Liquidity Provision, Bank Capital, and the Macroeconomy

New bank equity must come from somewhere. In general equilibrium, raising bank capital requirements means either that banks produce less short-term debt (as debt holders must become shareholders), or short-term debt is not reduced and the banking system acquires nonbank equity (as the shareholders in nonbanks become shareholders in banks). The welfare effects involve a trade-off because bank debt is special as it is used for transactions purposes, but more bank capital can reduce the chance of bank failure (producing welfare losses).

JEL codes: G21, G28
Keywords: liquidity provision, bank capital.

When we wrote this paper 21 years ago there was little to no interest in bank capital. It was considered a boring topic. Today type the words “bank capital” into Google Scholar and look at the results since 2012: 13,800 results (March 18, 2016). Clearly, interest has perked up since the Financial Crisis of 2007–2008. But many of the basic conceptual questions remain (although we have not reviewed all 13,800 papers!). In this paper, we address the following questions: (1) What is the role of bank capital and why do the private and social choices for the level of bank capital differ? (2) What is the optimal policy of a welfare-maximizing bank

We are grateful to Robert DeYoung (the editor), two anonymous referees, William Emmons, Steven Fries, Joseph Haubrich, David Hirshleifer, Bengt Holmström, Charles Kahn, Ross Levine, George Pennacchi, Jianping Qi, Lemma Senbet, Sonya Williams Stanton, and Luigi Zingales for helpful comments. We also thank seminar participants at the London and Stockholm Schools of Economics, Ohio State University, the IMF, the CEPR Conference on Industrial Organization and Finance, the I.G.I.E.R. Banking Conference, the American Finance Association’s 1995 Annual Meetings, the Federal Reserve Bank of Chicago’s 1996 Bank Structure Conference, and the Association of Financial Economists’ 1998 Annual Meeting. Winton thanks Northwestern University’s Banking Research Center and the Federal Reserve Bank of Cleveland for research support. Some of the ideas in this paper originated in an earlier draft entitled “Bank Capital Regulation in General Equilibrium.” The usual disclaimer applies.

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Received October 26, 2015; and accepted in revised form September 22, 2016.
regulator? Another way to state these questions, and our results, is in terms of the cost of bank capital. Our model determines the private and social costs of bank capital, showing when and how these costs are special compared to the cost of capital for nonbanks.

A model that addresses these issues must have three ingredients. First, the model must provide a reason for the existence of banks and have a role for bank capital that is unique to banks. Second, bank capital must have a source, an alternative use that is modeled, so the model must be general equilibrium in this sense. Finally, the model must have a bank regulator. In our model, as in reality, banks produce deposits and originate and hold loans. We focus more on modeling the details of deposit production rather than the details of lending because we want to keep the model tractable. Bank capital increases require that some agents in the economy rebalance their portfolios, either selling some of their assets to the bank in order to acquire the new bank capital or substituting one kind of bank liability for another. This discipline of general equilibrium is critical for our results. Finally, we introduce a bank regulator with the goal of maximizing social welfare to serve as a benchmark for policy evaluation.

We argue that bank equity capital is in fact uniquely costly, and that this cost comes from the role of demand deposits as a desirable medium of exchange. Following Gorton and Pennacchi (1990), suppose that an agent with uncertain consumption needs may have to finance unexpectedly high consumption by selling any securities she holds before their cash flows have been realized. To the extent that other agents gather private information and trade strategically, the uninformed agent with such liquidity needs is exposed to trading losses at this interim date. If she holds a riskless security, she will not suffer a loss to strategic traders because there cannot be any private information about this security’s payoff. Thus, there is a demand for low-risk, information-insensitive, trading securities; banks meet this demand by issuing demand deposits or other forms of short-term debt. To the extent that privately issued demand deposits are not riskless, government deposit insurance can further improve welfare. This leads to unique private and social liquidity costs of bank capital.

Bank debt is special because of its liquidity services. Banks also make loans, which involve the production of valuable information about borrowers; rents or quasi-rents accruing from this information are an intangible asset of the bank which can be lost or significantly diminished in value if the bank fails. These informational quasi-rents are the bank’s private “charter value,” yet we emphasize that these are not an artifact of government regulation but rather a fundamental feature of the bank’s lending

1. For simplicity, we assume deposits are insured. If bank deposits were not insured, they would be risky, and thus information sensitive—though less so than bank equity. If this risk were high enough, some bank depositors might have an incentive to gather information and sell deposits if bank returns proved to be bad. Thus, bank deposits would also have liquidity-related costs, and so, by reducing the risk of bank deposits, an increase in bank equity would have the social benefit of reducing these costs. We have abstracted from this issue for simplicity.

2. James (1991), Slovin, Sushka, and Polonchek (1993), and Kang and Stulz (1997) provide evidence that these costs are significant.
activities. There may also be social costs involving losses above and beyond the loss of the bank’s private charter value. By reducing the likelihood of bank failure, bank capital reduces the likelihood of these private and social losses. Nevertheless, if avoiding these costs of bank failure were the whole story, regulators would be best off requiring banks to hold high capital ratios, perhaps even requiring banks to be financed entirely with equity.

Explicitly incorporating bank lending and deposit production in general equilibrium leads to a fundamental tension in setting bank capital levels. In our benchmark model, raising bank capital means that banks produce less debt. On the one hand, bank failure with its concomitant loss of social charter value is reduced. But, on the other hand, less bank debt is produced, a welfare loss. This is the fundamental trade-off that arises in general equilibrium.

As we show, the private liquidity costs of raising bank capital exceed the social costs. Moreover, private and social costs, and the wedge between them, are all greatest in economic downturns, just when bank capital is most useful as a buffer against failure. Even if regulators are willing to incur the social costs of additional capital in a downturn, high private costs may lead banks to exit rather than comply. If so, regulators face the choice between shrinking the banking system or acquiescing in suboptimal capital levels. Exit does not literally happen in the model, nor do we model a game between banks threatening to exit and bank regulators. Our point is that over time new shadow banks could arise if the private costs of additional capital are too high.

Although our discussion thus far has focused on bank deposits and bank equity as the main financial assets in the economy, in Section 5 of the paper we show that the results still hold when nonbank equity is present. Start from an equilibrium in which banks are making the optimal amount of loans. If investors sell their holdings of nonbank shares in order to purchase newly issued bank shares, then someone must buy these shares. In general equilibrium, only two outcomes are possible: either the overall level of deposits falls to pay for the shares, or else the banking system acquires nonbank shares, expanding total bank assets. Because nonbank shares are riskier than other bank assets (loans), this second case results in no change in banks’ chance of failure in the relevant case of macroeconomic risk: bank capital increases do not reduce the system’s fragility.

Obviously we cannot review all of the massive literature on bank capital that has recently developed, although we do say more about this literature in the penultimate section. Our work differs from the existing literature in this area primarily by our emphasis on the special trading role of bank debt and resulting unique cost of bank equity capital in general equilibrium. There are a few related papers, however. In Holmström and Tirole (1997), firms with insufficient collateral to post against a loan can be monitored by a bank, as a substitute. But, in order for this to be accomplished.

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3. This is sometimes called “franchise value.” See Marcus (1984). There is an empirical literature documenting the decline in U.S. bank charter value in the 1980s; see Keeley (1990) and Demsetz, Saidenberg, and Strahan (1996).
for a number of firms, the bank must have enough of its own capital to invest in a project, to be a credible monitor. Bolton and Freixas (2006) argue this by showing that “good” banks may refuse to raise capital in order to avoid Myers and Majluf (1984) “lemons” costs of equity issuance. In Diamond and Rajan (2000, 2001), it is optimal for banks to have a fragile capital structure, relying on demand deposits to force the bank to behave; if not, then there can be a bank run. But, if there is nonverifiable yet observable uncertainty, then the all-debt capital structure is too fragile and the banker must invest some equity to trade-off the disciplining role of debt against the inessential fragility that is created. Gorton and Pennacchi (1990) study the amount of bank equity needed to make the bank’s debt safe but do not consider whether there are costs to requiring banks to hold more equity. They do not study the trade-off we consider here: the benefit of reducing bank failures versus the costs of reducing the liquidity of the bank’s debt.

Our model of bank capital is significantly different because general equilibrium imposes discipline. Bank debt is special because it is immune to adverse selection when trading. (In Diamond and Rajan, liquidity has to do with being able to demand real consumption units from the bank.) When we explicitly focus on the issue of where additional capital comes from if capital requirements are raised, general equilibrium imposes an important constraint on this issue—namely, where does the additional capital come from?

Our paper proceeds as follows. Section 1 sets out our modeling framework. Section 2 analyzes how investors behave in meeting their liquidity needs, given existing bank characteristics; Section 3 uses this to determine the cost of additional capital requirements and their impact on bank shareholders and on social welfare. Section 4 analyzes how the costs and benefits of additional bank capital vary with macroeconomic conditions. Section 5 incorporates nonbank assets into our model. Section 6 briefly reviews some more literature and Section 7 concludes.

1. THE MODEL

The economy exists over three dates, 1, 2, and 3. There is a continuum of risk neutral consumers with total mass 1, bank regulators, and many competitive, risk neutral, market makers. Bank deposits are insured. Bank regulators levy taxes to support deposit insurance and enforce capital standards with the goal of maximizing aggregate welfare.

At date 1, consumers may rebalance their initial portfolios (see below) of bank deposits and bank equity; they consume at either date 2 or date 3. As in Diamond and Dybvig (1983), consumers vary in how likely they are to be forced to consume early (“suffer a liquidity shock”). At date 1, each consumer knows her type, which is the probability \( t \) with which she must consume at date 2 (“be an early consumer”); however, the shock itself is not realized until the beginning of date 2. Consumer types and the outcome of shocks are private information. There is a continuum of consumers with total mass 1 who have each type \( t \), and the total distribution of
types is uniform over $[0,1]$; thus, the mass of consumers of type $t$ who are forced to consume early is precisely $t$. Given this framework, a type $t$ consumer’s expected utility $U(C_2(t), C_3(t))$ at date 1 is $t \cdot C_2(t) + (1 - t) \cdot C_3(t)$, where $C_\tau(t)$ is type $t$’s consumption at date $\tau$.

Because our focus is on policy in countries with established banking systems, at date 1 banks already exist and have outstanding deposits and equity capital. Implicitly, consumers have previously invested their endowments in claims on a large number of symmetric banks with fixed scale of 1 unit each, which have in turn invested in productive assets; in an early version of this model with exogenous liquidity costs (Gorton and Winton 1995), we explicitly analyzed this “beginning-of-the-world” problem. The model is starting in that equilibrium. As a result, the representative bank has issued $D_0$ deposits promising to pay interest factor $R_D$ at date 2 or date 3 (per unit invested), and $N_0$ shares (with $n_0$ per shareholder), which it has invested in 1 unit of bank assets. Because consumers are risk neutral, they optimally choose portfolios that are either all deposits or all equity; because (as we later show) selling equity at date 2 involves “lemons” costs, those with the lowest ex ante chance of liquidity shocks find bank equity shares most attractive. Thus, there exists a marginal shareholder “type” $t^*$ such that all consumers with $t$ less than $t^*$ have bought equity, so that $n_0 t^* = N_0$. Market clearing implies that all remaining consumers hold deposits, so that $D_0 = 1 - t^*$.

Bank asset returns $\tilde{r}$ are nonnegative and distributed with mean $R$, distribution $F(\cdot)$, and density $f(\cdot)$. We assume that $\tilde{r}$ is symmetrically distributed, which implies it has support on some subset of $[0, 2R]$; this assumption is not essential, but it simplifies later analysis. Implicitly, bank returns come from loans. We assume that banks have private information about these lending opportunities. Furthermore, this private information is valuable and cannot be salvaged if the bank fails; it is an intangible asset linked to the bank’s continued operation. As short-hand, we call this asset the bank’s private “charter value.” For simplicity, rather than model the bank’s informational quasi-rents directly, we specify an exogenous private charter value $C_B$; if the bank’s asset cash flows cover its liabilities (the bank is “solvent”) at the model’s horizon, date 3, then its charter value is preserved (i.e., it can be consumed by the shareholders); otherwise, the bank “fails” and its charter value completely dissipates.

4. As noted, $R_D$ is endogenized in Gorton and Winton (1995). In our setting, the existence of risk-free storage at date 2 rules out a difference between the deposit rate at date 2 and that at date 3, but this is not essential for our results; all that is needed is that deposits are debt (and so relatively insensitive to risk) that provides low-risk liquidity to early consumers at date 2.

5. As will be apparent in our analysis in Section 5, we assume that bank asset returns are perfectly correlated across banks. This is not critical for most of our results; one could assume that banks are only partly correlated but cannot fully diversify across regions or sectors due to diseconomies of scale. Nevertheless, assuming all risk is systematic simplifies analysis, especially in Section 5. It also means that, with no fixed costs of operation, our assumption that the representative bank has a fixed scale of 1 unit is one of convenience only; optimal bank scale is indefinite.

6. Bank charters may have value to bank shareholders for other reasons as well. If entry into banking is restricted, bank charters carry monopoly rents; if deposit insurance is underpriced, charters carry a government subsidy.
As discussed in the introduction, the social cost of bank failure may well exceed the loss of the bank’s quasi-rents from private information. Accordingly, define the bank’s social “charter value” as $C_S \geq C_B$. As with private charter value, this social charter value is lost if the bank fails.

At date 1, banks may raise additional equity capital, either on their own accord or because they acquiesce to the bank regulators’ requirements. If banks do not meet a regulatory capital requirement, regulators can force them to “exit” the industry, where exit means that the returns on the existing portfolio of assets accrue to the bank’s claimants, but charter value is dissipated. Essentially, capital leaves the banking sector, which shrinks.\(^7\) We concentrate on a symmetric outcome in which the representative bank raises an amount of capital $K_1 = N_1 \cdot P_1$, where $N_1$ is the total number of new shares issued and $P_1$ is the price per share. Since existing shareholders are already fully invested in bank equity, this additional capital must come from depositors (again, this is modified when we add nonbank assets to the model in Section 5). We will show that those with the lowest chance of early consumption have the most incentive to buy equity, so all depositors with $t$ between $t^\ast$ and some $t'$ strictly prefer to buy bank equity; thus, they each buy $n_1$ shares such that $n_1 \cdot P_1 = 1$ (i.e., they use up all their deposits), and so $N_1 = n_1 \cdot (t' - t^\ast)$. Market clearing requires that $K_1$ is also the decline in bank deposits at each bank, so that the new marginal shareholder $t'$ satisfies $t' - t^\ast = K_1$, and the new deposit level $D_1 = 1 - t'$.

At the beginning of date 2, new shareholders decide whether to expend effort on gathering private information about their bank’s asset returns; the utility cost of this effort is equivalent to $g$ units of consumption. For simplicity, old shareholders are assumed to have costlessly acquired this information. Those who gather information privately learn whether the bank’s date 3 asset return will be above or below its mean of $R$.\(^8\) Immediately thereafter, investors find out whether they are early or late consumers. All consumers receive an extra endowment of $G$ units of the consumption good, and regulators levy any lump-sum taxes that are required to cover expected bank losses. To simplify analysis, we assume that $G$ is large enough to pay for deposit insurance and early consumption.

At this point, early consumers will wish to exchange their financial claims for units of consumption. Those who hold shares can sell them to late consumers in exchange for part of the late consumers’ date 2 endowments of consumption goods; we describe the structure of this market in the next section. At the same time, early consumers who hold demand deposits use them to purchase consumption from late consumers, who in turn redeposit these at their own banks. Implicitly, we assume that each bank receives redeposits that offset any “checks” written by initial depositors.

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7. As mentioned in the introduction, “exit” does not happen in the model, and threats of exit are not modeled. We think of “exit” as occurring over a long period of time, corresponding to less growth in the regulated banking sector than would otherwise occur, that is, shadow banking develops. This form of exit has been studied by Begenau and Landvoigt (2016) and Moreira and Savov (2016).

8. For simplicity, we assume that, just as all banks’ asset returns are perfectly correlated, these signals are perfectly correlated as well. Assuming that the signal was noisy and imperfectly correlated across banks would be more realistic, but would not the basic thrust of our results; all that we need is that equity is more information sensitive than deposits.
Date 1:
• Banks exist, with \( D_0 \) deposits at rate \( R_D \) and \( N_0 \) shares of equity.
• Regulators may announce new capital standards.
• Banks decide whether to raise more capital.
• Competitive stock market opens; bank stock is issued.

Date 2:
• All investors get additional endowment \( G \).
• Regulators impose lump-sum tax to cover expected shortfalls on deposit insurance.
• New shareholders decide whether to gather information.
• Old shareholders as well as new shareholders that gathered information get signal on bank's date 3 return.
• Investors find out whether they must consume now.
• Competitive stock market opens; shares are traded.
• Banks issue deposits to late consumers to obtain goods so as to meet withdrawals by early consumers with deposits.

Date 3:
• Bank return is realized and divided among investors.

At the end of date 2, early consumers consume, and late consumers invest any residual endowments in a risk-free storage technology with zero net return. This storage technology implies that insured deposits will trade at one unit per unit of consumption.

Finally, at date 3, bank asset returns are realized; holders of deposits and shares receive their contractual payments; late consumers consume. If the bank cannot honor its deposits at face value at date 3, then it fails. Failure means that the value of the charter is lost. If the bank does not fail, then the shareholders consume this value at date 3. Figure 1 reviews this sequence of events.

Although the machinery of the model may seem rather complex—extra endowments at date 2, risk-free storage at date 2 but not before, lump-sum taxes, etc.—this machinery plays little role in the analysis. In fact, these assumptions simplify the issues of consumption allocation and deposit insurance so that we can focus on the shareholders' possible lemons problem at date 2 and the impact that this has on bank capital decisions at date 1.

Note that, in our model, for simplicity the information gathered by shareholders serves no socially useful role: shareholders use it to trade more effectively at the expense of liquidity traders, so information costs are a deadweight loss.

We solve the model recursively. Since date 3 behavior is straightforward, our analysis begins with the behavior of investors at date 2.
2. INFORMATION ACQUISITION AND TRADING AT DATE 2

Recall that, at the beginning of date 2, old shareholders and those other consumers that expend $g$ in effort privately learn whether their bank’s date 3 asset return ($\tilde{r}$) will be above or below the mean return $R$. They can then use this information for trading in the market for shares. Of course, shareholders who become early consumers (“experience liquidity shocks”) must sell their shares, so they may be exploited by these informed traders. Equilibrium at date 2 consists of the optimal information-gathering decision for consumers of different types and the equilibrium prices that clear the stock market.

For simplicity, we follow the modified version of Glosten and Milgrom (1985) used by Admati and Pfleiderer (1989) and Easley and O’Hara (1992) and assume that the market for shares consists of a large number of risk-neutral market makers who compete for trades by offering a bid price $P_B$ and an ask price $P_A$. (To be clear, these prices are set before market makers see order flow and are not contingent on the number of shares that other traders offer to buy or sell.) In equilibrium, Bertrand competition forces market makers to break even, so that $P_B$ ($P_A$) price equals the expected value of a share conditional on its being sold (purchased) by other traders. Since our model has no “liquidity buyers,” the ask side of the market is completely transparent: only informed traders buy shares, so market makers infer that the bank’s returns will be above average and price shares accordingly. However, there are “liquidity sellers” (shareholders who prove to be early consumers), so it can be profitable to sell on the private information that bank returns will be below average. For simplicity, we assume short sales are not allowed. As a result, only (new) shareholders have any incentive to gather information.

Define $E^+_{1}$ as the expected value of the bank’s equity conditional on asset returns exceeding the mean $R$, and $E^-_{1}$ as the expected value conditional on returns being below $R$. Then the expected value of equity at the end of date 1 (before any information is received) is $E_1 = \frac{1}{2} [E^+_{1} + E^-_{1}]$, and the standard deviation of equity’s value across realizations of the informed shareholders’ signal is $\Sigma = \frac{1}{2} [E^+_{1} - E^-_{1}]$. Specific values of these expressions depend critically on whether or not the bank’s promised payment on deposits, $R_D \cdot D_1$, exceeds the mean bank asset returns $R$. We concentrate on the case of $R_D \cdot D_1 < R$, so that banks’ ex ante chance of failure is

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9. Assuming that there is only one bid price and one ask price regardless of the trade size to avoid unnecessary complexity. Otherwise, in order to camouflage their trading, late consumers trying to profit from their information would have to submit orders of the same size as early consumers (who must sell regardless of information). However, some early consumers are old shareholders and some are new; having bought their shares at different times and prices, their holdings need not be the same size, complicating informed traders’ strategies in a manner unrelated to our focus.

10. If we allowed short sales subject to collateral requirements, rather than buy shares initially, agents with low chances of early consumption might choose to hold cash to back future short sales.
less than half, which seems most plausible. (Online Appendix A2 analyzes the case where \( R_D D_1 \geq R \).) Under this assumption, we have:

\[
E_2^+ = \int_R^{2R} r \cdot 2f(r) \, dr - R_D \cdot D_1 + C_B = R - R_D \cdot D_1 + C_B + 2 \int_0^R F(r) \, dr, \tag{1}
\]

where the second equality follows by substituting the mean return less the lower integral of \( r \cdot f(r) \) for the upper integral of \( r \cdot f(r) \), and then integrating by parts (recall that symmetry implies \( F(R) \) equals half). When the good signal is obtained, the bank is certain to survive, so it pays off its deposits at par, obtains its private charter value \( C_B \) for certain, and average bank asset returns exceed the \textit{ex ante} mean \( R \) by the final integral term. Similarly,

\[
E_2^- = \int_{R_D D_1}^R r \cdot 2f(r) \, dr + (C_B - R_D D_1) \cdot [1 - 2F(R_D \cdot D_1)]
\]

\[
= R - R_D \cdot D_1 + C_B \cdot [1 - 2F(R_D \cdot D_1)] - 2 \cdot \int_{R_D D_1}^R F(r) \, dr, \tag{2}
\]

from which it follows that

\[
E_1 = R - R_D \cdot D_1 + C_B \cdot [1 - F(R_D \cdot D_1)] + \int_{R_D D_1}^R F(r) \, dr, \tag{3}
\]

and

\[
\Sigma = C_B \cdot F(R_D \cdot D_1) + \int_0^R F(r) \, dr + \int_{R_D D_1}^R F(r) \, dr. \tag{4}
\]

Returning to the date 2 stock market, we can now derive the ask and bid prices \( P_A \) and \( P_B \). As noted before, since only informed traders would buy shares, market makers know that any purchase of shares means bank returns will be above average; thus, they set \( P_A = E_2^+/(N_0+N_1) \). By contrast, the price when investors sell shares is more complicated. If a new shareholder with probability \( t \) of early consumption becomes informed, with probability \( t \) she is still forced to sell at the bid price, regardless of her information. With probability \( 1-t \) she can act strategically, based on the information that she has acquired. Half of the time, her bank’s return will be above \( R \), so she holds on to her shares, which are worth \( E_2^+/(N_0+N_1) \); the rest of the time, she sells her shares at the bid price \( P_B \). Thus, her total return if she becomes informed is

\[
n_1 \cdot \left[ \frac{1+t}{2} \cdot P_B + \frac{1-t}{2} \cdot \frac{E_2^+}{N_0+N_1} \right] - g. \tag{5}
\]

(Old shareholders’ returns are similar, save that they hold \( n_0 \) rather than \( n_1 \) shares and bear no information cost \( g \).) A new shareholder who does not gather information
has return

\[ n_{1} \cdot \left[ t \cdot P_{B} + (1-t) \cdot \frac{E_{1}}{N_{0} + N_{1}} \right]. \tag{6} \]

Thus, the difference between the two strategies (gather information or not) is that gathering information allows the shareholder to sell at the bid price when she knows her shares are worth only \( E_{2}^{-} \). She gathers information when (5) exceeds (6), which is equivalent to:

\[ n_{1} \cdot \left[ \frac{1-t}{2} \cdot P_{B} - \frac{E_{2}^{-}}{N_{0} + N_{1}} \right] \geq g. \tag{7} \]

Define \( S \) as the total volume of strategic trades by informed shareholders, and \( \Lambda \) as the total volume of liquidity trades; we will calculate these shortly. Since the bid price \( P_{B} \) is the expected value of a share conditional on its being sold, it follows that

\[ P_{B} = \frac{S \cdot E_{2}^{-} + \Lambda \cdot E_{1}}{S + \Lambda} \cdot \frac{1}{N_{0} + N_{1}} = \left[ 1 - \frac{S}{S + \Lambda} \cdot \frac{\Sigma}{E_{1}} \right] \cdot \frac{E_{1}}{N_{0} + N_{1}} \equiv (1 - \Delta) \frac{E_{1}}{N_{0} + N_{1}}. \tag{8} \]

In other words, rather than receiving a price of \( E_{1}/(N_{0}+N_{1}) \) (reflecting their lack of information), liquidity sellers receive a discounted price, where the discount or “lemons cost” \( \Delta \) is increasing in the relative risk of bank equity \( \Sigma/E_{1} \) and in the relative volume of strategic trades \( S/(S + \Lambda) \), all else equal. Conversely, informed sellers receive a profit above the share’s true value of \( E_{2}^{-}/(N_{0}+N_{1}) \) which is proportional to the relative volume of liquidity trades and the risk of bank equity.

Substituting (8) into (7), new shareholder \( t \) gathers information if and only if:

\[ \frac{n_{1}}{N_{0} + N_{1}} \cdot \frac{1-t}{2} \cdot \frac{\Lambda}{S + \Lambda} \cdot \Sigma - g \geq 0. \tag{9} \]

It may be the case that none, some, or all of the new shareholders \( t \in (t^{*}, t') \) satisfy this condition. Define \( a_{1} \in (t^{*}, t') \) as the new shareholder with the highest \( t \) for whom (9) holds (or \( t^{*} \), otherwise), and recall that, by assumption, all old shareholders are informed. We can now calculate \( S \) and \( \Lambda \). Informed shareholders of type \( t \) sell
strategically with probability $\frac{1}{2}(1-t)$, so $S$ equals

$$
\int_0^{t^*} n_0 \frac{(1-t)}{2} dt + \int_{t^*}^{t_1} n_1 \frac{(1-t)}{2} dt = \frac{N_0}{2} \cdot \left(1 - \frac{t^*}{2}\right) + \frac{N_1}{2} \cdot \frac{a_1 - t^*}{t' - t^*} \cdot \left(1 - \frac{a_1 + t^*}{2}\right),
$$

(10)

where we have made use of the definitions of $N_0$ and $N_1$. Shareholders of type $t$ sell for liquidity reasons with probability $t$, so $\Lambda$ equals

$$
\int_0^{t^*} n_0 t^* dt + \int_{t^*}^{t'} n_1 t^* dt = \frac{N_0}{2} \cdot t^* + \frac{N_1}{2} \cdot (t^* + t').
$$

(11)

This discussion is summarized in the following lemma.

**Lemma 1 (Information Production and Equilibrium in the Date 2 Stock Market).**

(i) Given the marginal informed shareholder $a_1$, the equilibrium stock price $P_B$ is determined by (8), where informed trading $S$ and liquidity trading $\Lambda$ are given by (10) and (11).

(ii) The information-gathering decision is summarized by the marginal informed shareholder $a_1$. (a) If the left-hand side of (9) is negative at $t = t^*$, then $a_1 = t^*$ (no new shareholders become informed). (b) If the left-hand side of (9) is positive at $t = t'$, then $a_1 = t'$ (all new shareholders become informed). (c) Otherwise, $a_1$ is the unique value of $t$ between $t^*$ and $t'$ for which (9) holds with equality, and all new shareholders in $[t^*, a_1]$ become informed.

The information-gathering decision and the equilibrium price $P_B$ are linked by (9), which determines the marginal informed shareholder’s type $a_1$. Although (9) depends on $S$, which in turn depends on $a_1$, a unique solution always exists: the left-hand side of (9) is decreasing in $t$ and $S$, while $S$ is increasing in $a_1$ so long as this is between 0 and 1. Finally, for future reference, we state a result concerning expected shareholder welfare at the start of date 2:

**Lemma 2 (Shareholder Welfare with Strategic Trading).** Aggregate shareholder welfare at date 2 is $E_1 - (a_1 - t^*) \cdot g$, that is, the expected value of bank equity less total costs of gathering information.

To see this, note that any trading gains of informed shareholders are losses to the shareholders suffering liquidity shocks. Since all shareholders are risk neutral, trading gains and losses cancel out, leaving the total cost of information gathering as a deadweight loss.

Although it is certainly possible that market information about future bank returns has some redeeming social value, our analysis abstracts from this because we focus on the impact of an increase in bank capital levels. Even if the market for bank stock yields some useful information, forcing more depositors to hold bank stock is unlikely
to improve matters; instead, as shown in the next section, expected liquidity trading in this market will increase, and new shareholders will have incentives to acquire information that others are already investing in. Such an increase in information gathering by relatively small investors is likely to be largely duplicative, leading to deadweight costs.

3. EQUILIBRIUM WHEN BANKS RAISE CAPITAL

Having examined the secondary stock market at date 2, we now turn to the primary market at date 1 in which banks may issue additional equity. First, given that all banks issue a set amount of additional equity, we determine the equilibrium price $P_1$ of this equity, which determines banks’ cost of capital. Of course, this price takes into account the date 2 equilibrium in which early consumers who sell shares in the secondary market face possible losses to informed consumers. We then compare the private and social costs of bank capital to determine if and when regulators can force banks to raise costly equity.

3.1 Equilibrium in the Date 1 Stock Market

Suppose that all banks raise $K_1$ more equity by issuing $N_1$ shares at price $P_1$ per share. Market clearing requires that deposits fall by the same amount, so we have $P_1 \cdot N_1 = K_1 = D_0 - D_1$. Also, in equilibrium, the marginal new shareholder $t'$ must be indifferent between buying a share at price $P_1$ and holding on to $P_1$ units of deposits and eventually earning $P_1 \cdot R_D$. The value of a share to this marginal shareholder depends in part on whether or not she chooses to gather information.

In the previous section, we assumed that investors with liquidity need type below some critical $t'$ put all their money in shares, and all those above that type put their money in deposits. In what follows, we will prove this. First, we state the consumer’s date-1 maximization problem:

**Date-1 Maximization Problem:** at date 1, the consumer of type $t$ chooses her holdings of shares, $n_1(t)$, and deposits, $D_1(t)$, to maximize her expected utility:

$$\text{Max } U(C_2(t), C_3(t)) = C_2(t) + (1 - t) C_3(t)$$

subject to

(i) $C_2(t) = R_D D_1(t) + \frac{n_1(t)}{N_0 + N_1} \cdot (1 - \Delta) E_1 + G - T_2$

(ii) $C_3(t) = R_D D_1(t) + \frac{n_1(t)}{N_0 + N_1} \cdot E_1 + \Phi(t) + G - T_2$

(iii) $(n_1(t) - n_0(t)) \cdot P_1 = D_0(t) - D_1(t)$

(iv) $n_1(t) \geq 0$

(v) $D_1(t) \geq 0$.  

(P1)
In this problem, \( \Phi(t) \) is the consumer’s expected profit from informed trading, which can be written as

\[
\Phi(t) = \frac{n_1(t)}{N_0 + N_1} \cdot \frac{1 - t}{2} \cdot \frac{\Lambda}{S + \Lambda} \cdot \Sigma, \text{ if } t \leq t^* \text{ (old shareholders)},
\]

\[
\Phi(t) = \max \left\{ \frac{n_1(t)}{N_0 + N_1} \cdot \frac{1 - t}{2} \cdot \frac{\Lambda}{S + \Lambda} \cdot \Sigma - g, 0 \right\}, \text{ if } t > t^* \text{ (new shareholders)},
\]

given that old shareholders are costlessly informed. Equation (i) is an early consumer’s date-2 budget constraint: she consumes by withdrawing deposits at \( R_D \) per unit, selling her shares of bank equity \( n_1(t) \) at the sale price \( P_B = (1 - \Delta) \cdot E_1/(N_0 + N_1) \), and consuming her date-2 endowment \( G \) less any taxes \( T_2 \). Equation (ii) is a late consumer’s date-3 budget constraint; she does not face a lemons problem and gets the full value of her shares of equity, plus any gains \( \Phi \) from informed selling at date 2. Equation (iii) keeps track of the consumer’s financial transactions at date 1: any sale or purchase of shares must be matched by an increase or decrease in her deposit holdings. Finally, (iv) and (v) are nonnegativity constraints.

We have the following result:

**Proposition 1 (Date-1 Equilibrium and the Cost of Bank Capital).** Suppose all banks increase capital by \( K_1 \). Then, so long as \( K_1 \) is less than or equal to \( kE_1/R_D \), where \( k \leq 1 \) is given in the Appendix, this increase in capital is feasible and the following results hold in equilibrium.

(i) The new marginal shareholder is \( t' = K_1 + t^* \). All consumers with \( t \) less than \( t' \) (old shareholders) retain their shares, so that \( n_1(t) = n_0 \) and \( D_1(t) = 0 \). All consumers with \( t \) between \( t' \) and \( t^* \) use all their deposits to buy shares at date 1, so that \( n_1(t) = 1/P_B \) shares and \( D_1(t) = 0 \). All consumers with \( t \) greater than \( t' \) retain their deposits, so that \( n_1(t) = 0 \) and \( D_1(t) = D_0(t) = 1 \). The total number of new shares issued is \( N_1 = n_1(t' - t^*) \).

(ii) There exist two cost levels \( g' \) and \( g^* \), with \( 0 \leq g' < g^* \), such that

(a) If the information-gathering cost \( g \in [0, g'] \), then all new shareholders become informed (i.e., \( a_1 = t' \)), and \( N_1 \) is the unique solution to

\[
(R_D + g)(t' - t^*) = \frac{N_1}{N_0 + N_1} \left\{ E_1 + \frac{\Sigma}{2} \left[ \frac{\Lambda}{S + \Lambda} - t' \left( 1 + \frac{S}{S + \Lambda} \right) \right] \right\}. \tag{14}
\]

In this range, \( N_1 \) is strictly increasing in \( g \).
(b) If \( g \in [g^*, g'] \), then the marginal informed shareholder \( a_1 \in (t^*, t') \), the equilibrium price of new shares \( P_1 \) satisfies

\[
P_1 R_D = \frac{1 - t'\Delta}{N_0 + N_1} E_1, \tag{15}
\]

and \( a_1 \) and \( N_1 \) are jointly and uniquely determined by

\[
\frac{N_1}{N_0 + N_1} \left(1 - t'\Delta\right) \cdot E_1 - R_D (t' - t^*) \equiv G = 0, \tag{16}
\]

and

\[
\frac{N_1}{N_0 + N_1} \cdot \frac{1 - a_1}{2} \cdot \frac{\Lambda}{S + \Lambda} \cdot \Sigma - g (t' - t^*) \equiv H = 0. \tag{17}
\]

In this range, \( a_1 \) and \( N_1 \) are strictly decreasing in \( g \), as is the share discount \( \Delta \).

(c) If \( g > g^* \), then the marginal informed shareholder is \( a_1 = t^* \), the share issue price \( P_1 \) satisfies (15), and \( N_1 \) is the unique solution to (16) with \( a_1 = t^* \), which does not depend on \( g \).

\textbf{Proof.} See the Appendix. \( \square \)

The limit on the amount of capital raised is straightforward: even if old shareholders are totally diluted (the number of new shares issued, \( N_1 \), goes to infinity), new shareholders as a group give up a sure future value of \( R_D K_1 \) in return for a total value of \( E_1 \). Moreover, the value of these shares to the marginal new shareholder is less than the future equity value due to expected liquidity costs. Thus, for equilibrium to exist, the total amount of capital raised is bounded above at some discount \( k \) to the true equity value \( E_1 \).

Part (i) of Proposition 1 follows from market clearing combined with the typical consumer’s date 1 maximization problem. Because consumers are risk neutral, those with lower probability of liquidity needs strictly prefer to invest all their wealth in shares, while those with higher liquidity needs continue to invest all their wealth in deposits. Finally, the total value of deposits used to buy new shares must equal the total value of shares issued.

When the cost of gathering information is sufficiently small, all new shareholders prefer to become informed (equation (9) holds). As shown in the Appendix, because the marginal new shareholder \( t' \) must be indifferent between deposits and shares, the share price \( P_1 \) can be obtained by substituting \( t' \) into equation (5), the total return to an informed new shareholder, and setting this equal to the total return to a depositor, \( R_D \). Combining this with market-clearing yields equation (14); since (as we show) the right-hand side of this is increasing in the total number of new shares issued,
Once the cost of information exceeds \( g' \) (derived in the Appendix), the marginal new shareholder strictly prefers not to become informed. In this case, the condition that she is indifferent between investing in deposits and investing in shares while being uninformed and selling early at the lemons discount with probability \( t' \) yields the equilibrium share price given in equation (15). Combining this with market clearing for the total number of shares issued yields equation (16).

If the cost \( g \) is not too high, the marginal informed shareholder’s type \( a_1 \) is less than \( t' \) but still above \( t^* \), and her indifference condition (for gathering information or not) yields equation (17). Using the Implicit Function Theorem, we show that the solution \((a_1, N_1)\) to the two equations is monotone in \( g \), which in turn can be shown to imply uniqueness. Intuitively, higher information costs mean becoming informed is less profitable, all else equal; for new shareholders with a high probability of liquidity needs, it is unprofitable, and so the type of the marginal informed shareholder falls and total informed trading decreases. This causes the lemons discount \( \Delta \) to fall, making new shares more attractive and lowering the number of shares that must be issued. (In the Online Appendix we show that the drop in \( N_1 \) is not large enough to reverse the drop in \( \Delta \).) This accounts for the results in part (ii.b) of Proposition 1.

Finally, once \( g \) exceeds \( g^* \) (derived in the Appendix), even the new shareholder with the lowest chance of liquidity needs does not want to become informed. At this point, the only informed traders are the old shareholders, so further increases in \( g \) have no effect on the relative numbers of liquidity and strategic trades; the lemons discount \( \Delta \) is constant, and the combination of the marginal shareholder’s indifference condition and market clearing in equation (17) is all that is needed to determine the equilibrium number of shares issued. This accounts for the results in part (ii.c) of Proposition 1.

Note that equation (15) makes clear how the date 2 lemons problem affects the date 1 cost of equity capital: the marginal new shareholder has chance \( t' \) of being forced to liquidate her holdings at date 2, at which time she will face the discount \( \Delta \) which reflects the presence of informed traders. This discount is not the same as that of Myers and Majluf (1984); indeed, we are assuming that there is no asymmetric information at date 1, ruling out the adverse selection effect of a new equity issue. Instead, the discount reflects the fact that the banking system is forcing agents to substitute away from holding demand deposits, the preferred medium of exchange.\(^{11}\)

3.2 Social and Private Incentives to Raise Capital at Date 1

Having shown how the equilibrium issue price of a new bank share is determined, we now examine the incentives of the regulators and of the banks to raise additional capital at date 1. Recall that the regulators’ goal is to maximize the aggregate welfare of all agents. We have the following result:

\(^{11}\) Again, if the information cost is less than \( g' \), the marginal shareholder’s indifference condition is more complex, but she still demands a discount on the value of new shares. Intuitively, she gets informed profits less often than do inframarginal shareholders with lower liquidity needs, so shares are less valuable to her than to the average shareholder.
**Lemma 3 (Regulatory Objectives).** Let $W_S(K_1)$ denote aggregate expected welfare at date 1 as a function of the total amount $K_1$ of new capital raised. Then:

$$W_s(K_1) = R + G + [1 - F(R_D D_1)] \cdot C_S - (a_t - t^*) \cdot g.$$  \hspace{1cm} \text{(18)}

**Proof.** See the Appendix. \hfill \Box

Thus, total expected welfare is the sum of expected bank asset returns $R$, the date 2 endowment $G$, and the social charter value of the bank times the bank’s expected survival probability, less costs of gathering information for use in date 2 trading, which (as previously discussed) are deadweight losses. Intuitively, trading gains and losses are zero-sum, leaving the costs of information gathering, and any taxes needed to insure deposits are cancelled out by transfers to depositors at date 3.

Recall that the decision whether an individual bank raises equity or not is made by the bank’s old shareholders (those who bought shares prior to date 1). We assume that their goal is to maximize their aggregate welfare $W_B(K_1)$, where again we emphasize the impact of the capital-raising decision. We have:

**Lemma 4 (Bank Shareholder Objectives).** Ignoring date 2 endowments and lump-sum taxes (which are not affected by any one bank’s actions), the aggregate welfare of old bank shareholders $W_B(K_1)$ is:

$$\left[ E_1 - \frac{R_D \cdot K_1}{1 - t' \Delta} \right] \cdot \left[ 1 + \frac{1}{2} \left( \frac{A}{s + A} \left( 1 + \frac{t^*}{2} \right) - t^* \right) \cdot \frac{\Sigma}{E_1} \right].$$  \hspace{1cm} \text{(19)}

The second bracketed term equals one if no new shares are issued ($t' = t^*$) and is greater than one otherwise.

**Proof.** See the Appendix. \hfill \Box

While seemingly complicated, (19) has a fairly simple interpretation. The first bracketed term is the difference between the total value of equity ($E_1$) and the new shareholders’ equilibrium share of this value; this term can be thought of as the “base” expected value of the old shareholders’ share in the firm. The second term is an adjustment reflecting the old shareholders’ expected profits from informed trading net of their expected lemons costs from making sales to meet liquidity needs at date 2.

If there were no lemons problem in the date 2 stock market, the new shareholders’ share would be worth $R_D \cdot K_1$, the future value of the deposits which they give up in exchange for shares. Instead, it is larger than $R_D \cdot K_1$ because new shareholders know that they will face lemons problems at date 2 and demand a higher share of the firm (lower price per share) in compensation. Note that the discount factor $1 - t' \Delta$ reflects the marginal new shareholder’s chance $t'$ of being forced to sell shares at date 2. Inframarginal new shareholders value the shares more highly, but they know
that banks are raising $K_1$ new equity, and so they know that the market clearing price reflects $t'$ rather than their own lower chances of facing liquidity needs.

The second term in (19)—the adjustment for trading profits—exceeds one because the old shareholders’ expected date 2 trading profits are positive. Recall that, across all shareholders, total expected trading profits are zero: expected trading profits of strategic traders’ equal total expected trading losses of liquidity sellers. However, the old shareholders are least likely to have liquidity needs and most likely to be able to use their private information strategically; thus, old shareholders have a net trading gain on average, while new shareholders have a net loss. (If no new shares are issued, the old shareholders are the only traders at date 2, and so their profits and losses cancel out.) Nevertheless, the discount on the date 1 issue of equity is so large that it more than offsets the old shareholders’ gain in date 2 trading profits. This is shown by the following result:

**Lemma 5 (Size of the Discount on New Shares).** Suppose banks issue new equity $K_1 > 0$. Then

$$
\left[ \frac{1}{1 - t'\Delta} - 1 \right] \cdot R_D K_1 > \left[ E_1 - \frac{R_D K_1}{1 - t'\Delta} \right] \cdot \frac{1}{2} \cdot \left[ \frac{\Lambda}{S + \Lambda} \left( 1 + \frac{t^*}{2} \right) - t^* \right] \cdot \frac{\Sigma}{E_1} + (a_1 - t^*) \cdot g,
$$

(20)

that is, the total discount on newly issued shares exceeds the sum of the old shareholders’ net expected date 2 trading gains and the new shareholders’ expected costs of gathering information.

**Proof.** See the Appendix.

Thus, in terms of combined liquidity effects (ex ante and ex post) linked to informed trading, issuing equity is always bad for the old shareholders. Intuitively, the issue price reflects the marginal new shareholder’s valuation. Since she is more likely than other shareholders to consume early, she values shares the least, so the price overstates the aggregate discount new shareholders would demand if share price discrimination were possible. This aggregate discount would equal the new shareholders’ aggregate net trading losses and costs of gathering information. Since the new shareholders’ aggregate net trading losses equal the old shareholders’ aggregate trading profits, the inequality easily follows.

This result is useful in contrasting the incentives of the regulators to raise capital with those of the bank shareholders. Suppose for a moment that bank shareholders can freely choose (without a regulatory penalty) how much equity $K_1$ to issue.

**Proposition 2 (The Change in Private and Social Welfare from Increased Bank Capital).** Suppose all bank shareholders freely choose (without threat of penalty) to increase bank equity capital by $K_1$. 
(i) The change in social welfare $W_{S}(K_1)-W_{S}(0)$ equals:

$$[F(R_D D_0) - F(R_D D_1)] \cdot C_s - (a_1 - t^*) \cdot g$$

(ii) The change in bank shareholder welfare $W_{B}(K_1)-W_{B}(0)$ equals:

$$[F(R_D D_0) - F(R_D D_1)] \cdot C_B - \int_{R_D D_0}^{R_D D_1} F(r) dr - \left[\frac{1}{1-t'^\Delta} - 1\right] \cdot R_D K_1$$

$$+ \left[E_1 - \frac{R_D K_1}{1-t'^\Delta}\right] \cdot \frac{1}{2} \left[\frac{\Lambda}{S+\Lambda} \left(1 + \frac{t^*}{2}\right) - t^*\right] \cdot \frac{\Sigma}{E_1}.$$  

(iii) Absent penalties for noncompliance, the change in bank shareholder welfare from raising additional capital $K_1$ is always strictly less than the change in social welfare.

**Proof.** See the Appendix.

Part (i) is straightforward; the impact of a capital increase on social welfare is the increase in the odds of bank survival times the social charter value of banks, less costs of information gathering by new shareholders.

Part (ii) follows by substituting in the value of $E_1$ from (3) into (19), and noting that $D_0$ equals $D_1 + K_1$. The first term in (22) reflects the increased chance of bank survival. The second term reflects “debt overhang” in the sense of Myers (1977): by increasing capital, bank shareholders lower the chance of bankruptcy, increasing expected payments on their deposits and reducing expected losses to the deposit insurer. Since deposit insurance is supported by lump sum taxes on all investors, the bank shareholders’ share in this benefit is negligible, while they bear the direct cost in terms of increased expected deposit payments. The third term is the total discount demanded on newly issued shares, while the fourth term is the increase in the old shareholders’ aggregate expected trading profits.

Part (iii) of the proposition follows by comparing (21) and (22). To the extent that bank failure involves significant negative externalities, $C_S$ exceeds $C_B$, and increasing the odds of bank survival has a greater impact on social welfare than on bank shareholders. Debt overhang is a transfer from bank shareholders to the deposit insurance fund and thus all taxpayers, so it has no effect on (21) while entering negatively into (22). Finally, by Lemma 5, the cost to social welfare from information gathering by new shareholders, $(a_1 - t^*) \cdot g$, is less than the difference between the discount on newly issued shares and the old shareholders’ expected trading profits.

Thus, issuing additional equity is less attractive to bank shareholders than to regulators for several reasons: negative externalities from bank failure, debt overhang effects created by deposit insurance, and the liquidity-related costs of newly issued shares which are our primary focus. Unless regulators can credibly threaten to penalize
banks for noncompliance, this limits their ability to force banks to raise capital. Indeed, given the order of events on our model—regulators set capital requirements, banks comply or not, and regulators then force banks to exit—we have the following result.

**Corollary 1 (Capital Requirements May Never Bind).** If regulators can only enforce date 1 capital requirements that increase social welfare ex post, regulators choose capital requirements which are those that bank shareholders would freely choose in the absence of regulatory penalties.

**Proof.** See Online Appendix A1.

The corollary just highlights that bank shareholders would prefer to not comply with higher capital requirements that they themselves would not freely choose. In reality, binding higher capital requirements could shrink the regulated banking system and might lead to a shadow banking system to arise. Bank regulators might prefer to allow the banks to remain without raising additional capital. But these considerations are outside the model.12

4. BANK CAPITAL AND THE MACROECONOMY

We now address how incentives to raise additional capital are affected by changes in the economy that affect the distribution of current bank asset returns. Throughout, we focus on the case where the marginal informed new shareholder $a_1$ is interior—that is, $a_1 \in (t^*, t')$, or, equivalently, the information cost $g \in (g', g^*)$. As we will see, the costs of raising additional capital are apt to be highest just when the benefits of additional capital are greatest.

Consider a general worsening of bank asset returns, such as might occur during a recession. In our model, an improvement in bank returns can be represented by a first-order-stochastic-dominance shift in the distribution $F(\cdot)$, so the opposite sort of shift would indicate a worsening. A particularly simple form is one in which the density of returns shifts left such that the new density $f_{\Delta R}(r)$ equals $f(r + \Delta R)$, which implies that the new mean of bank asset returns is $R - \Delta R$. We have the following results on how this affects the costs and benefits (social and private) of raising additional capital:

**Corollary 2 (Effects of Lower Bank Asset Returns).** Suppose that $g \in (g', g^*)$ and that the distribution of bank asset returns deteriorates, so that the new density $f_{\Delta R}(r)$ equals $f(r + dR)$ and the new mean equals $R - dR$, where $dR$ is positive. Then, for any fixed capital increase $K_1$:

12. This time inconsistency problem, where regulators are reluctant to close failed banks ex post even though this is ex ante efficient, was first explored by Mailath and Mester (1994) in the context of deposit insurance regulation. More recently, DeYoung, Kowalik, and Reidhill (2013) examined this issue in a repeated-game where banks have incentive to increase their complexity so as to become “too-complex-to-close.”
(i) If the density of asset returns is single peaked, the social and private gross benefits of increased bank capital (through lower probability of failure) increase;
(ii) Expenditures on information gathering \((a_1 - t^*) \cdot g\) increase;
(iii) The private cost of debt overhang increases;
(iv) If the relative volume of informed trades \(S/(S+\Lambda)\) either decreases slightly or increases, the net discount on new shares less old shareholders’ trading profits decreases (becomes more negative).

**Proof.** See Online Appendix A2.

Before discussing these results, some intuition is in order. The benefit (social or private) of increased capital is the decreased chance of bank failure times the charter value. Any worsening of bank returns means that failure cutoffs both before \((R_D \cdot D_0)\) and after \((R_D \cdot D_1)\) capital is raised are shifted upwards in the distribution; so long as the density \(f(r)\) is monotone increasing in this region, the reduction in the probability of bank failure caused by a given increase in bank capital increases, which is part (i).

Part (ii) of the corollary deals with the new shareholders’ decision to gather information. A worsening of bank asset returns increases the relative risk of bank equity \(\Sigma/E_1\) based on the costly signal, making information more valuable; intuitively, the bank shareholders’ claim resembles a “call option” on bank assets, and a worsening of underlying asset returns increases this option’s relative risk. It also decreases the value of bank equity \(E_1\), so that more shares must be issued to the new shareholders to get them to part with their deposits. Since new shareholders have higher chances of liquidity needs than old shareholders, this increases the relative fraction of liquidity trades, again making informed trading more attractive. Thus, total expenditures on information increase, which is socially wasteful.

Part (iii) looks at one element of the private cost of additional capital, the reduction in debt overhang. As bank returns worsen, expected shortfalls on deposits (to the deposit insurer) increase, so any given capital infusion has greater effect.

Finally, part (iv) looks at the other private cost of bank capital, the discount that new shareholders demand less any increase in old shareholders’ trading profits. Recall that this is always a net cost; it can be shown that this cost tends to increase with the relative risk of bank equity and with the relative volume of strategic trades. If bank asset returns worsen, the relative risk of bank equity increases, while relative strategic trading is affected ambiguously (more new shareholders gather information, increasing strategic trading, but more shares are issued to new shareholders, which tends to increase liquidity trading). As long as any relative decrease in strategic trading is not too large, the risk effect dominates, and the net cost to the old shareholders rises.\(^{13}\)

The upshot is that, in a recession, just when the increased chance of bank failure makes increasing bank capital seem attractive, the gross social and private costs of such capital are likely to increase: bank equity risk increases, increasing incentives

\(^{13}\) In the Online Appendix, Corollary 3 examines the effects of increased charter value.
to gather (socially wasteful) strategic information and worsening debt overhang and the discount demanded on new shares.

5. BANK CAPITAL REQUIREMENTS IN AN ECONOMY WITH NONBANK ASSETS

One drawback to the preceding analysis is that the only financial assets in the economy are bank equity and deposits, which implies that the only source for new bank capital is bank deposits. In reality, other equities are available, and individuals who buy bank shares may well pay for their purchases by selling holdings of nonbank shares. To incorporate these effects, in this section we expand the set of available assets by assuming that firms in the economy are financed by a combination of bank loans and publicly traded equity; thus, individual investors may now hold nonbank shares, bank shares, or bank deposits.

We show that, in this setting, an increase in bank capital has one (or both) of two effects: either aggregate deposits fall, or else the banking system acquires nonbank shares—in essence, banks use proceeds from their newly issued shares to acquire equity in nonbank firms. In the first case, the results of the preceding sections are unaffected; in the second case, the liquidity costs of an increase in bank capital are lower, but bank safety is not increased nearly as much. Intuitively, nonbank shares are much riskier than loans to the same nonbank firm, so average bank asset risk increases. Since the goal of increased bank capital is to reduce banks’ risk of failure, it is unlikely that this is a desirable outcome.

We focus on macroeconomic (systematic) shocks to the economy. This is the relevant case for studying how capital requirements impact the banking system’s fragility. Therefore, we assume that the returns on all (nonbank) firms are perfectly correlated; the return is described by $M(y)$ where $y \in [0, \infty)$. Because assets are perfectly correlated, information about bank asset returns is also information about firm asset returns, and vice versa. Firms are financed by bank loans and publicly traded equity. Bank loans have a principal amount $L$ and gross promised return $R_L$. At the start of the world there exists an interval of consumers, $[0, t_F]$, who hold the firm shares. Bank equity is held by consumers of type $(t_F, t_B]$, and the remaining consumers, $(t_B, 1]$, hold bank deposits (see Figure 2). Later, we verify that this is the appropriate equilibrium configuration; intuitively, firm equity is riskier than bank equity and has a greater lemons discount when sold, making it a worse hedge against liquidity shocks.

Bank assets are the loans to the firms. Thus, bank deposits are a senior claim on these loans and bank equity is a junior claim on these loans. The loans themselves are a senior claim on firm returns. It follows that firm equity is the riskiest claim in the economy (in the sense of Rothschild and Stiglitz 1970), followed by bank equity.

14. It is obvious that higher capital requirements reduce the cost to resolving individual failed banks when bank shocks are idiosyncratic. Nevertheless, a key goal of capital requirements is to reduce systemic risk, hence we focus on the case of perfectly correlated returns.
and then deposits. We establish this result formally in Online Appendix A3. Figure 2 shows the economy’s consolidated balance sheet. Effectively, deposits have the most senior claim on firm assets, followed by bank equity and then firm equity.

Now consider what happens if new bank capital can be purchased by current holders of nonbank shares. In equilibrium, if nonbank shareholders sell their shares to buy new bank equity, the nonbank shares must be purchased either by depositors or by the bank itself. In the first case, we are back in the situation we have already analyzed, that is, deposits fall, creating a liquidity cost. In the second case, the average risk of bank assets increases, offsetting the benefits of additional bank capital. Figure 3 illustrates these effects.

Under our simple assumptions, the case where nonbank shareholders sell their shares to the bank does not result in a social liquidity cost: new owners of bank shares would have otherwise held firm shares, and we assume (as before) that they have already acquired information about future returns. Intuitively, shifting one illiquid asset for another does not affect aggregate liquidity costs very much. On the other hand, in this case additional bank capital does not reduce the chance of bank failure:

**Proposition 3 (Higher Bank Capital Requirements May Not Reduce Systemic Risk).** Suppose that the bank increases bank equity capital by a dollar amount equal to \( K_1 \), and that this is purchased by nonbank shareholders in exchange for their nonbank shareholdings. Then the probability of bank failure is unchanged at \( M(R_D D_0) \).

**Proof of Proposition 3.** The bank fails whenever bank loan returns are below \( R_D D_0 \). This, in turn, occurs whenever firm asset returns are less than \( R_D D_0 \). Any substitution between bank equity and firm equity simply gives the bank more of the upper tail of the firm asset return distribution. It does not affect the probability that the firm asset returns are less than \( R_D D_0 \).
In the case of macroeconomic risk, when all firms’ values are perfectly correlated, the bank’s loan portfolio distribution is simply a truncated version of the distribution of the firms’ assets. Note that equities are much riskier than bank loans, reflecting the fact that equities are junior claims on firm assets while loans are senior claims to firm assets. And equities are positively correlated with the performance of bank loans: recessions hurt firms, which in turn damages their ability to pay back their debts. The upshot is that equity holdings are a poor hedge against aggregate credit risk. Thus, the mere existence of nonbank shares is not an argument against our results.

A few related issues warrant discussion here. First, although our model assumes that all financing of nonbank firms takes the form of bank loans or equity, in reality such firms may also raise financing through other debt such as corporate bonds. This means that another possible equilibrium outcome from an increase in bank capital requirements would be for holders of corporate bonds to sell them in exchange for bank shares and for the bonds to be bought by banks. Once again, the effect of the capital increase would be to increase the banking system’s exposure to the nonbank sector, offsetting all or part of the reduction in bank failure risk resulting from higher capital requirements. (The precise risk reduction would depend on whether these bonds were subordinated to bank loans or pari passu with them.)

Second, in reality, capital requirements are tied in part to the risk categories of the banks’ assets, and, whereas loans have a fractional capital requirement, bank investments in equities typically have a 100% capital requirement. Thus, if banks

15. When firms have idiosyncratic risk as well, this result will be somewhat softened, because idiosyncratic upside on some shares can offset loans to other firms that fail. Nevertheless, macroeconomic risk is likely to dominate during major downturns.
acquired nonbank equity, they would need to raise even more equity capital of their own, etc., making it more likely that the most of any capital increase would eventually come from reduced deposits rather than greater holdings of nonbank shares. Nevertheless, as just noted, bank purchases of corporate bonds and other bank loan alternatives would continue to receive fractional capital requirements, and so the importance of the scenario where banks that raise capital buy corporate bonds would be unaffected.

Third, large banks often use nondeposit debt (commercial paper, medium-term notes, senior bonds, subordinated bonds) as well as deposits and equity as funding sources. It follows that bank shares that are issued to increase bank capital ratios might be bought by nondeposit debt holders rather than depositors. However, short-term bank debt is usually fairly liquid, and although bonds are much more illiquid, they are typically held by institutional investors, who can use them as collateral for repurchase agreements (albeit at a haircut).

By contrast, use of contingent convertible debt (“CoCo” bonds) might potentially square the circle by counting as equity capital while being less exposed to bank risk outside of very bad scenarios. By being less sensitive to bank risk, it is possible such bonds may be more liquid than shares while providing the same disaster insurance, allowing them to be used to meet increased capital requirements without much loss of liquidity.16 Thus far, it is not clear that this is the case: a recent study by Avdjiev, Kartasheva, and Bogdanova (2013) finds that these bonds are typically held by small investors, and that their spreads are most correlated with (albeit higher than) spreads on other subordinated bank debt. This seems most consistent with CoCo bonds being a vehicle marketed for high but less risky-than-equity returns rather than liquidity per se (corporate bonds being illiquid, as noted before). However, Avdjiev, Kartasheva, and Bogdanova do not specifically analyze the liquidity of these bonds in the secondary market per se. In any event, there has been relatively little use of CoCo bonds by U.S.-based banks, so it seems premature to argue that these are a dominant solution.

There is another important point, however. The model here has no way of thinking about different maturities of debt instruments. Bank debt is typically short maturity or on demand-type debt, whereas other debt is longer term. One reason for short maturity is that it results in the information-insensitivity of the claim. That is, as per Dang, Gorton, and Holmström (2013), it is not profitable for any agent to produce private information about the payoffs on the assets backing the debt when the debt is short-maturity.17 Other short-term bank debt, for example, commercial paper or wholesale CDs, would be information insensitive, while longer term debt would be information-sensitive. Similarly, CoCo bonds are information sensitive. For simplicity, we do not formally model these issues in detail.

16. Mathematically, the lower sensitivity of CoCo debt (as compared with common shares) to good outcomes is straightforward. Sensitivity to bad outcomes is less clear; indeed, some CoCos suffer write-downs when bank capital is sufficiently eroded, which creates a gain to shareholders, making the CoCos potentially more sensitive to bad outcomes than common shares are.

17. Dang, Gorton, and Holmström (2013) do not address the issue of bank capital; they analyze an optimal contracting problem.
The bottom line is that allowing for assets other than bank loans, deposits, and bank shares does not alter our main conclusions. An increase in bank capital will either lead to a reduction in bank deposits, or it will tend to increase the banking system’s exposure to the nonfinancial sector, or both. In the first case, higher liquidity costs will result; in the second, the risk-reducing effect of higher bank capital requirements will be diluted.

6. RELATION TO THE LITERATURE

As we mentioned in the introduction, the literature on bank capital requirements is now larger than anyone could possibly read. Some work was discussed in the introduction. In this section we very briefly review some of the related literature.

A key question for regulators concerns exactly how much capital should be required for banks. This requires a credible general equilibrium model of the economy with banks. Banks must be special in the economy and there must be a reason for bank capital. In the model above, we did not include bank runs. Recently, there has been some work in this area creating calibrated models of banks and capital requirements, including Van den Heuvel (2008), Begenau (2015), Nguyen (2014), and Corbae and D’Erasmo (2014), which we now discuss.

The first two papers simply assume that households prefer deposits over equity, and that banks and that deposits receive a government guarantee (in Van den Heuvel, deposits are insured; in Begenau, banks receive an exogenous government transfer). Despite these similarities, they find opposite results: Van den Heuvel finds that moving to then-current capital requirements of 10% of risk-weighted assets (RWA) entails a loss of liquidity equivalent to as much as 1% of current consumption, whereas Begenau finds that a move from current capital levels to 14% of RWA increases output and consumption by 0.1%. By contrast with these two papers, Nguyen (2014) and Corbae and D’Erasmo (2014) focus their models on the industrial organization of the banking sector in settings where lending is the main function of banks and consider how increases in capital requirements affect banking sector structure as well as overall welfare. As in the case of the previous two papers, they find somewhat opposite effects: Corbae and D’Erasmo find that a 50% increase in the minimum capital to RWA ratio increases banking sector concentration and greatly reduces lending, Nguyen finds that doubling the minimum capital to RWA ratio would be optimal. These differing results demonstrate the current lack of consensus on about how the banking system should be modeled and underscore the importance of the various idiosyncrasies in these models when evaluating policy.18

18. Another model that takes a calibration approach to bank capital requirements is Egan, Hortaçsu, and Matvos (2015); however, they take a partial equilibrium approach that focuses on estimating the demand for insured and uninsured bank deposits and modeling how competition among banks for deposits can lead to increased fragility and thus a need for higher capital requirements.
Another key question is how (if at all) banks change their lending in response to increases in capital requirements. Since the financial crisis a large empirical literature on this topic has come into existence. Mésonnier and Monks (2015) analyze the introduction of higher capital requirements by the European Banking Authority in October 2011. The way this was done created a natural experiment. Mésonnier and Monks (2015) found that banks forced to raise their tier 1 capital had lower loan growth than unconstrained banks and that the unconstrained banks did not make up the difference in lending. Fraisse and Thesmar (2015) and Behn, Haselmann, and Wachtel (2016) find a large effect of capital requirements on bank lending. Adrian and Shin (2008) argue that banks adjust their balance sheets to attain a target level of leverage. Consequently, a negative shock to capital can lead to downward shifts in credit supply, resulting in procyclical effects of bank capital management. Chodorow-Reich (2014) finds significant effects on lending when banks suffer and adverse shock to their capital. On the other hand, Berrospide and Edge (2010) find relatively small effects of capital ratios on loan growth. Finally, looking at loans to publicly traded firms, Santos and Winton (2016) find that bank lending to firms with access to many debt funding sources is little affected by banks’ capital levels, whereas banks with unusually low capital levels charge significantly higher rates to their bank-dependent borrowers, especially those with low cash flows.

7. CONCLUSION

In this paper, we model a cost of bank capital tied to the unique role of bank liabilities in providing an efficient medium of exchange. Though bank equity capital reduces the chance of bank failure and subsequent private and social deadweight losses, to investors, bank equity is an information-sensitive asset that makes a poor hedge against liquidity needs. In equilibrium in an existing banking system, investors hold deposits to the extent they need coverage against potential liquidity shocks. A system-wide increase in required bank capital forces investors to reduce their deposit holdings in favor of equity, increasing the odds that the marginal bank shareholder will have to sell to meet liquidity needs and increasing the resulting discount for expected trading losses. Moreover, once investors have acquired bank shares, they have an incentive to acquire costly information about the value of the bank; though privately attractive ex post, these information costs are ex ante social losses.

Our results suggest that if banks are forced to raise capital, they can exit the industry. This is because of the wedge between private and social costs of capital. Exit reduces the production of liquid demand deposits, but can also lead to a “shadow banking” system, although we did not model this. Nevertheless, our analysis suggests that if the shadow system created private and social charter value and was outside the regulatory sphere, it would have a socially suboptimal level of capital.

Our results also suggest that the private and social costs of raising additional capital are highest when bank asset returns are low. One implication is that it may be easiest to force banks to raise additional capital during good times, when the wedge between
social and private costs (and thus banks’ resistance to raising capital) is likely to be lower. Conversely, this might lead to apparent “forbearance” in downturns, where regulators choose to allow banks to operate with impaired capital rather than impose higher standards and face increased bank exit.

APPENDIX: SELECTED PROOFS

PROOF OF PROPOSITION 1. For now, we will assume that raising new capital $K_1$ is in fact feasible; we will derive a sufficient condition in part (ii) of the proof.

(i) Let $t'$ denote the shareholder with highest liquidity needs after the equity issue. Because total bank equity increases, it is immediate that $t'$ exceeds $t^*$. Next, consider the maximization problem (P1). Substituting constraints (i)–(iii) into the objective function $U(\bullet)$, we have

$$U(C_2(t), C_3(t)) = R_D D_1(t) + \frac{n_1(t)}{N_0 + N_1} \cdot [(1-t\Delta)E_1]$$
$$+ \Phi(t) + G - T_2$$
$$= R_D [D_0(t) + (n_0(t) - n_1(t))P_1]$$
$$+ \frac{n_1(t)}{N_0 + N_1} \cdot [(1-t\Delta)E_1] + \Phi(t) + G - T_2. \quad (A1)$$

Note first that, for $t \leq t^*$, $\Phi(t)$ is linear and increasing in $n_1$ and linear and decreasing in $t$. Moreover, for $t > t^*$, $\Phi(t)$ is constant at 0 for $n_1$ sufficiently close to 0; for larger $n_1$, it may become positive, linear, and increasing in $n_1$, and linear and decreasing in $t$. Finally, the rest of the objective function is always linear in $n_1$ and linear and decreasing in $t$. It immediately follows that if some consumer with type $t$ is indifferent to increasing her shareholdings $n_1$ at the equilibrium price $P_1$, then all consumers with lower values of $t$ strictly prefer to increase their shareholdings as much as possible subject to their financing constraint, and all with higher values of $t$ strictly prefer to hold deposits. The results in part (i) on equilibrium portfolio holdings follow easily. Given these holdings, the value of shares issued, $K_1$, must equal the total deposits used to buy new shares, which equals $t' - t^*$, and so $t' = K_1 + t'$, and total new shares issued are $N_1 = n_1(t' - t^*)$.

(ii) (a) Suppose the information cost $g$ equals 0. Then, so long as $t' < 1$, it is immediate that equation (9) holds strictly for all $t \leq t'$, and so all new shareholders choose to become informed ($a_1 = t'$). (If $t' = 1$, then we define $g' = 0$ and move on to case (b).) It is also clear that all new shareholders will have incentive to become informed if $g$ is positive but sufficiently small.
From equations (10) and (11), we have
\[
\Lambda = \frac{N_0 t^*}{2} \cdot \frac{N_1 (t^* + t')}{2}, \quad \text{and} \quad S = \frac{N_0}{2} \cdot \left(1 - \frac{t^*}{2}\right) + \frac{N_1}{2} \cdot \left(1 - \frac{t' + t^*}{2}\right) = \frac{N_0 + N_1 - \Lambda}{2}.
\] (A2)

From equation (5), the marginal new shareholder \(t'\) is informed and values her shares at
\[
\Pi (t') \overset{\text{def}}{=} \frac{n_1}{N_0 + N_1} \cdot \left\{ E_1 + \frac{S}{S + \Lambda} \cdot \left[ \frac{N_1}{N_0 + N_1} \cdot \left(1 + \frac{S}{S + \Lambda}\right) - t' \left(1 + \frac{S}{S + \Lambda}\right) \right] - g \right\} - R_D = 0.
\] (A3)

As shown in the Online Appendix, \(S/(S+\Lambda)\) is strictly decreasing in \(N_1\), from which it follows that the left-hand side of (A4) is strictly increasing in \(N_1\). Also, for \(N_1 = 0\), the left-hand side is negative. If it is true that, for \(N_1 = \infty\) (total dilution of old shareholders), the left-hand side is positive, then there will be a unique \(N_1\) that solves (A4). In the Online Appendix, we show that a sufficient condition for this is that
\[
\frac{E_1}{R_D} \cdot \left\{ 1 - t' \frac{\sum}{E_1} \cdot \left[ \frac{2 - t' - t^*}{2 + t' + t^*} \right] \right\} \equiv k \cdot \frac{E_1}{R_D} \geq K_1.
\] (A5)

This is basically a requirement that if there were total dilution of old shareholders, the marginal new shareholder would be willing to buy shares even if uninformed. Given that the marginal new shareholder is in fact informed, this is enough to guarantee that sufficient dilution will allow equation (A4) to hold. Moreover, it is easy to see that \(k\) as defined in equation (A5) is less than 1, so this verifies the sufficient condition given in the beginning of the proposition.

Finally, the left-hand side of (A4) is clearly decreasing in \(g\), so by the Implicit Function Theorem the value of \(N_1\) that solves this is increasing in \(g\). But we can also
\[
\Pi(t') = \frac{n_1}{N_0 + N_1} \cdot E_1 \left(1 - t' \Delta\right) + \frac{n_1}{N_0 + N_1} \cdot \frac{1 - t'}{2} \cdot \Sigma \cdot \frac{\Lambda}{S + \Lambda} - g. \tag{A6}
\]

Again, this must equal \(R_D\) in equilibrium. Because \(S/(S+\Lambda)\) is strictly decreasing in \(N_1\), which itself is increasing in \(g\), it follows that \(1 - t' \Delta\) is increasing in \(g\), and so is the first term on the right-hand side of (A6). Eventually, this first term will equal \(R_D\), which means the rest of the right-hand side equals zero. But these terms are in fact the gain to becoming informed, and so we have shown that there exists a \(g' > 0\) at which the marginal new shareholder \(t'\) is indifferent to becoming informed. Further increases in \(g\) bring us to case (b).

(b) As just noted, at \(g = g'\), the marginal new shareholder gets 0 gain from becoming informed; that is, equation (9) holds with equality for \(t = t' = a_1\). Multiplying through by \(K_1 = t' - t^*\) and using \(N_1 = n_1(t' - t^*)\) yields equation (17). Also, it is still the case that \(\Pi(t') = R_D\); using (A6) and equation (9), we have

\[
\Pi(t') = \frac{n_1}{N_0 + N_1} \cdot E_1 \left(1 - t' \Delta\right) = R_D. \tag{A7}
\]

Again, multiplying through by \(K_1 = t' - t^*\) yields equation (16).

We now claim that, as \(g\) increases further, \(a_1\) and \(N_1\) both decrease. If this is true, then it is immediate that new shareholder \(t'\) will continue to be uninformed, and so (A7) will continue to hold, as will equation (16). Similarly, by definition, \(t = a_1\) satisfies equation (9) with equality, yielding equation (17).

To see this result, suppose that we are at a point where both equations (16) and (17) hold. These two equations jointly determine \(a_1\) and \(N_1\), and so we can use the Implicit Function Theorem to sign \(da_1/dg\) and \(dN_1/dg\). In the Online Appendix, we show that \(da_1/dg < 0\) and \(dN_1/dg < 0\).

We know both equations do hold for \(a_1 = t'\). Thus, an infinitesimal increase in \(g\) will cause \(a_1\) and \(N_1\) to decrease. But then both equations continue to hold at the new equilibrium, and so the Implicit Function Theorem still applies, and changes in \(g\) continue to decrease \(a_1\) and \(N_1\). Eventually, for \(g\) sufficiently large, we will have \(a_1 = t^*\). (To see this, note that the gross profit from informed trading—that is, the first term in equation (9)—is bounded above by \(\Sigma/2\), so net profits will be zero at some \(g^* \leq \Sigma/2\).) The monotonicity of the two key variables and the fact that they are uniquely determined at \(g'\) means that they are uniquely determined for \(g \in [g', g^*]\).

Further, the lemons discount on \(\Delta\) is directly proportional to \(S/(S+\Lambda)\). This is decreasing in \(N_1\) but increasing in \(a_1\) (increasing \(a_1\) increases \(S\) while leaving \(\Lambda\) unchanged), so it is not immediately clear how an increase in \(g\) affects \(S/(S+\Lambda)\). However, in the Online Appendix we show that the net impact is in fact negative, so an increase in \(g\) decreases \(\Delta\). This in turn implies that the sufficient condition for feasibility given in part (a) applies in this case as well: if full dilution allows an
uninformed marginal shareholder to earn at least $R_D$, then it is feasible to successfully issue equity with less dilution ($N_1 < \infty$).  

(c) If $g > g^*$, then it is immediate that no new shareholders find it profitable to become informed. It follows that $S = \frac{1}{2}N_0 \cdot (1 - \frac{1}{2}t^*)$, which is independent of $g$ and $N_1$. Likewise, $\Lambda$ is given by (11), which is increasing in $N_1$ but independent of $g$. It follows that equilibrium is now independent of $g$, and $N_1$ will be pinned down by the requirement that shareholder $t'$ earns $R_D$. Since $t'$ is uninformed, this condition is given by (A7); once more, multiplying through by $K_1$ yields equation (16). Because $S/(S+\Lambda)$ is decreasing in $N_1$, the left-hand side of equation (16) ($G$) is increasing in $N_1$. When $N_1 = 0$, $G$ is negative; when $N_1 = \infty$ (full dilution), $G$ goes to $E_1 - R_D K_1$. (The discount on shares goes to zero because the only informed traders are old shareholders, whose volume of trading becomes negligible.) Thus, as long as $E_1/R_D \geq K_1$, a unique solution (possibly $\infty$) exists. It follows that in this region, the feasibility constant $k$ can be set equal to 1. □

PROOF OF LEMMA 3. Lemma 2 shows that shareholders’ objective function equals the sum of expected cash flows to equity (including future charter value), less costs of gathering information. In addition, shareholders may pay lump sum taxes to support deposit insurance, and may receive a positive externality from the survival of other banks. Depositors receive $R_D \cdot D_1$ in aggregate, plus positive externalities from bank survival, less lump sum taxes. Summing these components up and realizing that taxes equal expected shortfalls on deposit payments leads to the desired result. □

PROOF OF LEMMA 4. Each old shareholder of type $t$ receives:

$$\frac{n_0}{N_0 + N_1} \cdot \left[ \frac{1 + t}{2} \cdot P_B + \frac{1 - t}{2} \cdot E_2^* \right]. \quad (A8)$$

Substituting in for $P_B$ from (8) and integrating $t$ over $0$ to $t^*$ yields:

$$\frac{N_0}{N_0 + N_1} \cdot \left[ E_1 + \left( \frac{\Lambda}{S + \Lambda} \left( 1 + \frac{t^*}{2} \right) - t^* \right) \cdot \frac{\Sigma}{2} \right]. \quad (A9)$$

Using (16) to solve for $(N_1/(N_0 + N_1))$, replacing $t^*$ with $K_1$, and substituting $1 - (N_1/(N_0 + N_1))$ for $(N_0/(N_0 + N_1))$ in (A9) yields (19) in the text. Next, if we calculate $\Lambda$ and $S$ at $t^* = t^*$ (no new shares, i.e., $N_1 = 0$), we find $\Lambda = N_0/2$ and $S = (N_0/2)(1 - t^*/2)$. Substituting these into the second bracketed term in (19) and simplifying yields 1. Because this term is clearly increasing in $\Lambda/(S+\Lambda)$, and this is increasing in $N_1$ (and thus $t^*$), it is immediate that this term exceeds 1 when new shares are issued and $t^*$ exceeds $t^*$. □

19. Indeed, this condition is more than sufficient; it assumes that all shareholders are informed, but we have just shown that this will not be true and that the actual discount $\Lambda$ on new shares will be less than in the case where everyone is informed.
**Proof of Lemma 5.** As discussed in the text, in order to attract a dollar of deposits from the marginal new shareholder, old shareholders must offer \( R_D \cdot [1 - t' \Delta]^{-1} \) dollars of expected future equity cash flows and private charter value. Since the marginal shareholder determines the market clearing price, and old shareholders need to raise \( K_1 \) dollars, the LHS of (20) is the net amount of future equity value over and above \( R_D \cdot K_1 \) that must be paid to new shareholders. Since new shareholders of type \( t < t' \) value each dollar of future equity value at \( (1 - t \Delta)/R_D \) if they do not gather information, and at a strictly higher amount if they do gather information (from the analysis leading up to (9) in the text), the LHS of (20) is strictly greater than the aggregate value of the new shareholders’ shares, including any costs of gathering information, less the amount that they actually pay for the shares. The lemma then follows from the logic in the text. □

**Proof of Proposition 2.** (i) Since \( a_1 = t^* \), when no new equity is issued, (21) follows by subtracting \( W_S(0) \) (which equals \( R + G + [1 - F(R_D D_0)] \cdot C_S \)) from \( W_S(K_1) \).

(ii) Lemma 4 shows that the second bracketed term in (19) equals one when no new equity is issued; (22) then follows by subtracting \( W_B(0) \) from \( W_B(K_1) \).

(iii) Since \( C_S \geq C_B \), the first term in (21) exceeds the first term in (22). The second term in (22) represents debt overhang and is strictly negative. Finally, by Lemma 5, the second term in (21) is less negative than the sum of the third and fourth terms in (22). □

**Literature Cited**


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