banks on the margin of adequate capitalization. As such, payout restrictions are efficient even for institutions far from the default boundary.

# 3 Model

We begin with a simplified model including wealth expropriation and signaling, but without a regulator or bank runs. Through both the limited liability protection of equity[5] holders and mispriced debt through government guarantees of debt, weak banks are incentivized to "cash-out" (expropriate wealth) through dividend payments. Even in the simplest version, signaling endogenously arises in equilibrium.

Assume that the debt holders are always paid in full (deposits are insured), but that fixed failure costs $c$ associated with failure are borne by the public, along with any shortfalls.[6] Thus, the stake holders (given Pareto weights in accordance with their claims) are the debt holders, management (which represents both inside and outside equity holders), and the regulator.

As an illustrative tool, we first examine the model under a *laissez faire* assumption, without a regulator. In this environment, there are three categories of banks. First, for poorly-capitalized banks, all or most returns from reinvestment would flow to debt holders. These banks would then pay a dividend because both short- and long-term share holders benefit at the expense of debt holders. In this case, dividends are paid for the sole purpose of wealth expropriation. Second, well-capitalized banks have a strong incentive to pay dividends. If marginal returns are low (or even negative), then the opportunity cost of dividends for long-term shareholders is low, while the short-term shareholders can benefit from signaling. So, these well-capitalized banks will be more incentivized to pay dividends. Finally, dividends at adequately capitalized banks come at a high opportunity cost to long-term shareholders who would forgo relatively high marginal returns. Being far from the default boundary, debt holders share none of this opportunity cost. Thus, the adequately

[5]Note that what we refer to in the model as "equity" is the residual liquidation value of the bank's assets, rather than the investor's expectation of future payments to equity holders. Hence, we use the term "equity" simply to connect to "capital" in the context of the banking industry.

[6]Without loss of generality, the model can accommodate pre-paid deposit insurance premiums.

capitalized banks have a relatively weak incentive for dividend payments. With the well- and under-capitalized institutions (those at either extreme) having the greatest incentive to make dividend payments, the interpretation of the dividend signal by outside investors is attenuated. A dividend payment signals a bank on either of the extremes, while a non-dividend signals a bank in the middle.

We extend the model to incorporate the equilibrium outcome with a regulator. The regulator releases its privately held information through the authorization to pay dividends. From a regulator's standpoint, the *laissez faire* outcome is problematic: Undercapitalized banks exploit the public safety net by transferring resources to underwater shareholders. To reduce this expropriation of wealth, regulators reasonably respond by restricting dividend payments at undercapitalized institutions. However, by preventing relatively weak banks from paying dividends, regulators inject information on the health and safety of the bank into the market. In short, when the market observes that a bank has not made (or increased) dividend payments, then it concludes that the bank is more likely weak. Thus, healthy banks that would have otherwise held additional capital may dividend it away to shareholders, simply to demonstrate that they have been permitted to do so by regulators. These banks would have used this capital more productively internally (to make loans), but instead these projects go unfunded and these banks are moved closer to failure (through lower capital levels).

## 3.1 Bank Characteristics

A key feature of the model is that outside investors do not observe a bank's true equity and asset values.[7] This assumption is reasonable in the context of financial firms given the

[7] This is similar to Duffie and Lando (2001) in which bond investors do not observe the issuer's assets directly, but instead receive noisy accounting reports. The opacity of bank assets is similar in spirit to Dang, Gorton, Holmström, and Ordoñez (2017). Adding this feature to the model improves the tractability, as it allows us to abstract away from ex-post bank uncertainty.

relative opaqueness of bank their assets.We assume that a continuum of firms enter in period 0 with equity that can take on values $E_0 \sim \Psi$ with support $[\underline{E}, \bar{E}]$. Note that, *ex ante*, banks are identical, with the same distribution on starting equity. Banks all have debt $D$, which is due at the end of period 1.[8]

Assets pay a gross return given by $R(\cdot) > 0$ with $R' > 0, R'' < 0$. Note that negative marginal returns ($R' < 1$) are allowed, though not required, reflecting the possibility of a free cash flow problem or, alternatively, that a bank's marginal loan does not outperform an investor's opportunity cost. For simplicity, we assume that all agents are risk neutral and that there is no discounting.

## 3.2 Management

The model timeline is depicted in Figure 3. In period 0, the management observes $E_0$ and the bank's current assets are $A_0 = R(D + E_0)$. The management chooses whether to pay a dividend $\tilde{d} \in \{0, d\}$. For simplicity, we assume the dividend payment is discrete. The remaining assets are reinvested into the bank so that future assets become $A_1 = R(D+E_0-\tilde{d})$, where $R$ is a revenue function that has decreasing marginal returns. Given limited liability, a bank's equity at the end of period 1 is given by $E_1(E_0, \tilde{d})$ defined as:

$$E_1(E_0, \tilde{d}) = \max\left\{0, R\left(D + E_0 - \tilde{d}\right) - D\right\}$$

.

To simplify notation, we often suppress the arguments of the functions and write $E_1$. We define the change in bank value due to dividend payments by, $\Delta R(D + E) = R(D + E) - R(D + E - d)$. $\Delta R > 0$ implies that keeping the dividends in the bank always generates additional bank value. If, on the other hand, $\Delta R > d$ for all $E_0$, then paying dividends is

[8]The model easily accommodates the interpretation that bank equity is distributed according to $\Psi$ conditional on any public observable information.

always inefficient. We allow for $\Delta R < d$, leaving open the possibility that dividend payments can be optimal. A number of extant theories would be consistent with this assumption. For example, a free cash flow problem, in which managers would expropriate excess cash or invest in negative NPV projects, is consistent with $\Delta R < d$. Clientele effects can also justify this condition. For instance, if shareholders have strong liquidity demands they value a unit of wealth more when held as dividends rather than as equity.[9]

The theory relies on managerial short-term incentives to generate a signaling effect. Following Miller and Rock (1985), we assume management acts in the joint interest of long-term shareholders, who will hold onto stock until the end of period 1 (e.g., because of vesting), and short-term shareholders, who will sell their stock after the bank pays dividends (e.g., because of liquidity needs). The parameter $\lambda \in (0,1)$ reflects the weight the management places on the interests of short-term shareholders, with the complementary weight given to long-term shareholders.

The bank's objective function is given by:

$$V\left(E_0\right) = \max_{\tilde{d}} \left\{ \tilde{d} + \lambda \mathbb{E}\left[E_1 | \tilde{d}\right] + (1-\lambda) E_1 \right\} \tag{1}$$

where the expectation operator is defined over the distribution of public information, $\Psi$. This is because although the manager observes $E_0$, the market can only infer the value of the bank through its dividend policy. Because short-term investors seek to sell their stock before the information asymmetry is resolved, they value the bank at $\tilde{d} + \mathbb{E}\left[E_1 | \tilde{d}\right]$, which depends only on the dividend choice of the bank as the private information is integrated out. Only the final term depends on $E_0$.

[9] Allen and Michaely (2003) survey the dividends literature, including discussions of free-cash flow and clientele effects. Jensen (1986) and Pettit (1977) are for an examples, among many, of free-cash flow and clientele effects, respectively.

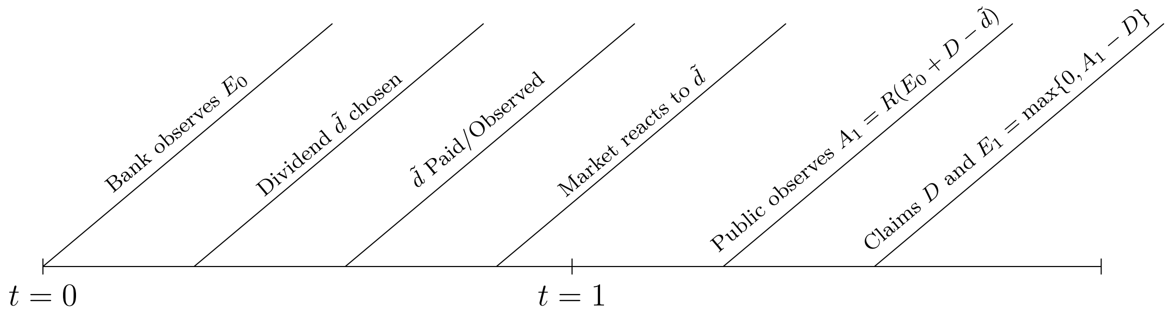


**Figure 3:** Model timeline.

## 3.3 First-Best Case

In first-best case the total bank value of all banks is maximized. Note that unlike the bank's objective function, the first-best allocation includes losses borne by the regulator and any failure costs. The first-best problem is written as:

$$\max_{\tilde{d}(\cdot)} \mathbb{E}\left[\tilde{d} + R(D + E_0 - \tilde{d}) - \mathbf{1}(E_1 = 0)c\right], \tag{2}$$

where $c$ represents failure costs and $\mathbf{1}$ is the indicator operator.

The first-best problem is solved piecewise on a bank by bank basis: For each $E_0$ solve $\max_{\tilde{d}(\cdot)} \tilde{d} + R(D + E_0 - \tilde{d}) - \mathbf{1}(E_1(E_0, \tilde{d}) = 0)c$. The first-best solution is that a bank pay a dividend only when the net present value of the marginal project is greater than 0, net of failure costs. That is,

$$d^*(E_0) = \begin{cases} d, & \text{if } d - \Delta R(D + E_0) - [\mathbf{1}_{E_1(E_0,d)=0} - \mathbf{1}_{E_1(E_0,0)=0}]c > 0 \\ 0, & \text{otherwise} \end{cases} \tag{3}$$

We restrict $d, c$ and $R(\cdot)$, so that dividends are efficient only for those banks with sufficient capital. Dividends are inefficient for low capital banks if the marginal return at $E_0 = d$ (i.e. $\Delta R(D + d)$) is sufficient large, the failure costs $c$ are sufficiently large, or the dividend payment $d$ is sufficiently small. In this way, dividends are only socially efficient as a result of decreasing marginal returns (free cash flow problem), rather than from wealth expropriation. This leads directly to the following assumption.

**Assumption 1.** *Paying dividends is never socially efficient at undercapitalized institutions:* $d - \Delta R(D + E_0) - [\mathbf{1}_{E_1(E_0,d)=0} - \mathbf{1}_{E_1(E_0,0)=0}]c < 0$ *for all* $E_0$ *such that* $E_1(E_0, d) = 0$*.*

It should be noticed that, in this simplified case, the first-best solution may be achieved by the regulator prohibiting dividends for undercapitalized banks and releasing all of its information. That is, by simply stating which banks are strong and which banks are insolvent solves the signaling problem. However, this does not account for the inherent fragility of the banks. The existence of runs fundamentally alters the environment faced by the regulator. Information release can become costly and withholding information valuable, as discussed in Section 4.

## 3.4 *Laissez Faire* Case

In the *laissez faire*[10] case, the regulator cannot restrict dividends, but limited liability remains. In addition, assume a pure strategy equilibrium. Since the manager's value function neglects failure costs, a bank with equity $E_0$ pays a dividend if and only if:

$$\begin{aligned} V(E_0|\tilde{d} = d) - V(E_0|\tilde{d} = 0) = d &+ \lambda \left(\mathbb{E}^K[E_1|\tilde{d} = d] - \mathbb{E}^K[E_1|\tilde{d} = 0]\right) \\ &+ (1-\lambda)\Big(\max\{0, R(D + E_0 - d) - D\} \\ &- \max\{0, R(D + E_0) - D\}\Big) \geq 0 \end{aligned}$$

[10]Since there remains a social safety net for debt holders, this is not truly a *laissez faire* environment. We use the term to indicate that there are no regulatory restrictions placed on dividends.

where $K$ is the bank's belief of the set of banks that will pay dividends and $E^K$ is the expectation operator over equity given $K$. Define

$$\hat{s}(K) = \left(\mathbb{E}^K[E_1|\tilde{d} = d] - \mathbb{E}^K[E_1|\tilde{d} = 0]\right)$$

representing the difference in expected future equity between banks that do and do not pay a dividend.

Then, for any given $\hat{s}$, define the dividend incentive condition:

$$\Phi(E_0, \hat{s}) = d + \lambda\hat{s} - (1-\lambda)\left(\max\{R(D+E_0) - D, 0\} - \max\{R(D+E_0-d) - D, 0\}\right)$$

Rewriting given the maximum operator gives

$$\Phi(E_0, \hat{s}) = \begin{cases} d + \lambda\hat{s} - (1-\lambda)\Delta R(D+E_0) & \text{if } R(D+E_0-d) > 0 \\ d + \lambda\hat{s} - (1-\lambda)\max\{R(D+E_0) - D, 0\} & \text{otherwise,} \end{cases} \tag{4}$$

where a bank pays a dividend if and only if $\Phi > 0$. For any given value of $\hat{s}$ (equilibrium value or not), we can draw $\Phi$ as a function of $E_0$. According to the dividend incentive condition a bank pays a dividend if and only if it lies above the horizontal axis, as shown in the top panel of Figure 4. Note that when $E_0$ is sufficiently small, the function $\Phi$ is flat. In this region, the bank is undercapitalized with or without the dividend. Consequently, in this region the future value of the bank is necessarily 0 and the incentive for dividends does not vary with $E_0$. As $E_0$ increases, the wealth expropriation incentive for dividends diminishes as the opportunity cost of foregoing returns on reinvested capital is borne by shareholders rather than creditors. However, as $E_0$ increases further, the marginal returns of reinvested capital decreases due to the assumption $R'' < 0$.

For any dividend incentive function $\Phi$, let $G(\Phi)$ be the dividend signal generated by the

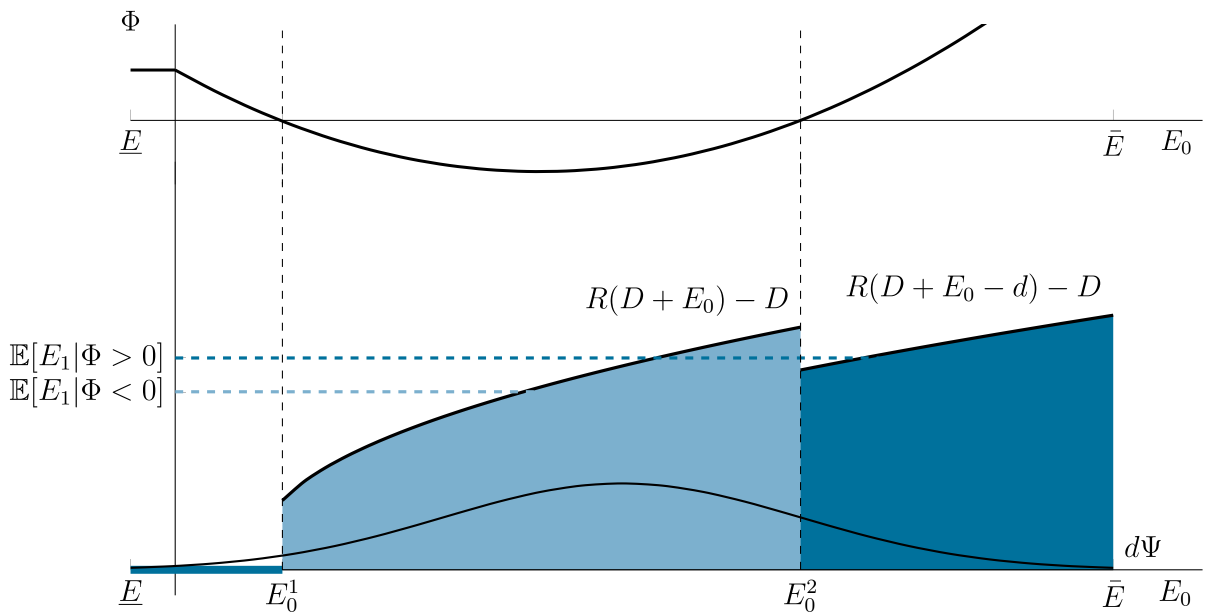


**Figure 4:** Top Graph: The incentive to dividend $\Phi$ for a fixed signal value $\hat{s}$. Bottom Graph: The future value of the bank given dividend decisions and the signal $\hat{s}$, from which $G(\hat{s}) = \mathbb{E}[E_1|\Phi > 0] - \mathbb{E}[E_1|\Phi \leq 0]$ is constructed. Dark gray areas denote equity levels where banks will choose to pay a dividend, below $E_0^1$ and above $E_0^2$. Correspondingly, light gray area denotes where banks do not pay dividends, $E' \in (E_0^1, E_0^2)$.

incentives. Abusing notation, we will often take the composite form and write $G(\Phi(\cdot, \hat{s})) = G(\cdot, \hat{s})$:

$$G(\Phi) = \mathbb{E}[\max\{R(D + E - d) - D, 0\}|\Phi(E, \hat{s}) > 0]$$
$$- \mathbb{E}[\max\{R(D + E) - D, 0\}|\Phi(E, \hat{s}) \leq 0].$$

The construction of $G$ is shown in the bottom part of Figure 4. For a given $\hat{s}$, the top graph divides the $E_0$ space into three regions: $[\underline{E}, E_0^1]$, $[E_0^1, E_0^2]$, $[E_0^2, \bar{E}]$. In the first and third intervals (darkly shaded in the bottom graph), $\Phi > 0$, so that banks pay dividends on these intervals. Thus, market expectations of a bank paying dividends are given by integrating future equity (given dividends) over the conditional distribution of dividend payors: $\Psi(E_0|E_0 \in [\underline{E}, E_0^1] \cup [E_0^2, \bar{E}])$. Meanwhile, the second interval (lightly shaded in the bottom graph) is the set of non-dividend banks. Market expectations for non-dividend-paying banks are similarly formed by integrating future equity of these banks (absent dividends) over the conditional distribution of non-dividend payors: $\Psi(E_0|E_0 \in [E_0^1, E_0^2])$. $G(\cdot, \hat{s})$ is then the difference between the market's expected future equity of dividend- and non-dividend-paying banks.

An equilibrium is defined as a fixed point where $G(\cdot, \hat{s}^*) = \hat{s}^*$. Notice that $G(\cdot, \hat{s})$ need not be monotonic in $\hat{s}$. This is because shifting the $\Phi$ curve up adds (down subtracts) banks at both the top and the bottom of the equity distribution of non-dividend-paying banks into (from) the dividend-paying population. Then, the effect of a change in $\hat{s}$ on the value of $G(\cdot, \hat{s})$ depends on the weight $d\Psi$ of each of these new additions (subtractions) and that group's expected mean relative to that of the set of dividend- and non-dividend-paying banks. The directional effect of $\hat{s}$ on $G(\cdot, \hat{s})$ consequently depends on the specific parameterization. Nevertheless, many of the conclusions and comparative statics from the model are valid even without a monotonic relationship between $\hat{s}$ and $G(\hat{s})$. Figure 5 is a graphical representation

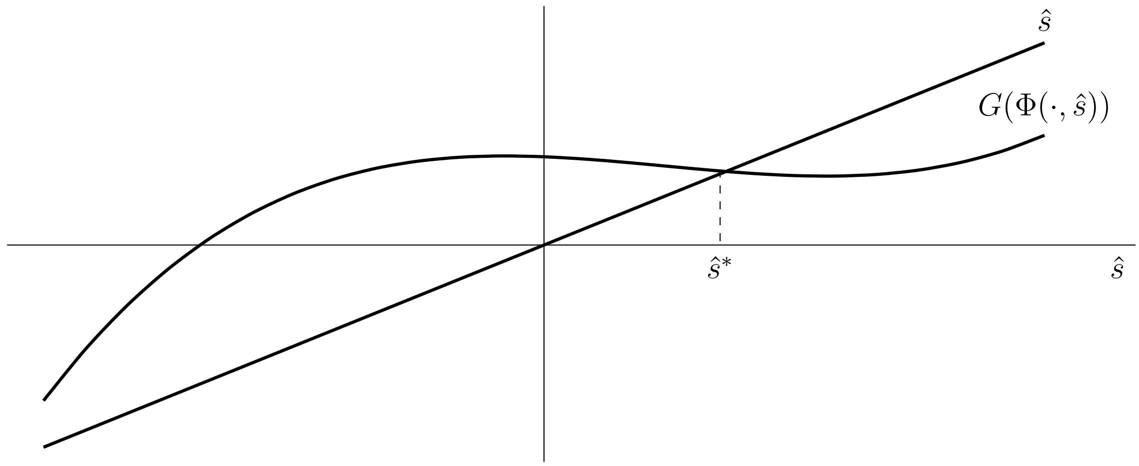


**Figure 5:** Equilibrium signal given $G(\cdot, \hat{s})$

of an equilibrium.

We make some assumptions to guarantee that both dividends and no dividends are observed in equilibrium. This negates the need to consider pooling equilibria that would then require additional assumptions on off-equilibrium beliefs.[11] Let the lower and upper feasible signals be given by

$$\begin{aligned}
\underline{\hat{s}} = \inf_K \mathbb{E}\Big[ &\max\{R(D+E_0-d)-D,0\}|E_0 \in K\Big] \\
&-\mathbb{E}\Big[\max\{R(D+E_0)-D,0\}|E_0 \notin K\Big], \text{and} \\
\bar{\hat{s}} = \sup_K \mathbb{E}\Big[ &\max\{R(D+E_0-d)-D,0\}|E_0 \in K\Big] \\
&-\mathbb{E}\Big[\max\{R(D+E_0)-D,0\}|E_0 \notin K\Big].
\end{aligned}$$

Let the production function, dividend size, and parameters be such that for any feasible signal, banks with the minimum and maximum possible values of $E_0$ find it optimal to pay a dividend. Further, for some intermediate value, $E' \in (\underline{E}, \bar{E})$ the returns from investment are sufficiently high such that for any feasible signal, the bank chooses not to pay a dividend.

[11] Alternatively, we could allow for pooling equilibria in which all banks pay and dividend and use the intuitive criterion Cho and Kreps (1987) to fix out-of-equilibrium beliefs on non-dividends as $\text{argmin}_{E_0}\{d + E_1(E_0, d)\}$. However, this would add complication without changing the underlying mechanisms.

**Assumption 2.** *A bank with the highest or lowest supported equity,* $\underline{E}$ *or* $\bar{E}$*, will have an incentive to pay a dividend. Further, there exists a bank with some equity* $E' \in (\underline{E}, \bar{E})$ *that does not have an incentive to pay a dividend. That is,* $\Phi(\underline{E}, \underline{\hat{s}}) > 0$*,* $\Phi(\underline{E}, \underline{\hat{s}}) > 0$*, and* $\Phi(E', \bar{\hat{s}}) < 0$

Under the maintained assumptions, the concavity of the production function, and the convexity of equity, there exist equity levels, $E_0^1$ and $E_0^2$, such that banks only pay dividends in that range; $\Phi(E, \hat{s}) \geq 0$ if and only if $E \in [E_0^1, E_0^2]$. That is to say, there will be two levels of equity, between which banks will choose to pay dividends. Below the lower equity level, $E_0^1$, banks will pay dividends to expropriate wealth. Above the higher equity level, $E_0^2$, banks will pay dividends to mitigate the free cash flow problem. These two levels of equity can be seen in Figure 4 as the vertical dashed lines. Setting $\Phi = 0$ gives the expressions for these bounds. In particular, $E_0^1(\hat{s}) = R^{-1}\left(\frac{d+\lambda\hat{s}}{1-\lambda} + D\right) - D$ and $E_0^2(\hat{s}) = \Delta R^{-1}\left(\frac{d+\lambda\hat{s}}{1-\lambda} + D\right) - D$.

Given this structure for $\Phi$, we can write the following expression for the dividend signal, $G(\cdot, \hat{s})$, in the *laissez faire* case as:

$$G(\cdot, \hat{s}) = \frac{\int_{E_0^2(\hat{s})}^{\bar{E}} (R(D + E_0 - d) - D) \mathrm{d}\Psi(E_0)}{1 - \Psi(E_0^2(\hat{s})) + \Psi(E_0^1(\hat{s}))} - \frac{\int_{E_0^1(\hat{s})}^{E_0^2(\hat{s})} (R(D + E_0) - D) \mathrm{d}\Psi(E_0)}{\Psi(E_0^2(\hat{s})) - \Psi(E_0^1(\hat{s}))} \tag{5}$$

**Proposition 1.** *There exists an equilibrium and an associated signal* $\hat{s}$ *such that a bank with capital* $E_0$ *does not pay a dividend if and only if* $E_0 \in [E_0^1, E_0^2]$.

*Proof.* The proof is established by the Brouwer Fixed Point Theorem, which requires that (a) $G(\cdot, \hat{s})$ is continuous in $\hat{s}$ and (b) $G(\cdot, \hat{s}) : [\underline{\hat{s}}, \bar{\hat{s}}] \to [\underline{\hat{s}}, \bar{\hat{s}}]$ maps to the same interval. The first condition is established by continuity and differentiability properties of $R$ and $\Psi$. The latter follows directly from the definitions of the lower and upper bounds of $\hat{s}$. □

The existence of equilibrium is guaranteed under fairly weak assumptions. However, if agents value the signal too strongly, multiple equilibria can arise. In particular, as more importance is placed on the value to outside equity holders, as $\lambda \to 1$, the behavior of most banks will be governed entirely by the signaling incentive. To ensure a unique equilibrium, assume that $\lambda$ is small enough to preclude this possibility. That is, we assume that enough value is placed on both short- and long-term equity holders to support a unique equilibrium, described in the proposition below. However, this restriction could easily be relaxed if we consider the possibility of multiple equilibria. Furthermore, all subsequent comparative static results would hold if we consider perturbations of the underlying parameters as movements around any particular equilibrium.

**Proposition 2.** *If the relative importance placed on outside equity holders, $\lambda$, is sufficiently small, then there exists a unique equilibrium.*

*Proof.* This result follows by differentiating $G(\cdot, \hat{s}; \lambda)$ with respect to $\hat{s}$ and showing it is a factor of $\lambda$. If $\lambda$ is sufficiently small, $\frac{\partial G}{\partial \hat{s}} < 1$ and thus $G(\cdot)$ cannot cross the 45-degree line more than once. □

## 3.5 A Prudential Regulator

One of the key features that makes dividend policy decisions especially interesting–in the context of systemically important financial institutions, and banking in general–is the unique role that regulators play. Either to prevent wealth expropriation or to maintain a sufficiently low probability of failure, regulators may restrict dividend payments at undercapitalized banks. In many cases, such restrictions are private or implicit, and therefore not directly visible to the market.[12]

Suppose that a regulator is perfectly informed and undertakes a policy of restricting dividends if and only if $R(D + E - d) - D < 0$ (the bank is undercapitalized conditional on paying a dividend). In the model, that would imply that the regulator may forbid dividend

[12]For example, while CCAR results are public, banks set their capital plans with expectations on what will be approved by regulators.

payments only when paying a dividend would cause the bank to be unable to meet its liabilities $D$ at the end of period 1. Note that 0 could easily be replaced with any nonzero capital requirement. Given the regulator's behavior, the incentive structure $\Phi$ is unchanged. However, banks that breach the capital requirement with dividends are exogenously restricted from dividends. Returning to Figure 5, the partitioning of $E_0$ into three intervals is unchanged as $\Phi$ is unchanged. However, while undercapitalized banks prefer to pay a dividend, they are unable to do so. This implies that these undercapitalized banks move from dividend payors (darkly shaded) to non-dividend payors (lightly shaded). Thus, the signal $G_R(\Phi)$ generated in the presence of a regulator differs from $G(\Phi)$. Figure 6 demonstrates the relative increase in the signal strength, $G_R(\hat{s})$. In particular,

$$G_R(\cdot, \hat{s}) = \frac{\int_{E_0^2(\hat{s})}^{\bar{E}} (R(D + E_0 - d) - D) \mathrm{d}\Psi(E_0(\hat{s}))}{1 - \Psi(E_0^2(\hat{s}))} - \frac{\int_{E_0^0(\hat{s})}^{E_0^2(\hat{s})} (R(D + E_0) - D) \mathrm{d}\Psi(E_0)}{\Psi(E_0^2(\hat{s}))} \qquad (6)$$

where $E_0^0 = R^{-1}(D) - D < E_0^1$ is the minimum equity required to guarantee positive future equity given no dividends. As in the *laissez faire* case, it is straightforward to show that an equilibrium exists when there is a regulator. Furthermore, uniqueness is similarly guaranteed under the appropriate parameter restriction on $\lambda$.

The first result is that the introduction of the regulator increases banks' value of the signal and increases the set of banks that would prefer to pay a dividend. Naturally, this does not mean that more banks *do* pay dividends, as the regulator precludes poorly capitalized banks from paying a dividend in any case. However, the nature of this regulatory action does induce some banks to pay a dividend that otherwise would not. In particular, if we let $\hat{s}_R^*$ be the value of the equilibrium signal with the regulator then it must be the case that this is greater than $\hat{s}^*$.

**Proposition 3.** *A regulator who restricts dividends to banks engaged in wealth expropriation*

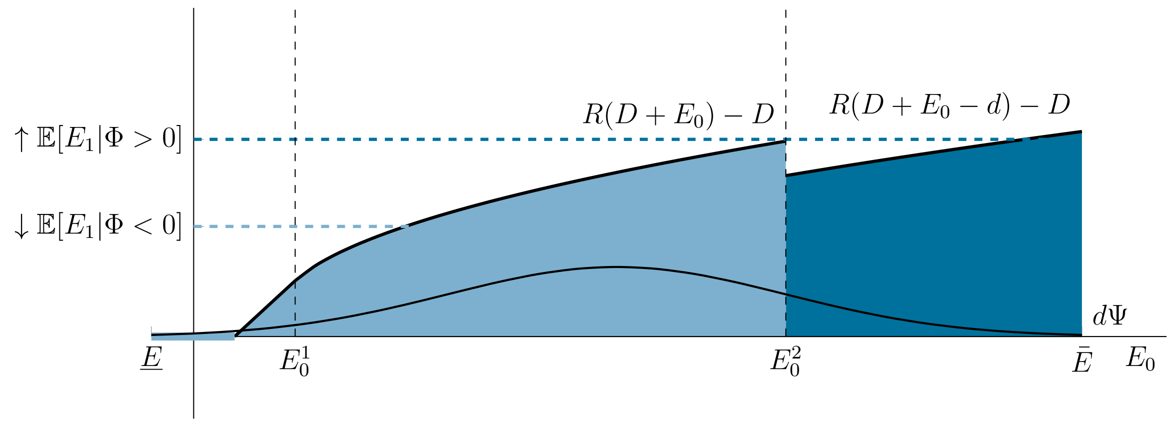


**Figure 6:** An The future value of the bank given dividend decisions and the signal $G(\hat{s}) = \mathbb{E}[E_1|\Phi > 0] - \mathbb{E}[E_1|\Phi <= 0]$.

*will increase the market's valuation of dividend-paying banks relative to the* laissez faire *case. In particular, $\hat{s}^* < \hat{s}_R^*$. Furthermore, banks with capital $E_0 \in [E_0^2(\hat{s}_R^*), E_0^2(\hat{s}^*)]$ do not dividend in the laissez faire case but do dividend in the regulator case.*

*Proof.* The proof follows directly from showing that $G(\cdot, \hat{s}) < G_R(\cdot, \hat{s})$ for all $\hat{s}$. Moving a mass of banks from the dividend-paying group to the non-dividend-paying group increases the expected value of the dividend payers and decreases the expected value of the non-payers. Thus, the regulator's behavior induces a positive shift in $G$, thereby increasing $\hat{s}^*$. The monotonicity of $E_0^2(\hat{s})$ in $\hat{s}$ guarantees that the change produces a non-empty set of new dividend-paying banks. □

### 3.6 Comparative Statics

This section examines comparative statics for the equilibrium with the prudential regulator. In particular, it examines how changes in the distribution of capital levels affect the strength of the dividend signaling mechanism. The following proposition states that an increase in the underlying uncertainty increases the equilibrium value of signaling and an increase in the proportion of banks that pay dividends. In particular, if the support of $E_0$ is expanded, $\hat{s}^*$ necessarily increases.

**Proposition 4.** *An increase in uncertainty increases the dividend signal value, $s^*$. Suppose that the support of $E_0$ is widened to $[\underline{E} - \eta, \bar{E} + \eta] \sim \Psi'$ for some $\eta > 0$ such that the mean of $\Psi'$ is equal to that of $\Psi$. Assume further that $\Psi'(\cdot|E_0 \in [\underline{E}, \bar{E}]) = \Psi$. Then the regulated equilibrium features an increased dividend signal value.*

The comparative statics in the case of mean shifts of the distribution of $\Psi$ are ambiguous because the effect of an increase in mean equity, $E_0$, has a non-monotonic effect on the increase in period 1 equity, $E_1$. For the region in which $E_1 = 0$ (i.e., the bank is undercapitalized), an increase in starting capital has no effect on future shareholder value. However, the concavity of the production function dictates that the effect of an increase in $E_0$ has the largest effect in the region just above $E_0^1$ where the bank is just above undercapitalized and decreasing thereafter.

Nevertheless, comparative statics can be drawn for distributions that give rise to equilibria where sufficiently few or sufficiently many banks pay a dividend. Suppose that there is a mean shift $\Delta$ of the distribution $\Psi$. In the case where the mass of banks is already paying a dividend, a positive mean shift ($\Delta > 0$) in $E_0$ further skews the distribution. As such, the signaling value of dividends is dampened, $\partial \hat{s}^*/\partial \Delta < 0$. In the case where the mass of banks already do not pay a dividend, the logic is reversed. $\Psi$ becomes more skewed and the signal less informative when $\Delta < 0$. Consequently, $\partial \hat{s}^*/\partial \Delta > 0$ when sufficiently many banks do not pay a dividend.

For the arguments above, we require one additional assumption: The density of banks on the boundary between dividends and non-dividends must be sufficiently small. This is guaranteed assuming that the density $d\Psi(E_0)$ is sufficiently small for all points in $\underline{E}, \bar{E}$.

**Assumption 3.** *For all possible values of $\hat{s} \in [\underline{E} - \bar{E}, \bar{E} - \underline{E}]$ and for all $E_0 \in [\underline{E}, \bar{E}]$,*

$$\frac{1}{d\Psi(E_0)} > \frac{\partial E_0^2}{\partial \hat{s}} d\Psi(E_0^2) \left[ \frac{\left( \int_{E_0^2}^{\bar{E}} E_1(E_0, d) d\Psi(E_0) - E_1(E_0^2, d)(1 - \Psi(E_0^2)) \right)}{(1 - \Psi(E_0^2))^2} \right.$$
$$\left. + \frac{\left( \int_{E_0^0(\hat{s})}^{E_0^2} E_1(E_0, 0) d\Psi(E_0) - E_1(E_0^2, 0)\Psi(E_0^2) \right)}{[\Psi(E_0^2)]^2} \right]$$
$$+ \frac{\partial E_0^0}{\partial \hat{s}} \frac{E_1(E_0^1, 0)\Psi(E_0^2) d\Psi(E_0^2)}{[\Psi(E_0^2)]^2}$$

Results on mean shifts follow given Assumption 3.

**Proposition 5.** *When sufficiently many (few) banks pay a dividend, a positive mean shift in equity decreases (increases) the value of the dividend signal, $s^*$. Let $\nu(\Psi)$ be the mass of banks that do not pay dividends in an equilibrium for a given distribution of $\Psi$. (i) There exists a $\underline{\nu}$ such that for any $\Psi'$ such that $\nu(\Psi') < \underline{\nu}$ and associated equilibrium signal $\hat{s}(\Psi')$, it is the case that $\partial \hat{s}(\Psi')/\partial \Delta < 0$ where $\Delta$ is a mean shift in $\Psi'$. (ii) Similarly, there exists a $\bar{\nu}$ such that for any $\Psi'$ such that $\nu(\Psi') > \bar{\nu}$ and associated equilibrium signal $\hat{s}(\Psi')$, it is the case that $\partial \hat{s}(\Psi')/\partial \Delta > 0$.*

## 3.7 Welfare Analysis

This section discusses the welfare implications of a dividend-restricting regulator relative to the *laissez faire* equilibrium. In addition, it addresses implementation of the efficient outcome by adjusting the set of banks over which dividends may be restricted. We show that the welfare implications of dividend restrictions on only undercapitalized institutions are generally ambiguous. Ultimately, welfare consequences are driven by the skewness in favor of overcapitalization. Only in the case of a distribution heavily skewed toward overcapitalized banks could dividend restrictions on undercapitalized banks decrease welfare through the signaling effect. We also show that by broadening the set of banks for which the regulator restricts dividends, the first-best allocation can be implemented with dividend restrictions.

A policy of restricting dividend on undercapitalized institutions is welfare improving if the regulated welfare is greater than welfare in the *laissez faire* case, denoted as $W_{Reg}$ and $W_{LF}$, respectively. The welfare implications of dividend restrictions of undercapitalized banks can then be written as $\Delta W = W_{Reg} - W_{LF}$. Similarly, denote other equilibrium objects with subscripts analogously (e.g. $E^1_{0,LF}$). In addition, note that in the case of dividend restrictions, $R^{-1}(D) - D$ represents the initial level of equity below which a bank fails and above which it does not. The expression for welfare in these two cases can be written as:

$$\begin{aligned} W_{LF} = &\int_{\underline{E}}^{E^1_{0,LF}} [d + R(D + E_0 - d) - c] d\Psi + \int_{E^1_{0,LF}}^{E^2_{0,LF}} R(D + E_0) d\Psi \\ &+ \int_{E^2_{0,LF}}^{\bar{E}} [d + R(D + E_0 - d)] d\Psi, \text{ and} \end{aligned} \tag{7}$$

$$\begin{aligned} W_{Reg} = &\int_{\underline{E}}^{R^{-1}(D)-D} [R(D + E_0) - c] d\Psi + \int_{R^{-1}(D)-D}^{E^2_{0,Reg}} R(D + E_0) d\Psi \\ &+ \int_{E^2_{0,Reg}}^{\bar{E}} [d + R(D + E_0 - d)] d\Psi. \end{aligned} \tag{8}$$

To evaluate $\Delta W$, a few notes are helpful. First, given the results of Section 3.5, $s^*_{LF} < s^*_{Reg}$.[13] This implies that $E^1_{0,LF} < E^1_{0,Reg}$ and $E^2_{0,LF} > E^2_{0,Reg}$. In addition, there is substantial overlap of bank behavior between the *laissez faire* and regulated regimes. In particular, banks with $E_0 > E^2_{0,LF}$ will pay dividends in both cases. Meanwhile, banks with $E_0 \in [E^1_{0,LF}, E^2_{0,R}]$ do not pay dividends in both cases. Thus, $\Delta W$ can be written with only the remaining parts

[13] Recall that in general there may be multiple equilibria. However, for any *laissez faire* equilibrium signal $s^*_{LF}$ there exists an equilibrium with a regulator where $s^*_{Reg} > s^*_{LF}$. This follows from the fact that $G(\cdot)$ is defined on the compact set $[s^*_{LF}, \bar{\hat{s}}]$, so that the Brouwer Fixed Point Theorem applies.

of the distribution of $E_0$ in mind. Namely,

$$\Delta W = \underbrace{\int_{\underline{E}}^{E^1_{0,LF}} [\Delta R(D+E_0) - d]\, d\Psi}_{\text{Increased Investment}} + \underbrace{\int_{R^{-1}(D)-D}^{E^1_{0,LF}} c\, d\Psi}_{\text{Reduced Failure}} - \underbrace{\int_{E^2_{0,Reg}}^{E^2_{0,LF}} [\Delta R(D+E_0) - d]\, d\Psi}_{\text{Decreased Investment}} \quad (9)$$

Dividend restriction policies for undercapitalized banks affect welfare through three channels. The first channel is increased investment in all low capital banks that without the policy would pay a dividend. Note that, due to decreasing marginal returns, low equity banks have the highest marginal return, $\Delta R$. Through this channel, dividend restrictions would have a positive effect on social welfare. The second channel is a decrease in failures among undercapitalized institutions that would otherwise survive with the extra equity from not paying a dividend. Even with dividend restrictions, some banks, namely those with capital $R^{-1}(D) - D$, will fail. The dividend restriction policy only avoids failure costs in a subset of undercapitalized banks, those with capital in $[R^{-1}(D) - D, E^1_{0,LF}]$. Like the first channel, decreasing failures would have a positive impact on overall social welfare. The third channel, however, has a negative effect. More highly capitalized institutions will invest less as a result of paying a dividend for signaling purposes. This affects banks with capital in $[E^2_{0,R}, E^2_{0,LF}]$ and offsets some of the benefit achieved from the first two channels.

In general, $\Delta W$ cannot be signed. However, the decomposition of the expression in Equation (9) highlights conditions under which the $\Delta W$ can be signed. The dividend is welfare improving unless a sufficient mass of highly capitalized banks exists. This follows from an examination of terms in the integrands. First, $\Delta R$ is lower at higher capital institutions (and bounded below by 0) so that the integrand in the first term is larger than the third. In addition, the integrand in the second term is a welfare benefit from reduced failure costs. Together, the integrands push in favor of welfare improvements from dividend restrictions. However, for specific distributions that are heavily skewed in favor of overcapitalized banks, it is theoretically possible that the signaling effects of the third term dominate and $\Delta W < 0$.

### 3.7.1 Implementation of first-best

With perfect information, the regulator can implement the first-best outcome through strict dividend regulation. In particular, Equation 3 requires that banks dividend if and only if they have sufficient capital so that they face negative marginal social returns. Given Assumption 1, this will be the case only when the bank also faces negative marginal private returns. In particular, it is efficient for a bank to pay a dividend if and only if the dividend payment is greater than the marginal revenue from investing the funds internally, $d - \Delta R(D + E_0) > 0$. Given the concavity of $R$, there is a unique equity level, $E^*$, such that $d - \Delta R(D + E^*) = 0$ above (below) which it is (not) efficient for a bank to pay a dividend.

**Proposition 6.** *A perfectly informed regulator may implement the efficient allocation by allowing dividend payments if and only if $E_0 \geq E^*$.*

The idea of the proof is as follows: Without any signaling incentives, well-capitalized banks would pay dividends in line with the efficient allocation, paying if and only if $E_0 > E^*$. By restricting the pool of possible dividend-paying banks only to the best capitalized ones, such a policy would force a positive dividend signal. This would push up the incentive to pay dividends for all banks, including those below $E^*$. However, such banks are precluded from paying dividends under the policy, leaving only those with $E_0 > E^*$ able to pay dividends. As these banks already had an incentive without a signaling incentive, they will continue to pay dividends with the policy.

While such a policy would induce the efficient allocation, it would be an expansion beyond what regulatory authority permits. In particular, it would restrict even those healthy banks that do not expropriate wealth from the public sector. Even if regulatory authority for such a restriction existed, it would require that the regulator have enough knowledge to confidently calibrate $E^*$.

# 4 Bank Runs

Thus far in the paper, welfare would be improved if only the information asymmetry were removed. In particular, if the public could be made aware of the bank's private information on $E_0$, then there would be no signaling incentive and–subject to dividend restrictions on undercapitalized banks–the first-best outcome would be implemented by the market. In practice, such a policy may give rise to concerns about bank runs. In this section, we extend the model to incorporate bank runs and highlight the tradeoffs associated with public information revelation. As is the case earlier in the paper, revealing private information promotes efficient investment decisions by reducing signaling incentives. On the other hand, information opaqueness allows undercapitalized banks to pool with well-capitalized banks and deter runs.

## 4.1 Management with Bank Runs

The model timeline is similar to that of Figure 3. In period 0, management observes $E_0$ and the bank's current assets are $A_0 = R(D + E_0)$. Management chooses whether to pay a dividend $\tilde{d} \in \{0, d\}$. The remaining assets are reinvested into the bank so that future assets become $A_1 = R(D + E_0 - \tilde{d})$, where $R$ is a revenue function that has decreasing marginal returns. In this section, we allow for a possibility of a bank run. We assume that a bank facing a run must liquidate assets inefficiently, resulting in a deadweight loss of bank asset values equal to $L$.[14] We denote a run by $\rho$, which is equal to one if there is a run, and zero otherwise. Given limited liability, a bank's equity at the end of period 1 is given by $E_1(E_0, \tilde{d}, \rho) = \max\left\{0, R\left(D + E_0 - \tilde{d}\right) - D - \rho L\right\}$. In addition, we place $L$ outside the return function $R$ for simplicity. The results are not materially different if $L$ appears inside the return function $R$.

[14] For example, a bank's specialized knowledge of its assets as in Shleifer and Vishny (1992) could result in a decreased performance of bank assets.

In the context of our model, deposits are insured and adding the possibility of runs to such a model requires comment. First, the run risk modeled here can be thought of as the reduced form outcome of a game in which a subset of deposits $U < D$ are uninsured and have the ability to withdraw their claims at par before the closure of the bank. This is consistent with the empirical literature (e.g. Iyer, Puri, and Ryan (2012)) who find that depositors with balances above the insured limit are more likely to run on the banks. As such, these uninsured depositors do not have explicit insurance, but are shielded from losses so long as they withdraw their deposits whenever they perceive a decline in bank health. Incorporating uninsured deposit runs more formally into the model adds considerable notation, without adding to the understanding of the role that dividend restrictions play in bank dividend decisions. Alternatively, the existence of runs can be motivating by behavioral responses among insured depositors. Empirical literature suggests that, despite insurance, some depositors may still withdraw funds at failing institutions (e.g. Davenport and McDill (2006)).

Bank runs occur when the market believes the probability of a bank being undercapitalized given the observed dividend decisions and a presumed bank run ($\rho = 1$) is greater than some exogenous threshold probability $1 - p^*$. More formally:

$$\rho(\tilde{d}) = \begin{cases} 1 & \text{if } Pr^K(E_1(E_0, \tilde{d}, 1) = 0|\tilde{d}) > 1 - p^* \\ 0 & \text{o/w} \end{cases} \tag{10}$$

where $Pr^K$ is the probability measure induced over $E_0$ for a set of banks $K$ paying dividends. Notice that $p^*$ is a measure of bank run fragility, with higher values of $p^*$ associated with banks more susceptible to runs. For example, $p^* = 0$ implies that banks are run-proof; even a bank known with certainty to be undercapitalized will not face a run. Prior sections could be understood as the case where $p^* = 0$. Alternatively, $p^* = 1$ implies that any bank for which the public perceives any chance of undercapitalization is subject to a run.

To highlight the role of bank runs and to simplify analysis, we model bank runs as being a first order concern for banks. That is, a well-capitalized bank will always prefer a dividend decision that deters a run to one that does not.

**Assumption 4.** *For a fixed short-term signal, well-capitalized banks prefer dividend decisions that deter runs. That is, for any $E_0$ such that $E_1(E_0, d, 1) \geq 0$ and any $d'$ and $d''$, $d' + (1 - \lambda)E_1(E_0, d', 0) \geq d'' + (1 - \lambda)E_1(E_0, d'', 1)$.*

## 4.2 Equilibrium with Bank Runs and a Prudential Regulator

The possibility of bank runs adds an additional signaling incentive. Without runs, the only signalling incentive for banks emanates from the desire to influence the short-term market price. In the presence of runs, banks have an additional signaling incentive to avoid a costly run. This additional signaling incentive produces a new equilibrium (not necessarily unique) in which *all* unrestricted banks pay dividends and *all* restricted banks face a bank run. Such a possibility arises out of the coordination game played among the unrestricted banks. Suppose the regulator restricts banks from paying dividends if and only if they are undercapitalized. Then, given a belief that only the undercapitalized banks do not pay dividends, an unrestricted bank will choose to separate by paying a dividend. Much like Diamond and Dybvig (1983), this belief will induce all unrestricted banks to signal health through dividends and bank runs will be self-fulfilling.

In this environment, we use an analog to the regulator's dividend restriction policy from Section 3.5. The regulator allows dividends if and only if $R\left(D + E_0 - d\right) - D - L \geq 0$. This implies that a bank that pays dividends will never be undercapitalized, even if it faces a run.

Let $E_L(\tilde{d})$ be the level of capital, given a level of dividends $\tilde{d}$, such that a run would cause the bank to be undercapitalized. That is $R(D + E_L(\tilde{d}) - \tilde{d}) - D - L = 0$.

**Proposition 7.** *When run fragility is not trivial ($p^* > 0$) and only banks at risk of undercapitalization are restricted from dividend payments by the regulator (i.e. $\{E_0 : R(D + E_0 - d) - D - L\} < 0\}$), there exists an equilibrium in which all unrestricted banks pay dividends and all dividend restricted banks face a run.*

*Proof.* We prove by construction and show that such an equilibrium is consistent with banks' incentives. Reusing earlier notation (adding in the possibility of bank runs) and given a belief $\hat{s}$ in which only restricted banks do not pay a dividend, a bank pays a dividend if and only if:

$$\begin{aligned}&\Phi(E_0, \hat{s}) = d + \lambda\hat{s} - (1 - \lambda) * \\ &(\max\{R(D + E_0) - D - \rho(0)L, 0\} - \max\{R(D + E_0 - d) - D - \rho(d)L, 0\}) \\ &\geq 0\end{aligned} \tag{11}$$

Given the belief that $\tilde{d} = 0$ if and only if $R(D + E_0 - d) - D - L < 0$ it will be the case that $\rho(d) = 0$ and $\rho(0) = 1$. Furthermore, such a belief implies that $\hat{s}^* = \int_{E_L(0)}^{\bar{E}} E_1(E_0, d, 0)d\Psi - \int_{\underline{E}}^{E_L(0)} E_1(E_0, 0, 1)d\Psi > 0$ by Assumption 4. In addition, the term of Equation 12 multiplying $(1 - \lambda)$ is also less than 0 given $\rho$ and Assumption 4. Therefore, $\Phi > 0$ for all $E_0$ given the belief that only restricted banks fail to pay dividends and $\hat{s}^*$ is a fixed point of $G(\hat{s})$. □

In this equilibrium, all well-capitalized banks pay a dividend, regardless of their investment opportunity cost and all undercapitalized banks face a run. Therefore, the possibility of bank runs combined with low capital minimums for dividend restrictions may induce severe signaling problems for well-capitalized banks, while simultaneously exacerbating runs for undercapitalized ones.

## 4.3 First-Best with Runs

We assume that the benevolent social planner has lexicographic preferences. The planner cares first and foremost about the mass of banks that have a run. And, to the extent that no banks have runs, has preferences equal to Section 3.7. Placing full weight on runs makes analysis more tractable and allows us to highlight the role that information opacity plays in dividend restrictions.[15]

$$W = \begin{cases} \int_{E_0} R(D + E_0 - \tilde{d}) d\Psi - c \int_{\{E_0 | E_1(E_0, \tilde{d}, \rho(\tilde{d}))=0)\}} d\Psi & \text{if } \rho(\tilde{d}(E_0)) = 0 \text{ for all } E_0 \\ -\int_{E_0} \rho(\tilde{d}(E_0)) d\Psi & \text{o/w} \end{cases}$$

As before, welfare with no runs reflects both the opportunity cost of bank investments and the cost of failures. Meanwhile, welfare in the presence of a run is defined as the negative mass of banks that run. This implies that if runs are unavoidable, the planner minimizes the mass of banks with runs. We assume that $R(D + \underline{E} - d) - c \geq 0$ for all $E_0$ to guarantee that an outcome with runs is strictly worse than any outcome without runs.

We make an additional assumption that the marginal returns of investment at undercapitalized banks exceeds the marginal returns of dividends at well capitalized banks. This assumption implies that if the planner chooses to pool well-capitalized banks with undercapitalized banks in order to deter runs, it is more efficient to do so by having neither pay a dividend rather than both pay a dividend. More formally,

**Assumption 5.** *The opportunity cost of investment is such that it is more efficient for any undercapitalized bank ($E' < E_L(0)$) and any well-capitalized bank ($E'' \geq E_L(0)$) to both reinvest than it is for them to both pay a dividend. That is, $\Delta R(D+E') - d \geq d - \Delta R(D+E'')$ for all $E' < E_L(0)$ and $E'' \geq E_L(0)$.*

[15] A planner that places weight on investment opportunity and bank runs can be thought of the convex combination of the case presented in this section and that in Section 3.7.

The possibility of runs implies that the planner's problem cannot be solved on a bank-by-bank basis. This can be seen in the planner's welfare $W$ by the conditionality of welfare on $\rho(\tilde{d}(E_0)) = 0$ *for all* $E_0$. If the set of banks not paying a dividend is sufficiently large and undercapitalized when solving the planner's problem bank-by-bank as in Section 3.7, then this will incite a run on *all* banks not paying a dividend. Consequently, the planner must factor in the effect of an individual bank's dividend on the overall distribution of dividend payors and non-payors. That is, the planner must consider the externality of a bank's dividend policy on runs at other banks with a similar dividend policy.

We allow the planner to affect the public's information both through its choice of dividend policy for each bank as well as through the release of information. We denote $I(E_0)$ as the planner's decision to release information for a bank with capital $E_0$, with $I = 1$ indicating a public release of information and $I = 0$ indicating no public release. We do not allow for mixed strategies. Thus, the planner chooses $(\tilde{d}, I)$ where both elements are implicitly functions of $E_0$.

For example, in the case without bank runs (i.e. $p^* = 0$), the planner could achieve the first-best outcome by restricting dividends on undercapitalized banks, but avoid any signalling concerns by setting $I(E_0)) = 1$ for all $E_0$. In the case with bank runs (i.e. $p^* > 0$), such a policy would induce a run on all undercapitalized banks.

**Proposition 8.** *When runs are preventable, a solution to the planner's problem features the disclosure of no individual bank's information and payment of dividend if and only if bank equity exceeds* $\max\{E^*, \hat{E}(p^*)\}$*, where* $\Delta R(D + E^*) = d$ *and*

$$\frac{\int_{\underline{E}}^{E_L} d\Psi}{\int_{\underline{E}}^{\hat{E}(p^*)} d\Psi} = 1 - p^*$$

*Formally,* $(\tilde{d}_P^*, I_P^*) = (0, 0)$ *for* $E_0 \leq \max\{E^*, \hat{E}(p^*)\}$ *and* $(\tilde{d}_P^*, I_P^*) = (d, 0)$ *otherwise.*

From the solution to the planner's problem, it follows directly that, so long as runs are preventable (i.e. there exists a feasible outcome with no bank runs), the planner restricts more banks from paying dividends as run fragility increases.

**Corollary 1.** *So long as runs are preventable (i.e. there exists a feasible outcome with no bank runs), optimal dividend restrictions increase (weakly) with run fragility. That is, the set of banks restricted from dividends increases with $p^*$.*

*Proof.* $\frac{\partial \hat{E}(p^*)}{\partial p^*} = \frac{\int_{\underline{E}}^{E_L} d\Psi}{d\Psi(\hat{E}(p^*))(1-p^*)^2} > 0$ for $p^*$ such that $\hat{E}(p^*) > E^*$. Meanwhile, the set of dividend restricted banks is fixed at $E^*$ for $p^*$ such that $\hat{E}(p^*) \leq E^*$. $\square$

Next, we solve the planner's problem when runs are not avoidable. That is, suppose that the mass of undercapitalized banks is so large that pooling all banks together would still result in a run. This is the case when $\int_{E_0<E_L(0)} d\Psi > 1 - p^*$. Pooling all banks together in this case would be the worst possible outcome, as it would result in a run not only on the undercapitalized banks, but also the well-capitalized ones. In this environment, the planner finds it optimal to reveal information on a subset of undercapitalized banks. This allows the planner to pool some of the undercapitalized banks with the well-capitalized banks, thereby minimizing the extent of the run on the system.

At first glance, the result that more information is released for unhealthy institutions appears counterintuitive. In practice, however, this is often the case. While regulators often keep certain pieces of bank-specific information confidential (e.g. CAMELS ratings in the U.S.), there is simultaneously relatively more regulatory information available (e.g. public enforcement actions) for banks with worse public accounting data.

**Proposition 9.** *If runs are not preventable (i.e. every feasible outcome features some bank runs), then it is efficient to release information for a subset of undercapitalized banks and pool the remaining banks. Formally, if $\int_{E_0<E_L(0)} d\Psi > 1 - p^*$, then $I^*(E_0) = 1$ for some subset $N^* \subset \{E_0 : E_0 < E_L(0)\}$ where $\int_{E_0 \subset N^*} d\Psi = 1 - \frac{\int_{E_0<E_L(0)}}{1-p^*}$ and $d^*(E') = d^*(E'')$ for all $E', E'' \notin N^*$.*

*Proof.* Suppose some optimum $(d^*, I^*)$. If a bank $E'$ faces a run given $d^*(E')$ faces a run, the planner is weakly better off if $I^*(E') = 1$. In the event that $E' < E_L(d^*(E')$ the run occurs in either case. In the event that $E' \geq E_L(d^*(E')$ the run no longer occurs if the information is known. Furthermore, the set of all banks with dividend policy $d^*$ for whom $I^* = 0$ already face a run and are therefore made no worse off given the revelation of other banks information with the same dividend policy.

Furthermore, this implies that the solution to the planner's problem corresponds to minimizing the set of institutions facing a bank run such that all other banks may be pooled. This is equivalent to solving:

$$\begin{aligned} & \min \int_{E_0 \subset N \subset [\underline{E}, E_L(0)]} d\Psi \\ s.t. \qquad & \frac{\int_{[\underline{E}, E_L(0)] \setminus N} d\Psi}{\int_{E_0 \notin N} d\Psi} \leq 1 - p^* \end{aligned}$$

□

## 4.4 Implementation

Unlike the social planner, a bank regulator often does not have the authority to make dividend decisions for individual banks. Instead, regulators choose a minimum capital requirement below which dividends are restricted and above which banks can choose pay dividends or not. In addition, regulators tend to have some discretion on the extent to which a bank condition is public versus private.[16] In this section, we study how the solution to the planner's problem can be implemented in an environment restricted to these tools.

Restricted to setting minimum capital requirements for regulatory purposes and choosing

[16]In the context of the U.S., public financial reports on banks produce a significant amount of bank-specific information. In addition, public enforcement actions provide additional detail on bank health, reflecting otherwise confidential regulatory information. However, some information, such as bank regulatory ratings, remain confidential at all times.

the level of public information, the modified planner's problem can be written as:

$$
\begin{aligned}
& \max_{C, I(E_0)} W((d^*, I^*)) \\
\text{s.t.} \quad & d^*(E_0) = \max_{\tilde{d}} d + \lambda \mathbb{E}^{K^*}[E_1|\tilde{d}] + (1-\lambda) E_1(E_0, \tilde{d}) \ \forall E_0 > C, I(E_0) = 0 \\
& d^*(E_0) = \max_{\tilde{d}} d + (1-\lambda) E_1(E_0, \tilde{d}) \ \forall E_0 > C, I(E_0) = 1 \\
& d^*(E_0) = 0 \text{ for all } E_0 \leq C
\end{aligned}
$$

We show that the solution to the modified planner's problem mimics that of the planner who has full control over bank dividend policies.

**Proposition 10.** *Let $(C_R^*, I_R^*(E_0))$ denote the solution to the modified planner's problem. The solution to the regular planner's problem can be implemented by setting sufficiently high regulatory capital minimums $C_R^* = \max\{E^*, \hat{E}(p^*)\}$ if $\hat{E}(p^*)$ exists and $\bar{E}$ otherwise. In addition, $I_R^*(E_0) = I_P^*(E_0)$. This implies that dividend restrictions increase with run-fragility as was the case for the planner.*

# 5 Conlcusion and Policy Implications

In this model, we demonstrate the powerful role that regulators play in disseminating information to the markets in the banking industry. Dividend restriction policy and banks' best responses to the policy affect both capital allocation and potentially the stability of the banking industry. When depositors are panicky, more broad-based dividend restrictions allow undercapitalized banks to pool with stronger banks to assuage the fears of depositors. These broader-based restrictions also deter the inefficient signaling incentives that arise when only the worst institutions are restricted. However, without sufficiently robust capital requirements against which the dividend restrictions are predicated, dividend restrictions can have more detrimental consequences. When only the worst institutions are restricted from paying dividends and depositors are panicky, those institutions are effectively identified in the markets through their absence of dividend payments. Furthermore, other institutions are incentivized to pay dividends in order to signal their health.

This paper models the informational role that regulators play in the banking industry through the lens of dividend restrictions, though future research may consider more broadly how bank regulatory policy interacts with bank incentives and market expectations.

# 6 Appendix

**Proposition 4**

*Proof.* The proof relies on the asymmetry of the effect of more or less capital today on the bank's future value. At the top end, this translates to additional capital. At the bottom end, given the limited liability protection, the corresponding decrease in the bank's future value from the decreased current capital is bounded below by zero.

$$G_R(\cdot, \hat{s}) = \frac{\int_{E_0^2(\hat{s})}^{\bar{E}+\eta} (R(D+E_0-d)-D)\mathrm{d}\Psi'(E_0(\hat{s}))}{1-\int_{E_0^2}^{\bar{E}+\eta} \mathrm{d}\Psi'(E_0)} - \frac{\int_{E_0^0(\hat{s})}^{E_0^2(\hat{s})} (R(D+E_0)-D)\mathrm{d}\Psi'(E_0)}{\int_{\underline{E}-\eta}^{E_0^2} \mathrm{d}\Psi'(E_0)}$$

Differentiating with respect to $\eta$ yields:

$$\begin{aligned}\frac{\partial G_R}{\partial \eta} =& \frac{(R(D+\bar{E}+\eta-d)-D)\mathrm{d}\Psi'(\bar{E}+\eta)(1-\Psi'(E_0^2))}{(1-\Psi'(E_0^2))^2} \\ &+ \frac{\mathrm{d}\Psi'(\bar{E}+\eta)\int_{E_0^2(\hat{s})}^{\bar{E}+\eta}(R(D+E_0-d)-D)\mathrm{d}\Psi'(E_0(\hat{s}))}{(1-\Psi'(E_0^2))^2} \\ &+ \frac{\mathrm{d}\Psi'(\bar{E}-\eta)\int_{E_0^0(\hat{s})}^{E_0^2(\hat{s})}(R(D+E_0)-D)\mathrm{d}\Psi'(E_0)}{(\Psi'(E_0^2))^2}\end{aligned}$$

As $\eta \to 0$, $\frac{\partial G_R}{\partial \eta} > 0$, concluding the proof. $\square$

**Proposition 5**

*Proof.* Define the following function:

$$\hat{G}_R(\Delta) = \frac{\displaystyle\int_{E_0^2(\hat{s}(\Delta))}^{\bar{E}+\Delta} E_1(E_0, d)d\Psi'(E_0)}{\displaystyle\int_{E_0^2(\hat{s}(\Delta))}^{\bar{E}+\Delta} d\Psi'(E_0)} - \frac{\displaystyle\int_{E_0^0(\hat{s}(\Delta))}^{E_0^2(\hat{s}(\Delta))} E_1(E_0, 0)d\Psi'(E_0)}{\displaystyle\int_{\underline{E}+\Delta}^{E_0^2(\hat{s}(\Delta))} d\Psi'(E_0)}$$

where $E_1(E_0, \hat{d}) = \max\{0, R(D + E_0 - \hat{d}) - D\}$ is the future equity function and $\Delta$ represents a mean shift in the distribution of $E_0$ giving rise to new equilibrium values including $\hat{s}(\Delta)$. The definition of equilibrium requires that $G_R(\Delta) = s^*(\Delta)$. Therefore, for any $\hat{s}^*(\Delta)$ it is the case that, $\partial \hat{G}(0)/\partial\Delta = \partial\hat{s}^*/\partial\Delta$. Writing out the derivative yields:

$$\frac{\partial \hat{G}_R(0)}{\partial\Delta} = A + B\frac{\partial\hat{s}^*}{\partial\Delta} = \frac{\partial\hat{s}^*}{\partial\Delta}$$
$$\Rightarrow A = (1-B)\frac{\partial\hat{s}^*}{\partial\Delta}$$

where

$$A = \frac{d\Psi(\bar{E})\left((1-\Psi(E_0^2))E_1(\bar{E},d) - \int_{E_0^2}^{\bar{E}} E_1(E_0,d)d\Psi(E_0)\right)}{(1-\Psi(E_0^2))^2}$$
$$- \frac{d\Psi(\underline{E})\int_{E_0^0(\hat{s}(\Delta))}^{E_0^2} E_1(E_0,0)d\Psi(E_0)}{[\Psi(E_0^2)]^2}$$
$$B = \frac{\partial E_0^2}{\partial\hat{s}^*}\left[\frac{d\Psi(E_0^2)\left(\int_{E_0^2}^{\bar{E}} E_1(E_0,d)d\Psi(E_0) - E_1(E_0^2,d)(1-\Psi(E_0^2))\right)}{(1-\Psi(E_0^2))^2}\right.$$
$$\left.+\frac{d\Psi(E_0^2)\left(\int_{E_0^0(\hat{s}(\Delta))}^{E_0^2} E_1(E_0,0)d\Psi(E_0) - E_1(E_0^2,0)\Psi(E_0^2)\right)}{[\Psi(E_0^2)]^2}\right]$$
$$+\frac{\partial E_0^0}{\partial\hat{s}^*}\frac{E_1(E_0^0,0)\Psi(E_0^2)d\Psi(E_0^2)}{[\Psi(E_0^2)]^2}$$

Assumption 3 guarantees that $B < 1$. Consequently, $\frac{\partial\hat{s}^*}{\partial\Delta}$ has the same sign as $A$.

Further, note that the increasing property of $R$ signs the numerator of the first term in the expression in $A$, while the second term is negative:

$$(1-\Psi(E_0^2))E_1(\bar{E},d) - \int_{E_0^2}^{\bar{E}} E_1(E_0,d)d\Psi(E_0) > 0$$

(i) Consider some distribution $\Psi'$ and some $\underline{\nu}$ such that $\Psi(E_0^2(\hat{s}^*)) = \underline{\nu}$. As $\underline{\nu} \to 0$ and the mass of banks pay a dividend, the second term of $A$ dominates and so, $A < 0$. Consequently,

$\frac{\partial \hat{s}^*}{\partial \Delta} < 0$.

(ii) Consider some distribution $\Psi'$ and some $\underline{\nu}$ such that $\Psi(E_0^2(\hat{s}^*)) = \underline{\nu}$. As $\underline{\nu} \to 1$ and the mass of banks do not pay a dividend, the first term of $A$ dominates and so, $A > 0$. Consequently, $\frac{\partial \hat{s}^*}{\partial \Delta} > 0$.

$\square$

**Proposition 8**

*Proof.* Given the preventability of runs and the planner's utility function, it must be the case that $I^*(E_0) = 0$ for all $E_0 \leq E_L(d)$, otherwise there would be a run on such a bank. In addition, $I^*(E_0) = 0$ is weakly dominant for $E_0 > E_L(d)$ when there are no runs: releasing information about such a bank does not change the run prospects for that bank (as there are no runs), but pooling a mass of such banks with undercapitalized banks may reduce the run prospects of the undercapitalized banks.

Next, we show that optimum dividend policy satisfies $(\tilde{d}^* = 0$ for $E_0 \leq \max\{E^*, \hat{E}(p^*)\}$ and $(\tilde{d}^*_P = d$ otherwise.

The claim is proven via contradiction. We first show that all undercapitalized banks must pay no dividend in the optimum. We then show that if one bank pays a dividend in the optimum, it must be the case that all banks with greater $E_0$ must also pay a dividend.

First, it must be the case that there are no runs for any dividend observation $\tilde{d}$, that is $Pr^{K^*}(E_1|\tilde{d}) \leq 1 - p^*$. Suppose that there existed a mass $M$ of banks with $E_1(E_0, d, 0) = 0$ with $d^* = d$. Given no runs, there must be a mass of at least $\frac{M}{1-p^*}$ such that $E_1(E_0, d, 0) > 0$ for which $d^* = d$. Given Assumption 5, it would be welfare improving for both the undercapitalized banks of mass $M$ and any mass of well-capitalized banks $\frac{M}{1-p^*}$ to move to pay no dividends. Meanwhile, doing so does not affect the propensity to run for either dividend payors or dividend non-payors. Thus, undercapitalized banks cannot pay dividends in the optimum.

Next, it must be the case that if $d^*(E') = d$ then $d^*(E'') = d$ for all $E'' > E'$. This follows directly from the concavity of $R$ and the welfare benefit of shifting dividend payors to those with the highest capital.

Given no runs and undercapitalized banks paying no dividends, there are two possibilities: $Pr^{K^*}(E_1 = 0|0) = 1 - p^*$ and $Pr^{K^*}(E_1 = 0|0) > 1 - p^*$. In the case of the former, $E_0$ increasing in $d^*$ and no runs implies that it must be that banks below $\hat{E}(p^*)$ do not pay a dividend. In the case of the latter, the no-run constraint is not binding and the planner must have no incentive to move banks from dividend non-payors to dividend payors. This can be true only if well-capitalized banks are efficiently paying dividends, that is, where $d^*(E_0) = d$ if and only if $E_0 > E^*$. □

**Proposition 10**

*Proof.* We show by construction. Given $C^*$, we note that the signal of a dividend is always positive. This follows from the fact that $\Phi$ is increasing in $E_0$ when $E_0 \geq E_L(0)$. In turn, this implies that $\mathbb{E}[E_1|d] \geq \mathbb{E}[E_1|0]$. Furthermore, for all banks with $E_0 \geq E^*$ it is the case that $d + E_1(E_0, d, 0) \geq 0 + E_1(E_0, 0, 0)$. Therefore, any bank with $E_0 \geq E^*$ will find it optimal to pay a dividend if allowed given $C^*$. Furthermore, all banks with capital below this level are restricted.

In the case where runs are avoidable, this is consistent with the solution to the planner's problem. Meanwhile, the information policy of the regulator is equal to the planner's by construction. Setting $C^*_R = \bar{E}$ also implies that all banks are restricted from dividends, consistent with the planner's policy in which all banks with $I^* = 0$ must have the same dividend policy. □

# References


Acharya, V. V., I. Gujral, N. Kulkarni, and H. S. Shin (2011): "Dividends and Bank Capital in the Financial Crisis of 2007-2009," NBER Working Paper No. 16896.

Acharya, V. V., H. Le, and H. S. Shin (2013): "Bank Capital and Dividends Externalities," NBER Working Paper No. 19707.

Admati, A., P. M. DeMarzo, M. F. Hellwig, and P. Pfleiderer (2011): "Fallacies, Irrelevant Facts, and Myths in the Discussion of Capital Regulation: Why Bank Equity is Not Expensive," Working Paper, Stanford GSB.

Aggarwal, R., and K. T. Jaques (2001): "The Impact of FDICIA and Prompt Corrective Action on Bank Capital and Risk: Estimates Using a Simultaneous Equations Model," *Journal of Banking and Finance*, 15(1).

Akerlof, G. A., P. M. Romer, R. E. Hall, and N. G. Mankiw (1993): "Looting," *Brookings papers on economic activity*, 15(2), 1–73.

Allen, F., and R. Michaely (2003): "Payout Policy," *Handbook of the Economics of Finance*, pp. 337–429.

Benston, J. G., and G. J. Kaufman (1997): "FDICIA after Five Years," *Journal of Economic Perspectives*, 11, 139–158.

Cho, I.-K., and D. M. Kreps (1987): "Signaling Games and Stable Equilibria," *Quarterly Journal of Econometrics*, 102(2), 179–222.

Dang, T. V., G. Gorton, B. Holmström, and G. Ordoñez (2017): "Banks as Secret Keepers," *American Economic Review*, 107(4), 1005–1029.

Davenport, A. M., and K. M. McDill (2006): "The depositor behind the discipline: A micro-level case study of Hamilton Bank," *Journal of Financial Services Research*, 30(1), 93–109.

Diamond, D. W., and P. H. Dybvig (1983): "Bank runs, deposit insurance, and liquidity," *Journal of Political Economy*, 91(3), 401–419.

Duffie, D., and D. Lando (2001): "Term Structures of Credit Spreads with Incomplete Accounting Information," *Econometrica*, 69(3), 633–664.

Easterbrook, F. H. (1984): "Two Agency-Cost Explanations of Dividends," *American Economic Review*, 74(4), 650–659.

Floyd, E., N. Li, and D. J. Skinner (2014): "Payout Policy Through the Financial Crisis: The Growth of Repurchases and the Resilience of Dividends," Chicago Booth Research Paper No. 12-01.

Galai, D., and R. Masulis (1976): "The Option Pricing Model and the Risk Factor of Stock," *Journal of Financial Economics*, 3, 53–81.

Gorton, G. (2014): "The Development of Opacity in U.S. Banking," *Yale Journal on Regulation*, 31, 825–851.

Grossman, S. J., and O. D. Hart (1980): "Takeover Bids, the Free-Rider Problem, and the Theory of the Corporation," *Bell Journal of Economics*, 11, 42–54.

Hanson, S. G., A. K. Kashyap, and J. C. Stein (2011): "A macroprudential approach to financial regulation," *The Journal of Economic Perspectives*, 25(1), 3–28.

Hirtle, B. (2014): "Bank Holding Company Dividends and Repurchases during the Financial Crisis," Federal Reserve Bank of New York Staff Reports No. 666.

Iyer, R., M. Puri, and N. Ryan (2012): "Understanding bank runs: do depositors monitor banks?," *The American Economic Review*, 102(4), 1414–1445.

Jensen, M. C. (1986): "Agency costs of free cash flow, corporate finance and takeovers," *American Economic Review*, 76, 323–329.

Jensen, M. C., and W. H. Meckling (1976): "Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure," *Journal of Financial Economics*, 3(4), 305–360.

Kanas, A. (2013): "Bank Dividends, Risk, and Regulatory Regimes," *Journal of Banking and Finance*, 37, 1–10.

Miller, M., and K. Rock (1985): "Dividend Policy Under Asymmetric Information," *Journal of Finance*, 40(4), 1031–1051.

Myers, S. C. (1977): "Determinants of Corporate Borrowing," *Journal of Financial Economics*, 5(2), 147–175.

Pettit, R. R. (1977): "Taxes, transactions costs and the clientele effect of dividends," *Journal of Financial Economics*, 5(3), 419–436.

Shleifer, A., and R. W. Vishny (1992): "Liquidation values and debt capacity: A market equilibrium approach," *The Journal of Finance*, 47(4), 1343–1366.