Institutional Liquidity Needs and the Structure of Monitored Finance

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A financial institution that finances and monitors firms learns private information about these firms. When the institution seeks funds to meet its own liquidity needs, it faces adverse selection ("liquidity") costs that increase with the risk of its claims on these firms. The institution can reduce its liquidity costs by holding debt rather than equity. Conversely, except in a limited setting resembling venture capital, firms that depend on monitored finance prefer to give the monitoring institution debt rather than equity. Institutions with less frequent or less severe liquidity needs have greater appetite for equity and for the debt of more risky borrowers. These predictions are consistent with general patterns of monitored finance.

Many financial institutions are delegated monitors, gathering funds from investors and then choosing and monitoring investments on their behalf [Diamond (1984), Ramakrishnan and Thakor (1984), and Boyd and Prescott (1986)]. Consider two consequences. First, if an institution monitors the firms that it invests in, the institution knows more about these firms than do the investors from whom the institution gets its funds. Second, this business of investing "other people's money" means that the institution faces ongoing needs for funds as firms come to it for financing or investors need to withdraw their funds. Failure to meet these "liquidity needs" hurts the institution's business. The institution can try to meet liquidity needs by either selling some of its monitored assets or issuing securities backed by these assets. Either way, the institution's private information about its assets' quality creates an Akerlof (1970) adverse selection or "lemons" problem: the more favorable its information, the less willingly the institution sells securities at a price that reflects average quality. Knowing this, investors discount securities prices, worsening the problem. On average, the institution cannot access the full value of its assets, so some of its liquidity needs go unmet, creating liquidity costs.

This is a substantial revision of an earlier article entitled "Monitored Finance, Liquidity, and Institutional Investment Choice."My research was supported in part by a grant from the Banking Research Center and by a First Chicago Research Chair, both at Northwestern University. I am grateful to John Boyd, Mark Carey, Peter DeMarzo, Doug Diamond, Gary Gorton, David Hirshleifer, Mike Fishman, Mark Flannery, Debbie Lucas, Raghu Rajan, Jaime Zender, and especially to Ravi Jagannathan and Maureen O'Hara (the editors) and two anonymous referees for comments and advice. I would also like to thank seminar participants at the 1997 WFA Meetings, the 1998 AFA Meetings, Boston College, London Business School, London School of Economics, Duke, Indiana, Northwestern, Ohio State, and Washington Universities, and the Universities of Maryland, Minnesota, Illinois, Michigan, Texas, and Washington for their comments. Address correspondence to Andrew Winton, Finance Department, Carlson School of Management, University of Minnesota, 321 19th Ave. S, Minneapolis, MN 55455, or e-mail: awinton@csom.umn.edu.

The Review of Financial Studies Winter 2003 Vol. 16, No. 4, pp. 1273–1313, DOI: 10.1093/rfs/hhg042

In this article, I model these liquidity costs and examine their implications for the asset structure of institutions providing monitored finance. I begin with a simple model of monitored finance. A manager-owned firm needs financing from an institution. After the firm is financed, both the manager and potentially the institution observe a private signal of the firm's prospects. If the signal is good, letting the firm continue operations maximizes contractible cash flows, but if the signal is bad, then liquidating the firm maximizes these cash flows. As per Diamond (1993), the manager receives noncontractible control benefits that are lost if the firm is liquidated. I assume that a policy of never liquidating the firm does not generate enough cash flows for the institution to break even on its initial investment, and I assume that bribing the manager to voluntarily liquidate does not leave enough cash for the institution to break even. It follows that if financing is to be feasible, the institution must have the ability to force liquidation and the incentive to try to observe the private signal ("monitor") so that it exercises control in a judicious fashion.[1]

Although many debt and equity combinations would be optimal in the absence of institutional liquidity needs, such liquidity needs generally make pure debt the optimal financial structure. To see this, suppose that the institution is forced to use its claim on the firm as a source of liquidity. As the institution's exposure to the risk of the firm is greater, the institution's private information about the firm matters more, increasing adverse selection costs. Because a dollar of debt is less exposed to the risk of the firm than is a dollar of equity, pure debt makes the institution's payments as "flat" a function of firm returns as possible, minimizing the adverse selection costs created by the institution's private information. Because the institution must compete for the firm's business in the first place, the institution's preferences get passed through to the manager — structures that reduce the institution's expected liquidity costs lead to a lower financing cost for the firm.

This relative preference for debt over equity depends on the size of the savings in expected liquidity costs. The more frequently that the institution has to use its claim on the firm as a source of liquidity, the more frequently it faces adverse selection costs; thus debt's cost advantage over equity increases. Similarly the greater the risk of the firm, the greater the risk of any claim (debt or equity) that the institution holds, and the greater the expected adverse selection costs that the institution must face; again, debt's cost advantage over equity increases.

[1] There is ample evidence that financial institutions do in fact act as delegated monitors of firms, adopting more or less restrictive policies based on firm performance. Venture capital and other private equity funds typically provide financing in stages, pruning firms that do not meet growth targets; see Sahlman (1990) and Fenn, Liang, and Prowse (1995). Bank lenders perform similar functions: even for firms that have publicly traded stock, a bank's tightening or loosening of loan terms conveys new information about the firm's prospects to market participants; see James (1987) and Lummer and McConnell (1989).

Although liquidity considerations favor debt for the institution's claim on the firm, other factors may favor equity. Suppose that the firm's ex ante expected cash flows are low relative to its liquidation value (ex ante, the firm is worth more "dead" than "alive"). Also, suppose that monitoring is noisy — that is, there is a significant chance that the institution cannot get a clear updated signal of the firm's interim status. If the institution holds only debt, then because it gets all liquidation proceeds and because expected proceeds in continuation are comparatively low, it may liquidate even when it has not obtained new information. By giving the institution more equity and less debt, the manager lowers the institution's claim on liquidation proceeds, softening its desire to liquidate and preserving the manager's control benefits. If this reduction in the loss of control benefits is not outweighed by equity's higher liquidity costs, then the manager may prefer that the institution hold equity. While this set of circumstances is limited in scope, it does match the features of firms that receive venture capital finance, which is one of the few settings in which private equity finance is widely used. I discuss this application in more detail in Section 4.

Although the model focuses on the structure of a financial institution's claim on a single firm, these results have implications for the overall asset structure of financial institutions that serve as delegated monitors. First, if potential liquidity costs are an important consideration, debt should be the predominant type of claim that these institutions hold on the firms which they monitor. Because an institution's private information and consequent liquidity costs are likely to be less significant when it holds claims on firms with easy access to public securities markets, the predominance of debt holdings should be most pronounced for institutions that finance firms with limited market access.

Second, an institution faced with liquidity needs can first use its most liquid assets as a source of financing, turning to less liquid assets only on those less frequent occasions when liquidity needs are especially large. By lowering the fraction of its monitored assets that are equity or high-risk debt, an institution can lower the likelihood that it is forced to draw on these assets as a funding source, allowing it to hold some of these assets without excessive liquidity costs. It follows that, as an institution's liquidity needs are more frequent or severe, it should hold less equity and less high-risk debt in its portfolio.

As detailed in Section 4, stylized evidence is consistent with these predictions. For example, the bulk of private finance takes the form of debt, and institutions that specialize in providing such finance (commercial banks, finance companies, life insurers) hold far more debt than equity. Pension funds and life insurers have longer-term funding and thus less frequent refinancing needs than finance companies and commercial banks; as predicted, pension funds and life insurers hold relatively more equity. Compared to finance companies, commercial banks specialize more in liquidity provision; as predicted, commercial bank loans are less risky than those of finance companies. Larger banks should be better diversified than smaller banks against liquidity shocks from different customers; larger banks do in fact hold relatively more equity.

Other researchers have explored different ways in which a delegated monitor's private information about its assets affects its behavior. The article closest to my own is DeMarzo and Duffie (1999). In their model, an institution with a given asset return distribution initially chooses the type of securities that it will issue to meet subsequent liquidity needs. The institution gets private information about its assets' returns after it chooses its securities' type but before it decides how many of these securities it will issue. The institution usually issues debt so as to minimize adverse selection, but it may issue equity if its liquidity needs are sufficiently severe. Thus DeMarzo and Duffie focus on how an institution's liquidity needs affect its choice of funding structure, taking the institution's asset structure as exogenous. By contrast, my primary focus is how an institution's liquidity needs affect its choice of asset structure. In Section 3, however, I do examine the relative merits of debt and equity funding for the institution.

I also extend DeMarzo and Duffie (1999) by allowing investors to have imperfect information about an institution's liquidity needs. DeMarzo and Duffie assume that the investors to whom an institution goes for funding have perfect knowledge of the institution's liquidity needs. Under standard equilibrium belief refinements, it follows that in equilibrium an institution with liquidity needs seeks strictly less funding from investors as its private information about its assets is more favorable. Thus investors perfectly infer the institution's private information from the amount of funding it seeks — there is a separating equilibrium.

Although my initial analysis in Section 2 follows DeMarzo and Duffie's assumption, in Section 3 I show that, if investors' information about the institution's liquidity needs is noisy, a pooling equilibrium is possible. Essentially, if investors see an institution seek less funding, they are now unsure whether it is an institution with severe liquidity needs and favorable private information about its assets or an institution with less severe liquidity needs and unfavorable asset information that is mimicking the first type. This makes it harder for the first type of institution to separate, and it may instead choose to seek as much funding as possible, pooling with institutions whose private information is unfavorable.

Such pooling reduces expected liquidity costs. Under separation, the immediate liquidity (cash) that institutions get is no greater than the worst possible value of their claim on the firm. By contrast, under pooling, institutions with severe liquidity needs get cash closer to the ex ante expected value of their claim on the firm. Pooling is more likely as the risk of the institution's claim on the firm decreases: lower risk means less difference between the claim's best possible value and its average value, making pooling relatively more attractive to institutions with favorable information. Because debt is less risky than equity, and pooling reduces expected liquidity costs, this reinforces the liquidity advantage of holding debt rather than equity.

A final contrast between my article and DeMarzo and Duffie (1999) concerns the impact of the institution's private information. In their article, improving the precision of the institution's private information about its assets lets the institution make better strategic funding decisions, reducing expected liquidity costs. In my article, improved precision also lets the institution control borrower agency problems more carefully, improving the distribution of returns on the institution's claim on the firm. As I discuss in Section 2, this may increase expected liquidity costs; improved control makes better outcomes more likely, but these are the outcomes for which (ex post) adverse selection costs are highest. Nevertheless, this liquidity effect is usually outweighed by the improvement in the expected value of the institution's claim.

In other related work, DeMarzo (2000) analyzes whether an institution with private information about its assets should issue claims backed by selected assets or by its entire portfolio. Lucas and McDonald (1987, 1992) show that potential lemon problems may lead a bank to hold riskless securities as precautionary reserves. O'Hara (1993) examines the impact of market value accounting on the maturity of bank loans when market values reflect lemons concerns. Stein (1998) examines how banks' private information about loans affects the impact of monetary policy. My article differs from these by focusing on how liquidity concerns affect the structure of the institution's monitored assets, especially the choice between debt and equity and (by implication) the choice between lending to firms of varying risk.

An older literature motivates the prevalence of debt on institutions' balance sheets by invoking costly state verification (CSV). Debt contracts minimize costs of verification [Gale and Hellwig (1985)]. For this reason, an institution that acts as a delegated monitor and is sufficiently diversified across borrowers both issues and holds debt [Williamson (1986), Krasa and Villamil (1992), and Winton (1995)]. This is consistent with the high leverage and high debt holdings of banks, finance companies, and life insurers. Nevertheless, one can arrive at the same prediction using liquidity-based models: my article suggests the institutions' liquidity costs are minimized by holding debt assets, and DeMarzo and Duffie (1999) suggest that these costs are generally minimized by using debt for funding. Moreover, because CSV models abstract from the question of interim changes in agents' needs for funds, these models say nothing about the structure of an institution's assets as a function of an institution's liquidity situation.[2] By contrast, my liquidity-based model predicts cross-sectional variation in institutions' debt and equity holdings based on the institutions' liquidity needs, which can in turn be linked to the institutions' funding structures (hence investor clienteles) and to their provision of liquidity facilities to borrowers.

The rest of the article is organized as follows. Section 1 outlines the basic setting and describes contracting between a firm and an institution when liquidity concerns are not an issue. Section 2 examines how liquidity concerns affect the optimal structure of the institution's claim on the firm. To simplify matters I first assume that investors perfectly observe the institution's liquidity needs, and that the institution meets liquidity needs by issuing equity in its claim on the firm; in Section 3 I relax both assumptions. Section 4 discusses the model's implications, supporting evidence, and avenues for further research.

1. A Simple Model of Monitored Finance

1.1 Assumptions

1.1.1 The firm. A manager owns a firm that operates over three time periods: 0, 1, and 2. At time 0, the firm requires an investment of I dollars. The manager has no other wealth, so she must obtain the necessary funds by issuing claims to outside investors. If the firm continues to operate until time 2, then it either succeeds, yielding a cash flow of $X > I$, or it fails, yielding a cash flow of zero. In either outcome, the value of the firm's other assets is assumed to be zero. If the firm is "liquidated" at time 1, then its assets can be redeployed for L dollars, where $L < I$. If the firm continues to operate through time 2, the manager receives nonpecuniary or otherwise noncontractible [see Diamond (1993)] control benefits that she values at C. If the firm is liquidated, she does not receive these benefits. All else being equal, she will not voluntarily liquidate the firm at time 1 unless she is compensated for losing C.[3]

At time 0, the firm's probability of success is commonly known to be q. At time 1/2 (i.e., after time 0 but before time 1), the manager freely observes whether or not the firm will be successful. Investors can only get updated information on the firm's chance of success by engaging in costly monitoring: at a cost m, a monitoring investor has a chance

[2] Most CSV models imply that institutions should hold only debt. An exception is Boyd and Smith (1999), who show that equity may be part of an optimal financing arrangement when some of a borrower's cash flows are freely observable.

[3] "Liquidation" need not be a Chapter 7 proceeding; it could be a major change in business strategy, replacement of the manager, or sale of the business. The key requirements are that "liquidation" is not optimal ex ante, that it is not to the manager's liking, and that it yields cash flows that are higher and safer than those from allowing a troubled firm to continue on its current course.

$\gamma \in (0, 1)$ of successfully learning what the manager knows, and a chance $1-\gamma$ of learning nothing. The decision to monitor must be made at time 0, and the manager knows whether monitoring has been successful or not.

Monitoring by investors would not be necessary if the manager's incentives never conflicted with those of investors. The next set of assumptions restricts attention to firms where such problems exist.

Assumption 1. *The following conditions hold*:

(i) $(1-q)(L-C)+qX<I$.
(ii) $\max\{qX, L\}<I$.
(iii) $\gamma[(1-q)L+qX]+(1-\gamma)\cdot\max\{qX, L\}-m\geq I$.

These assumptions guarantee an agency problem that can only be overcome by an investor that has control rights and monitors the firm's situation. Expected cash flows are maximized by liquidating the firm when the manager learns that the firm will fail and otherwise allowing the firm to continue and succeed. Assumption 1(i) states that, if the manager were bribed to follow this strategy by getting compensation for her loss of control benefits in liquidation, the firm's residual cash flow would not allow investors to break even on the required investment I. Assumption 1(ii) rules out unmonitored investing, where the firm is either always allowed to continue (yielding expected cash flow qX) or always liquidated (yielding L). Finally, Assumption 1(iii) implies that having one investor monitor and liquidate or continue the firm based on information obtained from monitoring *does* allow investors to break even on the required investment I; implicitly this limits how imprecise monitoring can be (how low γ can be).

1.1.2 Financial institutions. I assume that the manager seeks funding from a financial institution. There are many institutions, each of which has sufficient funds to finance the entire firm. Institutions are risk neutral and initially have zero time preference; in Section 2, I allow for random shocks to time preference ("liquidity needs"). Because monitoring requires a significant cost and is not contractible, only an institution that makes a large investment will monitor. For simplicity, I assume that the manager chooses a single institution to finance the firm by means of a competitive auction.[4] Also, my basic analysis focuses on an institution's claim on one firm in isolation. In Section 4 I discuss how diversification across different firms affects the institution's behavior.

[4] Although having several institutions invest in and monitor the firm might have liquidity benefits — an institution facing a liquidity need could try to sell its stake to an informed party — monitoring efficiency would be undermined by duplication of effort and free rider problems. See Winton (1993) for analysis.

1.1.3 Financing choices. The manager can issue two securities: debt and equity. Debt has priority over equity and specifies a face value D that must be repaid at time 1. If the debt is not repaid, the debt holder has the right to take control of the firm; otherwise the debt is rolled over and must be repaid at time 2. I focus on short-term debt for simplicity; Rajan and Winton (1995) analyze the choice between short-term debt and long-term debt with covenants.

Equity is junior to debt and is specified by the fraction ν of the firm's shares that a shareholder owns. I assume that all shares have equal cash flow rights, but voting rights can be allocated in such a way as to give any one shareholder control of the firm without restriction or cost.[5]

If the institution has control and tries to exercise it, the manager may try to renegotiate via a take-it-or-leave-it offer. It follows that the investor will accept any offer that has at least the same expected value as that which the investor would obtain by exercising control.

1.1.4 Timing of events: review. At time 0, the firm issues D debt and ν shares to an institution in exchange for cash. (Note that if $D=0$, the institution holds pure equity, whereas if $\nu=0$, it holds pure debt.) Next, the institution monitors with some probability α. At time 1/2, the manager observes whether the firm will succeed or fail; if the institution has monitored successfully (probability $\alpha\gamma$), it too observes this. At time 1, the institution may exercise any control rights it has, in which case the manager responds with a take-it-or-leave-it offer. If the firm is liquidated, cash flows are distributed as per contract. Otherwise, the firm continues and succeeds or fails, the manager receives her control benefit, and cash flows are distributed as per contract (which may have been renegotiated). This sequence of events is summarized in Table 1.[6]

1.1.5 Equilibrium. In equilibrium, behavior at time 1 (when control may be exercised) must be optimal for both the institution and the manager, given their information. Given this behavior, the institution's time 0 decision to monitor with probability α must maximize the institution's subsequent returns. Also, because the manager solicits competitive bids, the institution invests an amount equal to the expected value of its claims as of time 0; this amount must weakly exceed I so that the firm's project can be financed. Finally, the manager chooses initial financial structure to maximize her net returns, subject to the constraint that the institution and the manager subsequently behave in an equilibrium fashion.

[5] In previous versions of this article, I assumed one share-one vote and majority rule; this does not change my key results, which focus on cash flow rights rather than the design of control rights per se.

[6] Although having the manager make a take-it-or-leave-it offer gives her all bargaining power in renegotiation, this is not critical to my results. In particular, Section 2's result that institutional liquidity costs favor debt over equity depends only on the fact that, so long as the institution does not receive all possible cash flows, debt is less risky than equity and so faces lower adverse selection costs.

Table 1
Sequence of events in the basic model

• Time 0	Firm needs funds. Manager issues debt, equity to institution. Institution monitors with some probability.
• Time 1/2	If institution has monitored, with probability γ it finds out whether firm will succeed or fail at time 2.
• Time 1	If institution has control, it can liquidate firm. Manager can make counteroffer to try to stop liquidation. If no liquidation, manager gets nonpecuniary control benefit. Otherwise, payments made to institution as per contract.
• Time 2	If not already liquidated, firm succeeds or fails. Payments made to institution as per contract.

I now examine equilibrium behavior. As is standard, I work backward from the last point at which choices must be made, which is time 1.

1.2 The institution's exercise of control rights at time 1

At time 1 the institution holds debt with face value $D \geq 0$ and a fraction $\nu \geq 0$ of the firm's shares. The institution's use of its control rights depends on what it knows about the firm's prospects, which can be summarized by its estimate p of the firm's chance of success. In this model, p has three possible values: if the institution has monitored successfully, it knows whether the firm will fail ($p = 0$) or succeed ($p = 1$), but otherwise it knows only the firm's ex ante probability of success ($p = q$). Let $V(p, \nu, D)$ equal the institution's expected cash flows if it acts optimally given its information p and its financial claims ν and D. Similarly, given p, ν, and D, let $A(p, \nu, D)$ equal $V(p, \nu, D)$ plus the manager's expected cash flows and noncontractible control benefits; henceforth I will refer to $A(p, \nu, D)$ as "total firm value."

Because Assumption 1 implies that *some* monitoring and control are necessary if the firm is to be funded in equilibrium, it immediately follows that either the debt's face value D must exceed zero, or else the institution's equity shares must be given a majority of voting rights. If this were not true, the manager would control the firm's equity, and the institution could not demand repayment of debt at time 1, so the institution would have no means of exercising control. With this in mind, the following lemma outlines how the institution optimally exercises its control rights at time 1 based on its knowledge of the firm's situation.

Lemma 1 (The Institution's Exercise of Control at Time 1). *Suppose that either $D > 0$ or the institution has equity with a majority of voting rights. Consider the institution's time 1 information about the firm.*

(i) If the institution knows that the firm will fail at time 2 ($p = 0$), then the firm is liquidated. Total firm value is $A(0, \nu, D) = L$. The institution's expected cash flows are $V(0, \nu, D) = \min\{L, D + \nu(L - D)\}$.

(ii) *If the institution knows that the firm will succeed at time 2* ($p = 1$), *then any debt is rolled over and the firm is allowed to continue. Total firm value is* $A(1, \nu, D) = X + C$. *The institution's expected cash flows are* $V(1, \nu, D) = D + \nu(X - D)$.

(iii) *If the institution is uninformed* ($p = q$), *then the firm is allowed to continue if* $qX \geq V(0, \nu, D)$ *and liquidated otherwise. Total firm value is* $A(q,\nu,D) = qX + C$ *if* $qX \geq V(0, \nu, D)$, *and* $A(q, \nu, D) = L$ *otherwise. The institution's expected cash flows are* $V(q, \nu, D) = \max\{V(0, \nu, D),\ q \cdot V(1, \nu, D)\}$.

Proof. See the appendix.

The intuition for parts (i) and (ii) of the lemma is as follows. If the institution knows that the firm will certainly fail, no offer that the manager can make will dissuade the institution from taking control (either by refusing to renew debt or by using voting rights) and liquidating. The manager loses her control benefits and the total value of the firm is its liquidation value L. If instead the institution knows that the firm will succeed, threatening to liquidate is never credible, because the firm and thus the institution's claim are certainly worth more if the firm is allowed to continue. The firm produces X in cash flows and C in control benefits.

Part (iii) of the lemma is slightly more complex. If the institution has not monitored successfully ("is uninformed"), it can threaten to liquidate the firm. Because the institution gets $V(0, \nu, D)$ if the firm is liquidated, the manager can forestall liquidation by offering expected payments of $V(0, \nu, D)$. As shown in the appendix, the manager wants to forestall liquidation whenever this is possible, so the firm is allowed to continue whenever unconditional expected cash flows qX exceed $V(0, \nu, D)$ and is liquidated otherwise. If the firm is allowed to continue, it produces qX in expected cash flows plus C in control benefits; if instead the firm is liquidated, it produces L in cash flows. The institution's expected cash flows follow from choosing the better of two options: (a) threaten to liquidate, which gives the institution $V(0, \nu, D)$ regardless of the manager's response, or (b) allow the firm to continue without threatening to liquidate, which gives the institution $V(1, \nu, D)$ with probability q.

Given the results of Lemma 1, it follows that if the institution monitors with probability α and holds ν shares and debt with face value D, then the firm pays the institution an expected amount equal to

$$\begin{aligned} E[V(p, \nu, D)] = {} & \alpha\gamma[(1 - q)V(0, \nu, D) + q \cdot V(1, \nu, D)] \\ & + (1 - \alpha\gamma)\max\{V(0, \nu, D), q \cdot V(1, \nu, D)\}. \end{aligned} \tag{1}$$

With probability $\alpha\gamma$, the institution is fully informed; if the firm fails (probability $1-q$), the institution receives $V(0,\nu,D)$, whereas if the firm succeeds (probability q), the institution receives $V(1,\nu,D)$. With probability $1-\alpha\gamma$, the institution is not informed, and it receives the greater of $V(0,\nu,D)$ and $q \cdot V(1,\nu,D)$.

1.3 Choice of monitoring and financial structure at time 0

Given that it holds D debt and ν equity, the institution chooses its monitoring probability α so as to maximize its expected return, which equals the expected payments it receives, $E[V(p,\nu,D)]$, less expected monitoring costs $m\alpha$. Let $\hat{\alpha}(\nu,D)$ be this maximizing choice of α. In turn, when the manager chooses the firm's initial financial structure (ν,D), she expects monitoring to be incentive compatible, that is, she expects monitoring probability to be $\hat{\alpha}(\nu,D)$. If the institution is indifferent between several values of α, I assume it chooses the value that is best for the manager. Finally, in light of the discussion preceding Lemma 1, in the rest of the article I assume that any financial structure with no debt ($D=0$) gives the institution a majority of voting rights.

Because the manager sells the mix of debt (D) and equity (ν) to an institution via a competitive auction, she raises cash equal to the institution's expected value net of monitoring costs, that is, $E[V(p,\nu,D)]-m\hat{\alpha}$. From this, the manager must spend I on the firm's initial investment. She then runs the firm subject to the institution's monitoring and control as specified in Lemma 1, making expected payments $E[V(p,\nu,D)]$. It follows that the manager's maximization problem is

$$\begin{aligned}
&\max_{\nu,D}\ \hat{\alpha}(\nu,D)\cdot\gamma[(1-q)L+q(X+C)]+[1-\hat{\alpha}(\nu,D)\gamma]\cdot A(q,\nu,D)\\
&\quad -I-m\hat{\alpha}(\nu,D),\\
&\quad \text{subject to } \hat{\alpha}(\nu,D)\in\operatorname{argmax}\{E[V(p,\nu,D)]-m\alpha\}\quad \text{(IC)},\\
&\qquad \text{and}\quad E[V(p,\nu,D)]-m\hat{\alpha}(\nu,D)\geq I\quad \text{(FC)}.
\end{aligned}\tag{2}$$

In the manager's objective function, with probability $\hat{\alpha}\gamma$, the institution monitors successfully and the firm is either liquidated or allowed to continue as detailed in Lemma 1(i) and (ii). With probability $1-\hat{\alpha}\gamma$, the institution is uninformed, and total cash flow plus control benefits are given by $A(q,\nu,D)$ in Lemma 1(iii). The manager raises $E[V(p,\nu,D)]-m\hat{\alpha}$ and pays out I for the initial required investment and $E[V(p,\nu,D)]$ to the institution, so her net payments are $I+m\hat{\alpha}$. (IC) is the institution's monitoring incentive compatibility constraint. (FC) is the firm's financing constraint; because the firm requires at least I in initial funding, the institution must expect to earn at least that much net of its monitoring costs.

Proposition 1 (Optimal Financial Structure Absent Liquidity Concerns). *The solution to the manager's problem* [*Equation* (2)] *is as follows.*

(i) *Whenever the institution is willing to invest I* (*i.e.,* (FC) *holds*), *incentive compatibility* (IC) *requires that the institution monitors as much as possible* ($\hat{\alpha} = 1$).

(ii) *Suppose $qX \geq L$. Then any of the following sets of claims* (ν, D) *are optimal: debt face value $D \geq 0$ and number of shares $\nu \geq \max\{\hat{\nu}(D), 0\}$, where $\hat{\nu}(D)$ satisfies $E[V(p, \nu, D)] = I + m$* when $\hat{\alpha} = 1$.

(iii) *Suppose $qX < L$. Define $\hat{\nu}(D)$ as in* (*ii*).

  (a) *If $\hat{\nu}(0) > qX/L$, then any $D \geq 0$ and $\nu \geq \max\{\hat{\nu}(D), 0\}$ are optimal.*

  (b) *If $\hat{\nu}(0) \leq qX/L$, then any $D \in [0, D^{\max}]$ and $\nu \in [\hat{\nu}(D), (qX - D)/(L - D)]$ are optimal, where $D^{\max} \equiv \{[\gamma q(X - L) + L](qX) - (I + m)L\}/\{qX + \gamma q(X - L) - (I + m)\} \in (0, qX)$.*

Proof. See the appendix.

The intuition for part (i) of the proposition is that, in this setting, the firm's financing constraint (*FC*) implies that the institution's exposure to the risk of excessive continuation by the manager is so large that the institution always benefits from monitoring as much as possible ($\hat{\alpha} = 1$); that is, (IC) is never binding. The only choice left in the manager's objective function is $A(q, \nu, D)$, which equals $qX + C$ if the manager can bribe an uninformed institution into letting the firm continue and L otherwise.

When the firm's ex ante expected cash flows qX exceed its liquidation value L, the manager can always forestall liquidation by an uninformed institution. Moreover, because $qX + C$ exceeds L, the manager prefers such continuation ex ante. Thus the only requirement is that the firm's financial structure meet the financing constraint (FC), and a wide variety of debt-equity mixes are optimal, as shown in part (ii). Since it seems likely that, on an ex ante basis, most firms are worth more "alive" than "dead" (ex ante expected cash flows exceed liquidation values), part (ii) should be the more common case.

Matters are slightly more complex when qX is less than L. It may be that financing needs are so stringent that the payment $V(0, \nu, D)$ that the institution receives in liquidation must exceed qX; if so, an uninformed institution always liquidates, and the manager is indifferent to any financial structure that meets the financing constraint. Otherwise, $V(0, \nu, D)$ can be set at or below qX, allowing continuation when the institution is uninformed. As shown in the appendix, in this case $qX + C$ exceeds L, so the manager prefers such continuation ex ante. This leads her to choose a structure that has relatively less debt and more equity; intuitively, equity gets less in liquidation than debt, softening the institution's desire to liquidate.

Thus, in this basic setting, a wide variety of debt-equity combinations are optimal. The one caveat is that if the firm is (ex ante) worth more "dead" than "alive" — ex ante expected cash flows from unconditional continuation are less than those from liquidation — then the manager may prefer a more equity-oriented structure so as to soften the institution's incentives to liquidate. As I show in the next section, once the institution's liquidity needs are considered, these results change dramatically.

2. The Impact of Institutional Liquidity Needs

I now address how institutional liquidity concerns affect the costs and structure of monitored finance. After outlining a simple model of these liquidity concerns, I show that if the institution is forced to seek funds from uninformed investors while using its claim on the firm as backing, an adverse selection problem arises. The institution knows more than the investors do about the firm's situation, and thus more about the value of the institution's claim on the firm and the value of securities backed by this claim. If the institution always issued as many securities as possible regardless of its private information, then the security price would reflect the ex ante average value of the institution's claim. Rather than issue underpriced securities, an institution that knows its claim has above-average value may prefer to "separate" by issuing a smaller number of these securities at a higher per unit price. Thus when the institution has favorable information and faces a sudden need for funds, it does not access the full value of its claim on the firm. This creates a wedge between the expected payments that the firm makes to the institution and the value of these payments to the institution. Finally, I show that this "liquidity cost" wedge changes the manager's optimal choice of financial structure: because debt minimizes this wedge, in most cases, debt now strictly dominates equity.

2.1 Assumptions

Suppose that, at the interim time 1/2, with probability λ, the institution has a sudden need for funds (liquidity needs). When this occurs, the value of one dollar of time 1/2 cash flows increases to $1 + \beta$ dollars ($\beta > 0$), while the value of one dollar of later cash flows remains one dollar. Although I do not explicitly model where these funds are needed, this could represent a limited-time investment opportunity, a contractual take-down or withdrawal of funds by another customer, or perhaps a full-blown financial crisis. In all cases, failure to raise funds at time 1/2 could lead to either direct losses or opportunity costs for the institution, and β measures the severity of these costs. Also, as discussed below, the liquidity need is large enough that, on the margin, the institution can only meet it by selling its claim on the firm, or by issuing securities backed by this claim.

I begin by assuming that all investors know λ and β and observe whether or not a liquidity need occurs. In practice, investors might be uncertain as to whether the institution has a real liquidity need or exactly how severe the liquidity need is, so in Section 3 I examine the impact of relaxing this assumption. I also assume that investors know the basic structure (ν, D) of the institution's claim. Thus, in this section, the only asymmetric information between the institution and other investors concerns the firm's situation at time 1/2, represented by its conditional chance of success p.

Focusing on liquidity needs that arise after an institution has acquired private information about its assets (at time 1/2), but before the assets produce verifiable returns (at time 1 or 2), captures the information asymmetry between the institution and its investors in a simple way. In reality, the institution would have many assets with varying degrees of information asymmetry on each; nevertheless, because most projects and firms have lives of several years or more, the institution is likely to have private information about most of its monitored assets when it faces liquidity needs.

Because it is critical to this article, the assumption that the institution meets liquidity needs by using its claim on the firm bears further discussion. Although in principal an institution could deal with all liquidity needs by holding a sufficiently large *unencumbered* reserve of cash or risk-free securities, this is likely to prove impractical; as shown by Myers and Rajan (1998), the institution may be tempted to switch these reserves into riskier assets or otherwise misuse them, and its incentive to misbehave increases with the volume of reserves. Unsecured investors will require compensation for this risk. If the institution instead finances the reserves with secured debt (as in a repurchase agreement), the reserves are no longer available as a source of additional liquidity.

As a result, institutions often meet their liquidity needs by selling or securitizing risky assets, issuing unsecured liabilities, or even issuing equity. In all cases, the possibility that the institution has private information about the claims it is selling or issuing opens the door to lemons problems.[7] Although there is undoubtedly a trade-off between these lemons costs and the costs of maintaining unencumbered liquidity reserves, in what follows, I simply assume that λ is the probability of a liquidity need

[7] Adverse selection is not avoided if the institution borrows under an existing line of credit: if the borrowing rate reflects the ex ante average quality of the institution's assets, an institution that is above average will be less willing to borrow (or will borrow less). The pricing of the line should reflect such behavior.

that is high enough to force the institution to either sell monitored assets or issue claims that are backed by such assets. In Section 4 I discuss various factors that affect this probability λ.

If the institution simply sold its claims on the firm, it would lose any control rights over the firm. A new owner could draw inferences on the firm's condition and exercise control appropriately, but there might be some loss of precision. Because this issue is tangential to my article's main thrust, I focus on the situation in which the institution issues new claims backed by its claims on the firm. For simplicity, I begin by assuming that the institution meets any liquidity needs by issuing equity claims on its position in the firm, creating a fraction φ of outside ownership of its combined stake (ν, D). (Note that the outsiders receive an equity claim on the *institution's* asset holdings (ν, D) rather than equity in the *firm*.) In Section 3 I show that issuing debt to meet liquidity needs does not alter my main qualitative results, though it does introduce some complications.

2.2 The institution's liquidity needs and the cost of monitored finance

Because the institution retains its claim on the firm and issues equity, at time 1 its control rights and information about the firm are the same as if it had no liquidity needs. This means that liquidity needs do not directly affect time 1 behavior, so the results detailed in Lemma 1 still hold.

Now consider the situation at time 1/2. As just discussed, the institution may have liquidity needs which it can meet by issuing a fraction φ of outside equity in its position. The institution's choice of how much equity to issue depends on the relationship between the price $P(\varphi)$ it expects to receive, the claim's innate value $V(p, \nu, D)$ given the institution's private information p, and the institution's liquidity situation. Once more, investors know the structure of the institution's claim on the firm and whether the institution has a liquidity need. Assuming that these investors behave competitively, then the equity price that the institution receives equals the investors' valuation of the institution's claim on the firm, which depends on their beliefs about the institution's private information. These beliefs may in turn depend on the amount of equity issued. The choice of how much equity to issue is a signaling game, and equilibrium beliefs must be consistent with the institution's behavior based on its liquidity needs and its information about the firm.

Because at time 1/2 the structure of the institution's claim on the firm is fixed at (ν, D), for simplicity I write $V(p, \nu, D)$ as $V(p)$, and expected payments $E[V(p, \nu, D)]$ as $E[V(p)]$. I refer to an institution that knows the firm will succeed ($p = 1$) as a "good" institution, to an institution that knows the firm will fail ($p = 0$) as "bad," and to an institution that has not monitored successfully ($p = q$) as "uninformed." Investors believe that the institution has monitored with probability α, which in equilibrium must be consistent with the institution's actual monitoring decision at time 0.

As is often true in signaling games, there may be many equilibria, which can be winnowed down by refining the beliefs investor have when faced with out-of-equilibrium behavior. Following DeMarzo and Duffie (1999), I assume that beliefs must satisfy the D1 criterion of Banks and Sobel (1987) and Cho and Kreps (1987), which means that they also satisfy weaker refinements such as the Intuitive Criterion or Divinity. Under D1, buyers that see an out-of-equilibrium equity level φ' focus their beliefs on those institutions that for any price P would benefit most from choosing φ'. This leads to the following result.

Lemma 2 (Institution's Equilibrium Response to Liquidity Needs). *Suppose that the institution has a liquidity need with severity β which it can meet by issuing equity in its claim on the firm, and that investor beliefs satisfy the D1 refinement. Then the unique equilibrium is as follows*:

(i) Based on its innate value $V(p)$, the institution issues a fraction $\varphi(p)$ of equity in its claim, where

$$\varphi(0)=1,\ \varphi(q)=\frac{\beta V(0)}{(1+\beta)V(q)-V(0)},\ \varphi(1)=\frac{\beta\varphi(q)V(q)}{(1+\beta)V(1)-V(q)}, \tag{3}$$

and $\varphi(0)\geq\varphi(q)>\varphi(1)$. The price of the equity is given by $P(\varphi(p))=V(p)$, so the institution receives current and future cash with a total expected value of $[1+\beta\cdot\varphi(p)]V(p)$.

(ii) If $V(q)=V(0)$, then $\varphi(q)=1$.

(iii) If $V(q)=qV(1)$, then $\varphi(1)=\varphi(q)\cdot\beta q/(1+\beta-q)<q\varphi(q)$, and $\varphi(q)<\varphi(0)$.

(iv) If $\beta=0$ (the institution has no liquidity need), then $\varphi(1)=0$; $\varphi(q)=0$ if $V(q)>V(0)$ and 1 otherwise.

Proof. See the appendix.

In this setting, there is perfect separation across "types," so that investors perfectly infer the innate value of the institution's claim on the firm from the amount of equity it issues. The proof follows that of similar results in DeMarzo and Duffie (1999). Essentially, if an institution of "type" p issues equity φ and receives a price $P(\varphi)$, then its total expected value is $(1+\beta)[\varphi P(\varphi)]+(1-\varphi)V(p)$: the institution gets $\varphi P(\varphi)$ of cash now, when it has the liquidity need and values cash at $1+\beta$ per dollar, and retains a fraction $(1-\varphi)$ of its claim, on which it eventually gets its innate value $V(p)$. It follows that, regardless of the equity price they receive, institutions of better type (higher p) always have the most incentive (or least disincentive) to issue less equity. Intuitively the institution most willing to sell equity in its assets at any given price is the one that values its assets least. This "single-crossing" property means that, under D1 beliefs, investors who see an equity issue that is smaller than they had expected believe that the institution's assets have high innate value. This rules out pooling where institutions with different values issue the same amount of equity: the better institution could always issue slightly less equity, be inferred to be the better institution, and thus receive a price equal to its innate value rather than the pooling price.[8]

Because the "bad" institution ($p = 0$) knows that it will be found out in equilibrium, it is best off issuing 100% equity in its claim so as to get maximum liquidity. Also, the equilibrium amount of equity issued by better institutions must be low enough to rule out imitation by worse institutions. The results on $\varphi(p)$ in (i)–(iii) follow immediately. In fact, this separating equilibrium is Pareto optimal among separating equilibria, because it makes the incentive compatibility constraints for better types as loose as possible [see DeMarzo and Duffie (1999)]. When, as in part (iv), the institution has no liquidity need, investors know that the institution would only seek financing so as to get a price in excess of its shares' true value. In equilibrium, only a bad institution is willing to issue any equity, and the equity price is $V(0)$.

The upshot is that, when the institution has liquidity needs, the average amount of immediate cash it gets is less than the expected value of its payments from the firm. Before explicitly calculating the cost of this shortfall, first consider the institution's time 0 opportunity cost of investing a dollar of cash in the firm. If it keeps the cash, with probability λ, it has a liquidity need at time 1/2 and the cash is worth $1+\beta$, and with probability $1-\lambda$, it has no liquidity need and the cash is worth 1. Thus, when evaluating its investment in the firm, the institution's required (gross) rate of return is $1+\lambda\beta$ per dollar invested.

Using the results of Lemma 2, given that the institution holds claims (ν, D) on the firm and monitors with probability α, the institution's expected return is

$$\begin{aligned}
&\lambda[\alpha\gamma(1-q)(1+\beta)V(0)+(1-\alpha\gamma)(1+\beta\varphi(q))V(q)\\
&\quad+\alpha\gamma q(1+\beta\varphi(1))V(1)]+(1-\lambda)E[V(p)]-m\alpha(1+\lambda\beta)\\
&\qquad=\{E[V(p)]-\Lambda-m\alpha\}(1+\lambda\beta),
\end{aligned}\tag{4}$$

where

$$\begin{aligned}
\Lambda &= \Lambda(\alpha,\nu,D)\\
&\equiv \frac{\lambda\beta}{1+\lambda\beta}\cdot[(1-\alpha\gamma)(1-\varphi(q))\cdot V(q)+\alpha\gamma q(1-\varphi(1))\cdot V(1)].
\end{aligned}\tag{5}$$

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[8] Pooling also fails here under weaker refinements, such as the Intuitive Criterion of Cho and Kreps (1987); the proof is available on request.

The left-hand side of Equation (4) comes about as follows. With probability λ, the institution has a liquidity need; based on its information p about the firm's prospects, it issues a fraction of equity $\varphi(p)$, getting a total value of $(1+\beta\cdot\varphi(p))V(p)$. With probability $1-\lambda$, it has no liquidity need and just receives $V(p)$, with expected value $E[V(p)]$. Finally, if it monitors with probability α, the institution expends initial resources $m\alpha$, for an effective cost of $m\alpha(1+\lambda\beta)$. Simple rearrangement leads to the equality in Equation (4).

If investors could freely observe the innate value of the institution's claim on the firm, then whenever the institution had liquidity needs it could issue 100% equity in this claim. Net of monitoring costs, investing in the firm would give the institution an expected value of $\{E[V(p)]-m\alpha\}(1+\lambda\beta)$. Because investors do not observe the innate value of its claim, the institution faces an adverse selection problem, and it only gets $\{E[V(p)]-\Lambda-m\alpha\}(1+\lambda\beta)$. Thus Λ measures expected costs from adverse selection, or "liquidity costs."

When the firm's manager solicits funds from the institution on a competitive basis at time 0, she receives an amount equal to the institution's expected returns discounted at its required rate of return, $1+\lambda\beta$. It follows that the manager receives $E[V(p)]-\Lambda-m\alpha$ from the institution. Because the manager's expected future payments to the institution equal $E[V(p)]$, the next result follows immediately.

Proposition 2 (The Cost of Monitored Finance with Institutional Liquidity Concerns). *When the institution monitors with probability α and has liquidity needs with frequency λ and severity β, the firm's net cost of monitored finance is $\Lambda+m\alpha$.*

In addition to any direct costs $m\alpha$ of monitoring the firm, the institution's liquidity needs and resulting adverse selection drive a wedge Λ between the firm's payments to the institution and the amount the institution is willing to invest. These costs are the critical focus of my article.

Corollary 1 (Behavior of Liquidity Costs)

(i) All else being equal, increases in the frequency λ or severity β of the institution's liquidity needs increase the institution's expected liquidity costs Λ.

(ii) All else being equal, an increase in the downside value of the institution's claim $V(0)$ decreases Λ, while an increase in the upside value of the institution's claim $V(1)$ increases Λ. Thus, if $V(1)$ increases and $V(0)$ decreases so that expected payments to the institution $E[V(p)]$ are unchanged, then Λ increases.

(iii) All else being equal, Λ increases with monitoring intensity α and monitoring precision γ.

(iv) All else being equal, Λ increases with the firm's probability of success q, unless $q^2 > V(0)/V(1) > (1+\beta)/2$. In the latter case, Λ decreases with q if both q and $\alpha\gamma$ are sufficiently close to one.

Proof. See the appendix.

In part (i) of the corollary, more frequent liquidity needs make it more likely that the institution has to issue claims backed by risky monitored assets, which in turn increases the frequency of adverse selection costs. Higher severity means that any adverse selection is more costly to the institution.[9] Part (ii) is also intuitive: anything that increases the spread between best- and worst-case values for the institution's claim increases the scope of potential lemons concerns, and vice versa. (Technically, increases in spread make it harder for good institutions to separate from bad ones: lower $V(0)$ makes it less costly for a bad institution to imitate a good institution by restricting its equity issue, and higher $V(1)$ makes such imitation more attractive.) This implies that a mean-preserving spread of possible outcomes — increasing $V(1)$ and decreasing $V(0)$ while holding expected payments $E[V(p)]$ fixed — increases liquidity costs.

In parts (iii) and (iv), expected liquidity costs increase as the institution monitors more intensively or precisely (α or γ increases) and generally increase as the firm is more likely to succeed (q increases). Such changes make it more likely that the institution's private information is favorable, which is when adverse selection is most severe; higher incidence of severe adverse selection increases expected liquidity costs.[10] Nevertheless, it must be emphasized that increases in α, γ, or q also increase the firm's expected cash flows, and, as shown by Corollary 2 below, the net impact on the institution is typically positive.

The impact of higher "quality" (higher incidence of good outcomes) on expected liquidity costs is accentuated by the nature of the equilibrium here: the fraction of equity $\varphi(p)$ that an institution of type p issues depends on the innate values of different types but not on their relative frequency.[11] In Section 3, I show that if investors do not perfectly observe the institution's liquidity needs, pooling equilibria are possible. In a pooling equilibrium, higher quality tends to increase the price institutions

[9] Higher β also makes it more costly for a bad institution to imitate better ones, so $\varphi(q)$ and $\varphi(1)$ increase; however, as shown in the appendix, the increased cost of any adverse selection more than offsets this.

[10] By contrast, DeMarzo and Duffie (1999) find that a better-informed institution has lower expected liquidity costs; intuitively, the institution can better tailor its funding decision to the true value of its underlying assets. The difference arises because in my model the institution makes use of its information to improve the overall distribution of returns on its claim, increasing the incidence of adverse selection, and this effect outweighs the strategic funding effect noted by DeMarzo and Duffie.

[11] The caveat is that higher q may increase the uninformed institution's value relative to that of the good institution, making it easier for the good institution to separate from the uninformed institution and thus reducing liquidity costs. Although higher q makes adverse selection more costly for the uninformed institution, if $\alpha\gamma$ is close to one, the institution is very likely to be informed and the first effect dominates.

receive when they issue equity, reducing the adverse selection cost for better institutions; this may offset the fact that higher quality still increases the incidence of relatively high adverse selection costs.

2.3 The manager's choice of financial structure at time 0

The final step in the analysis is the manager's time 0 choice of financial structure. As in Section 1, given financial structure (ν, D), the institution chooses its monitoring probability $\hat{\alpha}(\nu, D)$ so as to maximize its expected return $E[V(p)] \equiv E[V(p, \nu, D)]$; knowing this, the manager chooses (ν, D) so as to maximize her own objective function. The main difference is that now the institution's expected return includes liquidity costs $\Lambda = \Lambda(\alpha, \nu, D)$. Because these costs are passed through to the firm, all else being equal, the manager wants to reduce them. As I show, this can be achieved by reducing the risk of the institution's claims (the spread between best- and worst-case outcomes), which is equivalent to using debt.

To establish this result, first consider the manager's objective function. As noted before, liquidity costs do not directly affect the institution's exercise of control rights at time 1, so for any financial structure (ν, D) and monitoring intensity α, the firm's expected cash flows and control benefits are exactly as in Section 1. Proposition 2 showed that the difference between the amount the institution invests and the expected payments it receives from the firm equals $-[\Lambda(\alpha, \nu, D) + m\alpha]$. Finally, the manager has to invest I in funds to start the firm in the first place. Thus the manager's problem can be stated as

$$\begin{aligned}
\max_{\nu, D}\ & \hat{\alpha}(\cdot) \cdot \gamma[(1-q)L + q(X+C)] + [1 - \hat{\alpha}(\cdot) \cdot \gamma] \cdot A(q, \nu, D) \\
& - I - m\hat{\alpha}(\cdot) - \Lambda(\hat{\alpha}(\cdot), \nu, D)), \\
& \text{subject to} \quad \hat{\alpha}(\nu, D) \in \operatorname{argmax}\{\{E[V(p, \nu, D)] - m\alpha \\
& \qquad\qquad - \Lambda(\alpha, \nu, D)\}(1 + \lambda\beta)\} \quad (\mathrm{IC}'), \\
& \qquad\qquad \text{and} \quad E[V(p, \nu, D)] - m\hat{\alpha}(\cdot) - \Lambda(\hat{\alpha}(\cdot), \nu, D)) \geq I \quad (\mathrm{FC}').
\end{aligned} \tag{6}$$

As before, (IC$'$) is the institution's incentive compatibility constraint, while (FC$'$) is the firm's financing constraint (the institution's investment must exceed the firm's required funding I). Both constraints make use of Equations (4) and (5) and Proposition 2, which define the institution's expected returns.

In solving this problem, two definitions are useful. First, recall that $V(1, \nu, D)$ is the payment that the institution gets when the firm succeeds $(p = 1)$. Define $V(1, \nu, D) = V^*$ as the solution to

$$\gamma[qV(1, \nu, D) + (1-q)L] + (1-\gamma)\max\{qV(1), L\} - m - \Lambda^* = I, \tag{7}$$

where Λ^* signifies expected liquidity costs when $\alpha = 1$ and $V(0, \nu, D) = L$. V^* is the level of $V(1, \nu, D)$ that just meets the financing constraint (FC') when the institution monitors as much as possible ($\alpha = 1$) and receives all proceeds L if the firm is liquidated (so that $V(0, \nu, D) = L$).

Similarly, if qX is less than L, define $V(1, \nu, D) = V^0$ as the solution to

$$\gamma[qV(1) + (1 - q)qX] + (1 - \gamma)qX - m - \Lambda^0 = I, \tag{8}$$

where Λ^0 signifies expected liquidity costs when $\alpha = 1$ and $V(0, \nu, D) = qX$. V^0 is the level of $V(1, \nu, D)$ that just meets the financing constraint (FC′) when the institution monitors as much as possible ($\alpha = 1$) and receives only qX in the event of liquidation ($V(0, \nu, D) = qX$). This structure allows the manager to bribe the institution into allowing continuation whenever monitoring is not successful.

Proposition 3 (Optimal Financial Structure with Liquidity Concerns). *When the institution may have interim liquidity needs, the solution to the manager's problem* [*Equation* (6)] *is as follows.*

- *(i)* *Whenever the institution is willing to invest I units* (*i.e.*, (FC′) *holds*), *incentive compatibility* (IC′) *requires that the institution monitors as much as possible* ($\hat{\alpha} = 1$).
- *(ii)* *Suppose that $V^* \leq X$ and any one of the following three conditions holds*: (*a*) $qX \geq L$; (b) $V^0/X > qX/L$; (c) $(1 - \gamma)[qX + C - L] < \Lambda^0 - \Lambda^*$. *Then the optimal set of claims satisfies $V(1, \nu, D) = V^*$ and $V(0, \nu, D) = L$, so a pure debt claim* (*debt level $D = V^*$, number of shares $\nu = 0$*) *is optimal.*
- *(iii)* *Suppose that $V^* \leq X$ and none of conditions* (*a*)–(*c*) *in* (*ii*) *hold. Then the unique optimal set of claims is number of shares $\nu = [V^0 - qX]/[X - L]$ and debt level $D = [qX^2 - V^0 \cdot L]/[X - L - (V^0 - qX)]$.*
- *(iv)* *Suppose that $V^* > X$. Then the firm cannot be financed in equilibrium.*

Proof. See the appendix.

As in Proposition 1, when the financing constraint (FC′) is met, the institution's exposure to the firm is so high that it monitors as much as possible. If the firm's ex ante expected cash flows qX exceed its liquidation value L, then the manager knows that she can always bribe an uninformed institution into allowing continuation. Her objective function becomes $\gamma[q(X + C) + (1 - q)L] + (1 - \gamma)[qX + C] - I - m - \Lambda$, so her goal is to minimize the institution's expected liquidity costs Λ subject to (FC′). From Corollary 1, for any level of expected payments to the institution, liquidity costs are minimized by keeping the spread between $V(0, \nu, D)$ and

$V(1, \nu, D)$ as small as possible. Thus it is optimal to set ν and D so that $V(0, \nu, D)$ is at its highest possible level, which is L, and so that $V(1, \nu, D)$ is at the lowest level that meets (FC′), which is V^*. This is equivalent to giving the institution no shares ($\nu = 0$) and debt with face value $D = V^*$.

Of course, given the firm's simple two-state return distribution, the optimal contract in Proposition 3(ii) can be implemented through other combinations of debt and equity.[12] Nevertheless, with more return realizations, liquidity concerns continue to dictate reducing the spread of the institution's possible outcomes as much as possible. For any expected payment level, debt has the lowest spread of possible outcomes, and so debt should dominate a mix of debt and equity. It is for this reason that I focus on the debt interpretation of the optimal contract.

Suppose instead that qX is less than L (on an unconditional basis, the firm is worth more "dead" than "alive"); then the manager might wish to set the institution's liquidation payment $V(0, \nu, D)$ at no more than qX so that an uninformed institution could be bribed into allowing continuation. When V^0/X exceeds qX/L, this is not feasible; even if the institution holds only equity (putting maximum weight on payments in success), the financing constraint (FC') cannot be met. Since the manager must pay the institution more than qX in liquidation, her only remaining goal is again to minimize liquidity costs. Even if V^0/X does not exceed qX/L, a contract that allows additional continuation is riskier than the contract that minimizes liquidity costs, and the manager may find that the savings in expected liquidity costs $\Lambda^0 - \Lambda^*$ outweigh her expected gains $(1-\gamma)[qX + C - L]$ from additional continuation. This is more likely either when monitoring is sufficiently precise (γ sufficiently close to one) or when the institution's liquidity needs are more frequent or severe (λ or β increases). Once more, the manager chooses claims that minimize liquidity costs.

When none of the conditions in Proposition 3(ii) hold, the manager prefers a structure that emphasizes equity in order to reduce the institution's incentive to liquidate. Unlike Proposition 1(iii)(b), the manager chooses claims so that $V(0, \nu, D)$ just equals qX, that is, she uses as little equity as possible so as to reduce the risk of the institution's claim and thus its expected liquidity costs. From part (ii), this case only occurs when the firm is worth more "dead" than "alive" ($qX < L$), required funding is not too large relative to potential profits (setting $V(0, \nu, D) = qX$ does not violate (FC')), the institution's monitoring precision γ is not too high, and the institution's liquidity needs are not too frequent or severe. As I argue in Section 4, these facts are consistent with a venture capital setting, where equity-debt hybrids are in fact used. Nevertheless, because this set of

[12] Specifically, any debt level $D \in [L, V^*]$ and number of shares $v = (V^* - D)/(X - D)$ is optimal.

circumstances is limited, the rest of my formal analysis focuses on the case where debt is preferred.

Corollary 2 (Comparative Statics on V^*).

(i) The optimal debt face value V^* is increasing in the firm's required investment I, the cost of monitoring m, and the frequency λ and severity β of the institution's liquidity needs. It is decreasing in the firm's liquidation value L and in monitoring precision γ.

(ii) V^* is decreasing in the firm's success probability q when any one of the following conditions holds: (a) $qV^* < L$; (b) $q^2 V^* \geq L$; (c) $I+m-L$ is sufficiently large.

Proof. See the appendix.

Intuitively increases in required investment, monitoring costs, or liquidity costs increase the minimum payment that the institution needs to break even. (Recall from Corollary 1 that higher frequency or severity of liquidity needs increases the institution's liquidity costs.) By contrast, increases in the firm's liquidation value or its likelihood of success reduce necessary payments when the firm succeeds. The one caveat occurs when $I+m-L$ is relatively small. All else being equal, an increase Δq in the firm's chance of success increases expected payments to the institution by $\Delta q(V^* - \gamma L)$, which allows a reduction in V^*. The impact on the institution's liquidity costs, however, is mixed: while the reduction in the spread between V^* and L tends to reduce liquidity costs, higher q tends to directly increase these costs, as per Corollary 1(iv). Although these liquidity effects are typically dominated by the increase in expected payments, when $I+m-L$ is small, $V^* - \gamma L$ is small, and the negative effect of higher q on liquidity costs may dominate, forcing the firm to pay the institution a higher face value to compensate.

Corollary 3 (Equilibrium Liquidity Costs). *Equilibrium liquidity costs Λ^* are increasing in the firm's required investment I, the cost of monitoring m, and the frequency λ and severity β of the institution's liquidity needs. Equilibrium liquidity costs are decreasing in the firm's liquidation value L.*

Proof. See the appendix.

These results follow from Corollary 1 and the formula for Λ. All else being equal, changes that increase V^* increase expected liquidity costs, and changes that decrease V^* decrease these costs. Also, because it is optimal to set $V(0, \nu, D)$ equal to L, an increase in L reduces the spread between the institution's best and worst-case outcomes, decreasing liquidity costs. An increase in λ increases the incidence of liquidity needs, increasing expected liquidity costs.

The effect of an increase in q on equilibrium liquidity costs is more complex. On the one hand, an increase in q tends to increase expected liquidity costs by increasing the incidence of outcomes where adverse selection is more costly. On the other hand, it may decrease V^* and thus the spread between good and bad outcomes, which has an offsetting effect. When q is relatively high, this offsetting effect is likely to dominate, since by Corollary 1 the direct liquidity effect is low or even negative.

To summarize the key results of this section, the institution's liquidity needs and its private information about the firm combine to create a costly adverse selection problem, creating a wedge between the institution's expected return and the expected payments that the firm makes. These liquidity costs increase as the frequency and severity of the institution's liquidity needs increase, as the institution monitors more intensively or precisely, and as the risk of the institution's claim increases. It is generally optimal to minimize expected liquidity costs by reducing the risk of the institution's claim as much as possible, which corresponds to using an all-debt structure. Both the face value of the debt and equilibrium liquidity costs decrease with the liquidation value of the firm; both increase with required investment, monitoring costs, and the frequency and severity of the institution's liquidity needs. As the firm's probability of success increases, the face value of debt generally decreases, whereas equilibrium liquidity costs increase unless the firm's quality is very high to begin with.

3. Institutional Liquidity Needs: Extensions

For simplicity, in Section 2 I assumed that investors perfectly observe the institution's liquidity needs and that the institution meets its liquidity needs by issuing equity rather than debt. In this section I examine the effects of weakening these two assumptions. As mentioned after Corollary 1, if investors cannot perfectly observe the institution's liquidity needs, a higher probability of good outcomes is more likely to decrease the institution's expected liquidity costs. Otherwise, my qualitative results are unchanged. In particular, the institution's expected liquidity costs still increase as the spread between good and bad outcomes increases, making debt more attractive than equity in the institution's asset mix.

3.1 Asset quality, pooling equilibria, and liquidity insurance

I now show that if investors observe the institution's liquidity needs with some noise, pooling equilibria are possible, and these equilibria are more likely both as the probability of good outcomes increases and as the spread between good and bad outcomes decreases. Because pooling equilibria have lower expected liquidity costs than separating equilibria, an increase in the probability of good outcomes may now reduce expected liquidity costs. Pooling equilibria also give the manager another reason to prefer debt over equity: by reducing the spread between good and bad outcomes, debt increases the likelihood that pooling is possible, providing a further reduction in expected liquidity costs.

In a pooling equilibrium, institutions of different quality levels issue the same amount of equity. Because the equilibrium price of equity reflects the average quality of issuers, better institutions subsidize worse institutions, and so better institutions may be tempted to separate by issuing less equity. Separation is easy when investors are perfectly informed about the institution's liquidity needs: for a given level of liquidity needs, the best institutions are always most willing to issue less equity, so even a small reduction in equity issuance signals the best type. On the other hand, better institutions with very severe liquidity needs may not be more willing to issue less equity than worse institutions with less severe liquidity needs. Thus, if investors do not perfectly observe the severity of the institution's liquidity needs, a reduction in equity issuance no longer clearly signals the best institution, and better institutions with severe liquidity needs may be content to pool by issuing the same amount of equity as worse institutions.

To make this explicit, assume that investors receive a public noisy signal of the institution's liquidity needs. The overall probability that an institution is thought to have a liquidity need is $\lambda + \delta$, where δ is between 0 and $1 - \lambda$; with probability λ, the institution truly does have liquidity needs worth $1 + \beta$ per dollar, but with probability δ, it seems to have liquidity needs but in fact does not.[13] Because the signal is public, the institution knows whether investors think it has a liquidity need. Finally, being rational, investors factor the possibility that they are wrong into their beliefs.

Suppose that δ is not large and all institutions that really *do* face liquidity needs issue the maximum amount of equity, that is, $\varphi = 1$ ("full pooling"). For simplicity, I once more write $V(p, \nu, D)$ as $V(p)$. The pooling price P_{pool} is slightly lower than $E[V(p)]$ because the mix of equity issuers is slightly weighted toward below-average institutions. Uninformed and bad institutions that are incorrectly thought to have liquidity needs are glad to issue equity at a price that exceeds their true valuations (respectively, $V(q)$ and $V(0)$), but because P_{pool} must be less than $V(1)$, good institutions without liquidity needs do not issue any equity.

Because a good institution that does have liquidity needs can always choose to issue no equity, a necessary condition for full pooling to be an equilibrium is $(1 + \beta)P_{\text{pool}} > V(1)$; the gains to getting P_{pool} immediately must exceed the value of waiting to collect the claim's full value $V(1)$ later on. Although this condition is necessary, it may not be sufficient; a good institution may be able to credibly signal its claim's true value by issuing an amount of equity φ that is greater than zero but less than one. The next

[13] My analysis extends easily to the case where with probability δ the institution has liquidity needs with severity $\beta' < \beta$; assuming β' is zero simplifies exposition without changing key results.

proposition shows that, given that my model has at most three quality types ($p = 0$, q, or 1), a somewhat stronger condition is required for pooling to survive common belief refinements.

Proposition 4 (Pooling Equilibria). *Suppose that an institution that does not have liquidity needs is thought to have them with probability δ. Consider a pooling equilibrium where investor beliefs satisfy the* D1 *refinement and where all institutions that have liquidity needs issue 100% equity ($\varphi = 1$) in their claim.*

(i) *Suppose $V(0) \geq [\delta/(\delta+\lambda)]V(q)$, which is always true if δ is sufficiently close to zero or if $V(q) = V(0)$. Then this pooling equilibrium exists if and only if $(1+\beta)V(q) > V(1)$, and the pooling price is given by*

$$P_{\text{pool}} = \frac{\lambda E[V(p)] + \delta[\alpha\gamma(1-q)V(0) + (1-\alpha\gamma)V(q)]}{\lambda + \delta[\alpha\gamma(1-q) + (1-\alpha\gamma)]}. \tag{9}$$

(ii) *This pooling equilibrium is more likely to exist as $V(1)$ decreases, $V(0)$ increases, or as the frequency λ or severity β of the institution's real liquidity needs increases. If the noise level δ is sufficiently small, the pooling equilibrium is more likely to exist as the firm's probability of success q increases.*

(iii) *When this pooling equilibrium exists, the institution's expected liquidity costs are given by*

$$\begin{aligned}\bar{\Lambda} &= \frac{\lambda\beta}{1+\lambda\beta} \cdot \{E[V(p)] - P_{\text{pool}}\} \\ &= \frac{\lambda\beta}{1+\lambda\beta} \cdot \frac{\delta\alpha\gamma q}{\lambda + \delta - \delta\alpha\gamma q} \cdot \{V(1) - E[V(p)]\},\end{aligned} \tag{10}$$

which is less than its expected liquidity costs Λ in the separating equilibrium of Lemma 2.

(iv) *All else being equal, $\bar{\Lambda}$ increases if $V(1)$ increases and decreases if $V(0)$ increases. $\bar{\Lambda}$ increases with the severity β of the institution's liquidity needs. $\bar{\Lambda}$ increases with the noise level δ, and goes to zero as δ goes to zero. $\bar{\Lambda}$ increases if the institution's frequency λ of liquidity needs increases while the relative noise level is unchanged (i.e., δ increases in proportion with λ). If q is close to zero, $\bar{\Lambda}$ increases in q; if q is close to one, $\bar{\Lambda}$ decreases in q.*

Proof. See the appendix.

The first condition in (i) guarantees that an uninformed institution without liquidity needs is willing to pool. As noted before, this is always true when the noise level δ is low because the pooling price is close to

$E[V(p)]$, which exceeds $V(q)$. The second condition guarantees that an uninformed institution without liquidity needs is always more willing to reduce the amount of equity it issues than is a good institution with liquidity needs. It follows that, under D1 beliefs, an institution that issues less than 100% equity is viewed as an uninformed institution without liquidity needs, so investors price the equity at $V(q)$. Because $E[V(p)]$ exceeds $V(q)$, the good institution prefers to issue 100% equity and receive the pooling price P_{pool}.[14]

The results in (ii) reflect comparative statics on the conditions in (i). As the spread between good and bad outcomes shrinks, a good institution with liquidity needs gets greater benefit from additional equity than an uninformed institution without liquidity needs. An increase in the severity of liquidity needs has similar effect. So does an increase in the firm's chance of success q, since this weakly increases the uninformed institution's value $V(q)$; the caveat is that the uninformed institution must still be willing to pool if it does not have liquidity needs.[15]

In the pooling equilibrium, any institution with liquidity needs gets P_{pool} in immediate cash. By contrast, in the separating equilibrium from Lemma 2, the bad institution with liquidity needs gets only $V(0)$ in immediate cash, and all other types get strictly less, since otherwise the bad institution would want to imitate them. Because P_{pool} exceeds $V(0)$, part (iii) follows: compared to separation, pooling gives the institution more immediate liquidity and thus lower expected liquidity costs. Essentially pooling provides liquidity insurance. If in equilibrium *all* types issued 100% equity, investors would pay $E[V(p)]$, and on average there would be *no* liquidity cost. Since good institutions without liquidity needs never issue equity, the pooling price is less than $E[V(p)]$, but it still dominates average liquidity under separation.

The results in part (iv) are comparative statics on the liquidity "shortfall" $E[V(p)] - P_{\text{pool}}$. As $V(1)$ increases, average payments $E[V(p)]$ increase by a lesser amount, so $V(1)$ is farther from $E[V(p)]$; thus the absence of some good institutions from the pool of equity issuers has relatively more impact, increasing the liquidity shortfall. An increase in $V(0)$ has the opposite effect. These two results imply that, as in Corollary 1,

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[14] If the first condition in (i) fails, pooling exists if $(1+\beta)V(0) > V(1)$ (a bad institution without liquidity needs is more willing to reduce equity issuance than a good institution with liquidity needs). Also, even when "full" pooling fails, partial pooling of bad and uninformed institutions with liquidity needs may be possible.

[15] Pooling is actually easier to support in the more realistic case where the institution's claim has a greater number of possible values. Full pooling requires both that (a) the best type of institution with liquidity needs prefers getting P_{pool} now over collecting its true value $V(1)$ later, and that (b) it is difficult for the best institution to separate itself from worse institutions that have less severe liquidity needs but are willing to pool. With fewer types, (b) is more binding; the best type that is willing to pool when it does not have severe liquidity needs has innate value strictly less than P_{pool}. As there are more types, (b) becomes less binding, and in the limit converges to condition (a). The proof is available on request.

expected liquidity costs increase if the spread $V(1) - V(0)$ increases while $E[V(p)]$ is unchanged.

As the noise level δ decreases and it is less likely that the institution is incorrectly perceived to have liquidity needs, there is less adverse selection and the pooling price is closer to $E[V(p)]$. If the institution's liquidity needs are more frequent and the relative accuracy of investors' perceptions is unchanged (λ and δ increase in proportion), expected liquidity costs increase; the institution is more likely to need funding, but the degree of adverse selection that it faces when it does seek funding is unchanged.

An increase in the firm's probability of success q has two effects on liquidity costs, which can be seen most clearly in the final formula for $\bar{\Lambda}$ in Equation (10). Because better institutions without liquidity needs do not pool, the shortfall in liquidity is proportional both to the difference in values between the good institution and the average institution, $V(1) - E[V(p)]$, and to the frequency of good institutions without liquidity needs relative to all other institutions perceived to have liquidity needs, $\delta\alpha\gamma q/(\lambda + \delta - \delta\alpha\gamma q)$. As q increases, average value increases and $V(1) - E[V(p)]$ decreases, but the incidence of adverse selection $\delta\alpha\gamma q/(\lambda + \delta - \delta\alpha\gamma q)$ increases. When q is small, the second effect dominates; when q is high, the first effect dominates.

In sum, if the severity of the institution's liquidity needs is not perfectly observable, pooling is possible when the institution's claim is not too risky or has sufficiently high quality. Because pooling reduces expected liquidity costs, the firm's manager has even more incentive to reduce the risk of the institution's claim, reinforcing the dominance of debt over equity. As before, higher liquidation value allows the spread between good and bad outcomes to be reduced further, decreasing liquidity costs; similarly, more frequent institutional liquidity needs increase expected liquidity costs. By contrast, it is now more likely that the relationship between the claim's quality (probability of good outcomes) and liquidity costs is hump-shaped: at low quality levels, separation dominates and increases in quality increase liquidity costs; at higher levels, partial pooling may occur, reducing these costs; finally, further increases in quality increase both the degree of pooling and the pooling price, offsetting the increased incidence of adverse selection for better types.

3.2 Issuing debt to meet liquidity needs

In DeMarzo and Duffie (1999), an institution may be able to reduce its expected liquidity costs by issuing debt rather than equity. I now show that, in my model, issuing debt may reduce but does not eliminate liquidity costs, and it may exacerbate agency problems between the institution and its investors.

For simplicity, assume that investors perfectly observe the institution's liquidity needs, and that the institution meets these needs by issuing debt with a face value F that matures at date 2. For simplicity I continue to write $V(p, \nu, D)$ as $V(p)$. Consider the actions of good and bad institutions in isolation. In any equilibrium with D1 beliefs, a good institution never issues debt with face value F greater than $V(0)$. Suppose instead that it does choose such an F. A bad institution always seeks to pool, because under separation the good institution's debt is worth F, whereas the bad institution's debt is worth at most $V(0)$. On the other hand, pooling at F above $V(0)$ is not an equilibrium. Such pooled debt has some chance of loss, so it is priced at less than its face value, giving the good institution (whose debt is really riskless) some desire to separate. Because a reduction in face value helps the good institution more than the bad institution, a slight reduction signals the good institution, giving it more immediate liquidity.[16] The upshot is that any F greater than $V(0)$ signals the bad institution and is valued at $V(0)$ regardless.

If the institution were perfectly informed ($\alpha = \gamma = 1$), then in equilibrium both good and bad institutions would issue riskless debt with face value $V(0)$. Since the good institution would only receive $V(0)$ in immediate funds rather than its full value $V(1)$, expected liquidity costs would equal $[\lambda\beta/(1 + \lambda\beta)]$ times $q[V(1) - V(0)]$. These costs are in fact lower than expected liquidity costs as γ goes to one under the equity-issuance equilibrium of Lemma 2, where the good institution receives strictly less than $V(0)$ in immediate funds so as to separate itself from the bad institution. Otherwise, the key results of Section 2 would be unchanged. Liquidity costs would increase with the frequency and severity of the institution's liquidity needs. Liquidity costs would also increase with the spread $V(1) - V(0)$ between good and bad outcomes, so it would still be optimal to have the institution hold debt and no equity in order to minimize liquidity costs. Holding debt rather than equity would increase $V(0)$, increasing the amount of low-risk, low adverse selection debt that the institution could issue.

Nevertheless, the institution may not be perfectly informed: monitoring precision γ is less than one, and the institution may choose monitoring intensity α less than one. This introduces two complications. First, debt funding biases an uninformed institution in favor of letting the firm continue even when this does not maximize overall cash flows; because continuation is riskier than liquidation, the institution gets greater potential upside while leaving debt holders with much of the downside. Such "risk-shifting" effects may also undermine the institution's incentive to monitor in the first place. Second, even if risk shifting is not an issue, an

[16] If both institutions pool at $F > V(0)$, their debt is priced at $(1 - q)V(0) + qF < F$. Lowering F by $\Delta F < F - V(0)$ reduces the good institution's payments to debt holders by ΔF but does not reduce the bad one's payments (it pays $V(0)$ regardless). Thus, under D1 beliefs, lowering F signals the good institution, and pooling breaks down: a small reduction ΔF lets it issue debt valued at $F - \Delta F$ rather than $(1 - q)V(0) + qF$.

uninformed institution that *optimally* lets the firm continue still defaults if the firm subsequently fails. If the institution's debt has face value $V(0)$, an uninformed institution's debt is worth *less* than that of a bad institution. Pooling at debt face value $V(0)$ is no longer supported by D1 beliefs, because both good and bad institutions prefer to separate from the uninformed institution by issuing debt with lower face value; indeed, since equity's price is never less than $V(0)$, the bad institution is actually better off issuing equity.

Thus, although issuing debt to meet liquidity needs may reduce the institution's liquidity costs, it may create other problems. Because issuing debt does not change my model's key qualitative results, my analysis has focused on the simpler case where the institution issues equity to meet its liquidity needs.

4. Conclusion

My model shows that institutions that finance firms with limited public market access face costly adverse selection problems when they need additional funds — liquidity costs. Because these costs increase with the risk of an institution's claim on the firm, these institutions should generally prefer to hold debt rather than equity. Even if an institution holds debt, liquidity costs increase with the risk of the borrowing firm and with the frequency and severity of the institution's liquidity needs. In this concluding section I discuss the empirical implications of these results, present some supporting evidence, and outline further avenues for research.

4.1 Overall preference for debt versus equity

The institutional preference for debt over equity should be most marked for firms with limited public market access, because here the gap between what the institution knows and what its own investors know is likely to be largest. This can be seen in two ways: through the composition of privately held financing from institutions (which largely goes to smaller or mid-size firms), and through the asset composition of institutions that specialize in financing such firms.

Privately held financing in the United States is in fact dominated by debt: Fenn, Liang, and Prowse (1995) estimate that private equity held by institutional investors totaled \$100 billion in 1994, whereas evidence from the *Flow of Funds* report [Federal Reserve (1997)] suggests that private corporate debt (also largely provided by institutions) was more than \$2 trillion.[17] Similarly the U.S. institutions that provide most of the

[17] Specifically, \$760 billion in bank loans, \$275 billion in net finance company loans, \$330 billion in privately placed bonds, and \$670 billion in commercial mortgages. Total privately placed bonds in

financing to firms with limited public market access — commercial banks, life insurers, and finance companies — hold much more debt than equity. Although regulations restricting shareholdings of banks and insurers undoubtedly play a role, finance companies are unregulated and also prefer debt: from the 1994 *Flow of Funds*, 75% of finance company assets are mortgages, loans, or leases, and the balance sheets of GMAC and GE Capital Services (two of the largest finance companies) suggest that few of the remaining assets are equity.[18]

Further supporting evidence comes from Germany. Here, although regulations historically placed few limits on shareholdings of banks and insurers, these institutions hold far more debt than equity.[19] Moreover, the equity that German banks hold is concentrated in large, actively traded firms, where information asymmetries are likely to be lowest: Saunders and Walters (1994) report that in 1989, banks held only 0.6% of all industrial firm's shares, but roughly 5% of the top 100 firms' shares. Note that, among banks in developed economies, Germany's are near the top for the ratio of shareholdings to total assets. Santos (1998) shows that, in 1995, only Switzerland's banks had a higher ratio, with shareholdings at 4.9% of total bank assets versus Germany's 4.8%.

4.2 Features of firms with private equity finance

Proposition 3(iii) outlines a limited set of conditions under which private equity finance is preferred. In fact, these conditions are characteristic of firms that receive venture capital financing, which is one of the few settings where institutional private equity investment is common. Venture capital target firms are typically start-ups with high but risky growth potential: returns are highly skewed, with a large chance of poor performance but a small chance of very strong returns [see Fenn, Liang, and Prowse (1995) and Sahlman (1990)]. Thus, in terms of the model, ex ante expected cash flows are low relative to liquidation value ($qX < L$), and targets require careful monitoring and frequent termination if the institution is to have any chance of positive expected profits. Because targets are usually in new industries or product lines, even careful monitoring may leave the venture capitalist facing significant business uncertainty (γ is not

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1994 were estimated by multiplying 1994 life insurer holdings [American Council of Life Insurance (1995)] by the 1992 ratio of total privately placed bonds [Carey et al. (1993)] to life insurer holdings. All other figures are from the *Flow of Funds* [Federal Reserve (1997)].

[18] For restrictions on bank and insurer equity holdings, see Carey et al. (1993), Roe (1994), Fenn, Liang, and Prowse (1995), and James (1995). In 1994, GE Capital Services reported \$2 billion in equity investments, \$29 billion in debt investments, and \$76 billion in net financing receivables; GMAC reported \$0.5 billion in equity investments, \$3.5 billion in debt investments, and \$55 billion net in financing receivables.

[19] In 1995, German banks had 4.8% of their assets in equities and participation rights versus 57.4% in loans to nonbanks. Life insurers had 9.5% of investment assets in shares or direct real estate holdings versus 14.0% in bonds and 63.8% in loans. See Santos (1998) and OECD (2000).

high). Consistent with Proposition 3(iii), venture capital financing typically takes the form of common or convertible preferred stock rather than pure debt.[20] Also, venture capital funds are financed by limited partners who are given strictly limited rights of redemption; this reduces the frequency with which the fund faces liquidity needs, reducing the liquidity costs of holding equity rather than debt.

4.3 Cross-sectional differences among institutional portfolios

My model predicts that the liquidity cost advantage of debt over equity is greater as the institution's liquidity needs are more frequent or more severe (λ or β increases). This leads to some simple predictions about cross-sectional differences in institutional holdings. An institution faced with liquidity needs of given size can first use its most liquid assets as a source of financing, turning to less liquid assets only on those less frequent occasions when liquidity needs are especially large. Thus, the smaller the fraction of its monitored assets that are most risky and information sensitive, the lower the probability that the institution is *forced* to draw on these particular assets for liquidity, lowering the λ that *these* assets face. Conversely, an institution that faces more frequent or severe liquidity needs should hold relatively less equity.

The equity holdings of U.S. pension funds, life insurers, and commercial banks offer a test of this prediction. Pension funds have long-term liabilities that allow little early redemption, so they face relatively limited liquidity needs. Life insurers also have long-term liabilities, but these generally allow some early redemption via surrender clauses and policy loans; thus insurers have more exposure to liquidity needs via customer withdrawals than do pension funds. Commercial banks are at the other extreme: they offer borrowers liquidity insurance via credit lines and letters of credit; a large part of their funding consists of transaction accounts such as demand and (redeemable) savings deposits which provide liquidity services; and much of their remaining funding has maturities of less than two weeks (Federal funds and short-term Eurodollar deposits). Thus banks should have the highest exposure to liquidity needs. Equity holdings follow the predicted pattern, with pension funds holding the most equity and banks the least.[21]

A similar pattern may apply to the risk of an institution's debt holdings. From Corollary 3, the debt of firms with a greater spread between required investment and bad outcomes (in my model, I and L) is more

[20] Equity finance also reduces the entrepreneur's incentives for risk shifting, which may be a big concern given the uncertain environment and high chance of failure these firms face. See Gompers (1993).

[21] In 1994, private pension funds held 41% of their assets in shares, life insurers 14%, and commercial banks less than 1%; also, private pension funds held 1% of their assets in private equity, life insurers 0.4%, and commercial banks 0.3%. [Assets and shareholdings are from the *Flow of Funds*, Federal Reserve (1997); private equity holdings from Fenn, Liang, and Prowse (1995).]

risky, increasing liquidity costs for their lenders; again, this cost differential increases as the institution's liquidity needs are more frequent or severe. A comparison of U.S. commercial banks and finance companies is consistent with this prediction. Although both provide short- or intermediate-term financing to borrowers, finance companies are less exposed to liquidity needs: they offer relatively few credit lines, they do not offer transaction accounts for investors, and only a quarter of their funding is short term [mostly commercial paper; see, e.g., Federal Reserve (2000)]. Given their less frequent liquidity needs, my model predicts that finance companies should have a greater appetite for riskier loans. In fact, finance companies have a higher ratio of loans/assets than banks, and Carey, Post, and Sharpe (1998) find that, controlling for borrower size and information availability, finance company loans are riskier than bank loans.

Finally, to the extent that investor or borrower liquidity needs are not perfectly correlated, it may be possible to diversify away some of the risk that liquidity needs are large as a fraction of the institution's total assets. If so, then all else being equal, larger institutions should face lower λ and thus have a greater appetite for equity.[22] There is some evidence of this pattern. For example, Edwards and Fischer (1994) report that, in 1975, the three biggest banks of Germany accounted for 41% of all German bank shareholdings, while in 1980 these banks accounted for only 12.5% of all nonmortgage loans [and 10% of all bank assets, according to Saunders and Walters (1994)]. Similarly Fenn, Liang, and Prowse (1995) report that the largest institutions account for the vast majority of U.S. institutional holdings of private equity. Santos (1998) finds that, in Germany, Switzerland, and Japan, the fraction of assets that are shares or equity participations are higher for large banks than for all banks.[23]

4.4 Avenues for further research

Looking ahead, the link between an institution's funding structure and liquidity needs can be modeled more explicitly. In particular, funding structure is partly driven by the need to control moral hazard on the institution's part. As shown by Calomiris and Kahn (1991), Flannery (1994), and Diamond and Rajan (2001), the use of short-term or demandable funding provides a liquidity threat that can help discipline the institution, so an institution with largely long-term financing might have weaker

[22] Subrahmanyam (1991) and Gorton and Pennacchi (1993) argue that increased size may also create liquidity benefits through improved *asset* diversification: if an institution uses more assets to back securities it issues, the securities are less sensitive to the institution's private information about any one asset, reducing adverse selection. On the other hand, DeMarzo (2000) shows that an institution may prefer to issue claims against separate assets rather than issuing claims against its overall portfolio in order to have greater flexibility in choosing which assets to use as collateral.

[23] In Germany in 1995, large banks had 6.3% of assets in shares and participations, versus 4.8% for all banks. For Japan, the numbers are 6.0% versus 4.6%; for Switzerland, 5.2% versus 4.9%.

monitoring incentives. Moreover, to the extent investor withdrawals are prompted by poor performance, there may be a negative correlation between liquidity needs and an institution's asset quality, as per Chari and Jagannathan (1988). Incorporating these issues should yield richer insights into institutional structure.

Appendix: Proofs of Results in the Text

Proof of Lemma 1. (i) $p=0$. The institution knows that it will receive nothing if it lets the firm continue and $\min\{L, D+\nu(L-D)\}$ if it forces liquidation, so it forces liquidation. Control benefits are destroyed, so total firm value $A(0,\nu,D)$ is L.

(ii) $p=1$. The institution gets $D+\nu(X-D)$ if it lets the firm continue and $\min\{L, D+\nu(L-D)\}$ if it forces liquidation. Because $X>L$, it lets the firm continue, producing X in cash flows and C in control benefits.

(iii) $p=q$. If the institution liquidates, then it gets cash flows of $\min\{L, D+\nu(L-D)\}=V(0,\nu,D)$. The manager can forestall liquidation by offering a new set of claims with expected cash flows equal to $V(0,\nu,D)$. This is feasible whenever $qX\geq V(0,\nu,D)$. (Note that expected cash flows use the institution's information.)

Below, I prove that the manager always wants to forestall liquidation whenever $qX\geq V(0,\nu,D)$. Thus, if $qX\geq V(0,\nu,D)$, the firm is allowed to continue, producing qX in expected cash flows and C in control benefits; $A(q,\nu,D)=qX+C$. If $qX<V(0,\nu,D)$, the institution liquidates the firm, and $A(q,\nu,D)=L$. If the institution threatens to liquidate, it gets expected cash flows of $V(0,\nu,D)$ regardless of whether liquidation occurs or the manager forestalls it. If the institution does not threaten to liquidate, it gets $V(1,\nu,D)$ with probability q. The institution chooses its best option, so $V(q,\nu,D)=\max\{V(0,\nu,D),\ q\cdot V(1,\nu,D)\}$.

To show that the manager always wants to forestall liquidation whenever $qX\geq V(0,\nu,D)$, I first claim that $C>L-V(0,\nu,D)$. To see this, note that the institution must break even on its investment and monitoring costs. Even if it had perfect information ($\gamma=1$), it would get $qV(1,\nu,D)+(1-q)V(0,\nu,D)$, so this must exceed I. Because $V(1,\nu,D)\leq X$, this implies that $(1-q)V(0,\nu,D)>I-qX$. But Assumption 1(i) implies that $(1-q)(L-C)<I-qX$, so $L-C<V(0,\nu,D)$, which proves the claim.

Suppose that the manager knows that the firm will succeed. To forestall liquidation, the manager must offer the institution a payment of $V(0,\nu,D)/q$ conditional on the firm succeeding, so she receives $X+C-[V(0,\nu,D)/q]$. If instead the manager lets liquidation occur, she receives $L-V(0,\nu,D)$. She prefers the offer iff $q(X+C-L)\geq(1-q)V(0,\nu,D)$. From the claim, $q(C-L)>-q\cdot V(0,\nu,D)$, and $qX\geq V(0,\nu,D)$ by assumption, so $q(X+C-L)>(1-q)V(0,\nu,D)$ and she strictly prefers the offer.

Now suppose that the manager knows that the firm will fail. If she makes an offer that is accepted, the firm eventually fails, so she pays nothing and receives C in control benefits. If she does not make the offer, she receives $L-V(0,\nu,D)$. The claim shows that she prefers to make the offer. (Because a manager who knows that her firm will fail can always imitate any offer made by a manager who knows that her firm will succeed, the second type of manager cannot separate and signal her true knowledge.) ■

Proof of Proposition 1. (i) For brevity, I write $V(p,\nu,D)$ as $V(p)$ and $E[V(p,\nu,D)]$ as $E[V(p)]$. If $\hat{\alpha}<1$, (IC) requires that $m=\partial E[V(p)]/\partial\alpha=\gamma[(1-q)V(1)+qV(1)-V(q)]$. Because $E[V(p)]=V(q)+\hat{\alpha}\cdot\{\partial E[V(p)]/\partial\alpha\}$, the institution's expected return is $V(q)+\hat{\alpha}\cdot\{\partial E[V(p)]/\partial\alpha\}-m\hat{\alpha}=V(q)<I$, violating the financing constraint (FC). Thus, whenever (FC) holds, $\gamma[(1-q)V(0)+qV(1)-V(q)]>m$, and (IC) implies $\hat{\alpha}=1$.

(ii) By (i), $\hat{\alpha}=1$ when (FC) holds, and (FC) is equivalent to $E[V(p)]-m \geq I$. By Lemma 1 (iii), because $qX \geq L \geq V(0)$, $A(q,\nu,D)=qX+C$, so the manager's objective function is constant whenever (FC) holds. Thus, for any $D \geq 0$, any ν that meets (FC) is optimal, giving the desired result.

(iii) By (i), $\hat{\alpha}=1$. If $qX<L$, then $V(0)=\min\{L, D+\nu(L-D)\}>q[\nu(X-D)+D]=qV(1)$ for all (ν,D). If $\hat{\nu}(0)>qX/L$, then at $D=0$, any equity share ν that meets (FC) is such that $qX<\nu L=V(0)$; by Lemma 1 (iii), $A(q,\nu,0)=L$. It is easy to show that $V(0,\hat{\nu}(D),D)$ increases in D. Thus any (ν,D) that meets (FC) must have $qX<V(0)$. The manager's objective function is constant subject to (FC), giving the desired result.

If $\hat{\nu}(0) \leq qX/L$, it is possible to have $V(0) \leq qX$ and meet (FC). From Assumption 1(i), $(1-q)(L-C)<I-qX$. By (FC), $I+m \leq (1-\gamma q)V(0)+\gamma qV(1)<(1-q)V(0)+qX$, so $(1-q)V(0)>I-qX$. Thus $V(0)>L-C$ and so $qX>L-C$ and the manager prefers $A(q,\nu,D)=qX+C$ to $A(q,\nu,D)=L$. Because her objective is otherwise constant, she prefers any (ν,D) that satisfies both (FC) and $V(0) \leq qX$. For any $D<L$, $\nu=(qX-D)/(L-D)$ is the ν for which $V(0,\nu,D)=qX$. $D^{\max}$ is the D such that $(\nu,D)=((qX-D)/(L-D),D)$ just meets (FC); straightforward algebra yields the formula in the proposition. ■

Proof of Lemma 2. I continue to write $V(p,\nu,D)$ as $V(p)$. As discussed in the text, if "type" p issues φ equity at price $P(\varphi)$, its total expected return is $(1+\beta)[\varphi P(\varphi)]+(1-\varphi)V(p)$. If it instead issues equity $\varphi'<\varphi$ with price $P(\varphi')$, its change in profits is $(1+\beta)[\varphi' P(\varphi')-\varphi P(\varphi)]+(\varphi-\varphi')V(p)$, which is increasing in $V(p)$ and thus p.

> ***Claim.*** *In equilibrium, $\varphi(p)$ and $\varphi(p)P[\varphi(p)]$ are both weakly decreasing in p.*
>
> *Proof of Claim.* Consider $p>p'$, and let $\varphi(p)\equiv\varphi$, $\varphi(p')\equiv\varphi'$. In equilibrium, p cannot gain by switching to φ', so $(1+\beta)[\varphi' P(\varphi')-\varphi P(\varphi)]+(\varphi-\varphi')V(p)\leq 0$. Also, p' cannot gain by switching to φ, so $(1+\beta)[\varphi P(\varphi)-\varphi' P(\varphi')]+(\varphi'-\varphi)V(p')\leq 0$. Adding gives $(\varphi-\varphi')[V(p)-V(p')]\leq 0$, so $\varphi\leq\varphi'$. This and $(1+\beta)[\varphi P(\varphi)-\varphi' P(\varphi')]+(\varphi'-\varphi)V(p')\leq 0$ imply that $\varphi' P(\varphi')-\varphi P(\varphi)\leq 0$. ■
>
> ***Claim.*** *In equilibrium, types with different values $V(p)$ do not issue the same amount of equity.*
>
> *Proof of Claim.* Suppose two types p', p'' pool at some φ'', and p' has the highest value among types that issue φ''. Because the change in profits from switching from φ'' to $\varphi'<\varphi''$ is increasing in p, any price $P(\varphi')$ that weakly tempts p'' to switch strictly tempts p' to switch. Moreover, if there are worse types that are supposed to issue more than φ'' in equilibrium, these types have even less incentive to switch to φ'. Thus, if an institution issues $\varphi'<\varphi''$, investors with D1 beliefs think that the institution is either p' or an even higher type, and so $P(\varphi')\geq V(p')$. $P(\varphi'')$ is the average value of the types that pool at φ'', so $P(\varphi'')<V(p')\leq P(\varphi')$. Thus, for φ' sufficiently close to φ'', p' will switch, and the pooling equilibrium breaks down. ■

(i) Because institutions with different values issue different equity amounts, investors price $\varphi(p)$ at $P[\varphi(p)]=V(p)$. If $\varphi(0)<1$, then the bad institution's expected return is $(1+\beta)\varphi V(0)+(1-\varphi)V(0)$. Because $V(0)$ is the lowest rational price, switching to $\varphi'=1$ gives it at least $(1+\beta)V(0)$, which is greater. Thus $\varphi(0)=1$.

Next, define $\varphi'\leq 1$ as follows: if $P(\varphi')=V(q)$, the bad institution is indifferent between issuing 1 and issuing φ', that is, $(1+\beta)[\varphi' V(q)-1\cdot V(0)]+(1-\varphi')V(0)=0$. Solving for φ' gives the expression for $\varphi(q)$ in the statement of the lemma. If the uninformed institution $(p=q)$ issues more than φ' in equilibrium, the bad one imitates it. If it issues less, it is easy to show that, for any possible price, increasing the equity issue to an amount that is still less than φ' always benefits the uninformed institution more than the bad one. Under D1 beliefs, this signals the uninformed institution or better and gets a price of at least $V(q)$, so the change gives the uninformed institution more liquidity, making it preferable. Thus, $\varphi(q) = \varphi'$ is the only possible equilibrium choice for the uninformed institution under D1 beliefs.

Finally, define φ'' as the issue amount for which the uninformed institution is indifferent between issuing $\varphi(q)$ at price $V(q)$ and issuing φ'' at price $V(1)$. This leads to the expression for $\varphi(1) = \varphi''$ given in the statement of the lemma. A similar line of argument shows that φ'' is the only possible equilibrium choice for the good institution ($p = 1$). The rest of part (*i*) follows easily.

(ii) This is intuitive; it also follows from substituting $V(q) = V(0)$ into the expression for $\varphi(q)$.

(iii) Because $V(q) = qV(1) > V(0)$, it is immediate that $\varphi(q) < 1 = \varphi(0)$. Substituting for $V(q)$ in the expression for $\varphi(1)$ gives $\varphi(1) = \varphi(q) \cdot \beta q/(1 + \beta - q)$; because $\beta < 1 + \beta - q$, $\varphi(1) < q\varphi(q)$.

(iv) This follows by letting β go to zero in the expressions for $\varphi(1)$ and $\varphi(q)$. ■

Proof of Corollary 1. Let $T \equiv \lambda\beta/(1 + \lambda\beta)$. Again, I write $V(p, \nu, D)$ as $V(p)$. (i) Note that T is increasing in λ and β, which immediately shows that Λ is increasing in λ. For the result on β, first consider the case where $V(q) = V(0)$, so that, from Equation (5), $\Lambda = T \cdot [\alpha\gamma qV(1)][1 - \varphi(1)]$. It follows that

$$\frac{\partial\Lambda}{\partial\beta} = \alpha\gamma qV(1) \cdot \frac{\lambda}{1 + \lambda\beta} \cdot \left[\frac{1 - \varphi(1)}{1 + \lambda\beta} - \frac{\partial\varphi(1)}{\partial\beta} \cdot \beta\right] \equiv \alpha\gamma qV(1) \cdot \frac{\lambda}{1 + \lambda\beta} \cdot a(\beta). \qquad \text{(A1)}$$

$a(\beta)$ is clearly decreasing in λ. Substitution shows that $a(\beta)$ is in fact positive at $\lambda = 1$. Thus $\partial\Lambda/\partial\beta > 0$.

When $V(q) = qV(1)$, $\partial\Lambda/\partial\beta$ is the sum of two terms, one being the right-hand side of Equation (A1), the other being $(1 - \alpha\gamma)qV(1) \cdot \lambda/(1 + \lambda\beta)$ times $a^*(\beta)$, where $a^*(\beta)$ is $a(\beta)$ with $\varphi(1)$ replaced by $\varphi(q)$. Similar logic shows that $a^*(\beta) > 0$, and $a(\beta) > [\beta q/(1 + \beta - q)] \cdot a^*(\beta) > 0$. Once more, $\partial\Lambda/\partial\beta > 0$.

(ii) Because $\varphi(q)$ and $\varphi(1)$ are weakly increasing in $V(0)$, $\partial\Lambda/\partial V(0)$ is negative. Because $\varphi(q)$ and $\varphi(1)$ are weakly decreasing in $V(1)$, $\partial\Lambda/\partial V(1)$ is positive. The rest of (ii) follows easily.

(iii) Note that $\varphi(1)$ and $\varphi(q)$ are independent of α and γ. When $V(q) = V(0)$, $\partial\Lambda/\partial\alpha$ is proportional to $1 - \varphi(1) > 0$. When $V(q) = qV(1)$, $\partial\Lambda/\partial\alpha$ is proportional to $\varphi(q) - \varphi(1) > 0$. Thus Λ is increasing in α. Similar steps show that Λ is increasing in γ.

(iv) When $V(q) = V(0)$, $\varphi(1)$ is independent of q, so Λ is clearly increasing in q. When $V(q) = qV(1)$, $\partial\Lambda/\partial q$ equals $T \cdot V(1)$ times

$$1 - \left[1 - \alpha\gamma + \alpha\gamma \cdot \frac{\beta q}{1 + \beta - q}\right] \cdot \varphi(q) - (1 - \alpha\gamma)q \cdot \frac{\partial\varphi(q)}{\partial q} - \alpha\gamma q \cdot \frac{\partial\varphi(1)}{\partial q}. \qquad \text{(A2)}$$

The sum of the first two terms is positive. Because $\partial\varphi(q)/\partial q < 0$, the third term is positive. Thus a sufficient condition for $\partial\Lambda/\partial q > 0$ is that $\partial\varphi(1)/\partial q \leq 0$. It can be shown that $\partial\varphi(1)/\partial q$ is proportional to $q^2V(1) - V(0)$, so $\partial\varphi(1)/\partial q \leq 0$ if and only if $q^2 \leq V(0)/V(1)$. If this does hold, $\partial\Lambda/\partial q > 0$.

Suppose instead that $q^2 > V(0)/V(1)$, ruling out $qV(1) \leq V(0)$. It can be shown that Equation (A2) decreases in α and γ if $V(0)[2(1 + \beta) - q] < (1 + \beta)^2 qV(1)$. Because $q^2 > V(0)/V(1)$, $qV(1) > V(0)/q$, so $V(0)[2(1 + \beta) - q] \leq (1 + \beta)^2 V(0)/q$ is sufficient for Equation (A2) to decrease in α and γ. This condition is equivalent to $(1 + \beta - q)^2 \geq 0$, which always holds. Thus $q^2 > V(0)/V(1)$ implies that if Equation (A2) is positive at $\alpha = \gamma = 1$, it is positive for $\alpha\gamma < 1$ as well. It can also be shown that at $\alpha = \gamma = 1$, Equation (A2) decreases in q. At $q = 1$,

$\varphi(1) = \varphi(q)$, and Equation (A2) becomes

$$1 - \frac{(1+\beta)V(0)}{(1+\beta)V(1) - V(0)} + \beta \cdot \left[\frac{V(0)}{(1+\beta)V(1) - V(0)}\right]^2. \tag{A3}$$

Let $z = \varphi(1)/\beta$; Equation (A3) equals $(1-z)(1-\beta z)$. Because $\beta z < 1$, Equation (A3) ≥ 0 iff $z \leq 1$, so $\partial\Lambda/\partial q \geq 0$ for all $\alpha, \gamma \leq 1$ and $q \leq 1$ if $z \leq 1$, which is equivalent to $2V(0) \leq (1+\beta)V(1)$. Thus $\partial\Lambda/\partial q < 0$ requires $V(0)/V(1) > (1+\beta)/2$, giving the other condition in (iv). When both conditions hold, $\partial\Lambda/\partial q$ is decreasing in α, γ, and q, and it is negative at $\alpha = \gamma = q = 1$. ■

Proof of Proposition 3. Let $T \equiv \lambda\beta/(1+\lambda\beta)$. Again, I write $V(p, \nu, D)$ as $V(p)$. (i) $E[V(p)] = \alpha\partial E[V(p)]/\partial\alpha + V(q)$, and $\Lambda = \alpha(\partial\Lambda/\partial\alpha) + T \cdot [1 - \varphi(q)] \cdot V(q)$. If $\hat{\alpha} < 1$, then (IC′) implies $\partial E[V(p)]/\partial\alpha - \partial\Lambda/\partial\alpha - m = 0$. But then $E[V(p)] - \Lambda - m \cdot \hat{\alpha} = V(q) - T \cdot [1 - \varphi(q)] \cdot V(q) < V(q) < I$, violating (FC′). Thus (FC′) implies $\hat{\alpha} = 1$.

(ii) If (*FC′*) holds, the manager's objective function is $\gamma[(1-q)L + q(X+C)] + (1-\gamma) \cdot A(q, \nu, D) - I - m - \Lambda$. If (a) holds, $A(q, \nu, D) = qX + C$. If (b) holds, then as in Proposition 1 (iii)(a) it is not feasible to meet (FC′) and bribe an uninformed institution into allowing continuation, so $A(q, \nu, D) = L$. In either case, the manager's objective is to minimize Λ subject to (FC′). By Corollary 1(ii), for any $V(1)$, Λ is minimized by making $V(0)$ as large as possible, that is, $V(0) = L$. Similarly, for any $V(0)$, Λ is minimized by making $V(1)$ as small as possible subject to (FC′). Thus it is optimal to set $V(0) = L$ and $V(1)$ such that (FC′) holds with equality, which defines V^*. If (c) holds, then the manager prefers this structure over the structure that minimizes liquidity costs subject to $V(0) = qX$ as well as (FC′). Finally, $\nu = 0$ and $D = V^*$ gives $V(0) = L$ and $V(1) = V^*$.

(iii) If none of the conditions in (ii) hold, then the manager maximizes $A(q, \nu, D)$ by setting $V(0) = qX$; subject to this, $V(1) = V^0$ meets (FC′) and minimizes liquidity costs; and the manager prefers this over the structure from (ii). Solving $V(0) = qX$ and $V(1) = V^0$ for D and ν yields the formulas in the text.

(iv) If $V^* > X$, no structure (ν, D) can meet (FC′), even if it minimizes liquidity costs. ■

Proof of Corollary 2. Let $T \equiv \lambda\beta/(1+\lambda\beta)$. (i) Equation (6) is equivalent to $F \equiv \gamma[qV^* + (1-q)L] + (1-\gamma) \cdot \max\{qV^*, L\} - I - m - \Lambda^* = 0$. By the Implicit Function Theorem, for any parameter y, $dV^*/dy = -(\partial F/\partial y)/(\partial F/\partial V^*)$. If $qV^* < L, \partial F/\partial V^* = \gamma q - [\partial\Lambda^*/\partial V^*] = \gamma q \cdot \{1 - T \cdot [1 + \varphi(1)^2/\beta]\} = \gamma q \cdot (1+\lambda\beta)^{-1} \cdot [1 - \lambda\varphi(1)^2] > 0$. If $qV^* \geq L, \partial F/\partial V^* = q - [\partial\Lambda^*/\partial V^*]$. $\partial\Lambda^*/\partial V^* < q \cdot T \cdot [1 + \varphi(q)^2/\beta]$, and so $\partial F/\partial V^* > q \cdot (1+\lambda\beta)^{-1}\,[1 - \lambda\varphi(q)^2] > 0$. It follows that $sgn\ dV^*/dy = sgn(-\partial F/\partial y)$.

F is decreasing in I and m. By Corollary 1(i), Λ is increasing in λ and β, so F is decreasing in λ and β. Thus V^* increases in I, m, λ, and β. Λ^* decreases in L, so F increases in L and V^* decreases in L.

If $qV^* < L, \partial F/\partial\gamma = q(V^* - L) - qV^* \cdot T \cdot [1 - \varphi(1)] > 0$, because the second term equals $q(V^* - L)$ times $[(\lambda + \lambda\beta)/(1+\lambda\beta)][\beta V^*]/[(1+\beta)V^* - L]$, which is less than 1. If $qV^* \geq L, \partial F/\partial\gamma = (1-q)L - \partial\Lambda^*/\partial\gamma$. $\partial\Lambda^*/\partial\gamma = T \cdot [qV^* \cdot \varphi(q)]\{1 - [\beta q/(1+\beta-q)]\}$. Because $1 - [\beta q/(1+\beta-q)] = (1-q)(1+\beta)/(1+\beta-q)$, and $qV^* \cdot \varphi(q) < L \cdot \varphi(0) = L, \partial\Lambda^*/\partial\gamma < (1-q)L \cdot [(\lambda+\lambda\beta)/(1+\lambda\beta)][\beta/(1+\beta-q)] < (1-q)L$. Again, $\partial F/\partial\gamma > 0$, so V^* decreases in γ.

(ii) V^* decreases in q iff $\partial F/\partial q > 0$. If $qV^* < L, \partial F/\partial q = \gamma(V^* - L) - \Lambda^*/q = (I + m - L)/q > 0$, where the second equality follows from $F = 0$; this proves (a).

If $qV^* \geq L, \partial F/\partial q = V^* - \gamma L - \partial\Lambda^*/\partial q = (1-\gamma)H + \gamma K$, where

$$H = V^*\left\{1 - \frac{\lambda\beta}{1+\lambda\beta} \cdot \left[1 - \varphi(q) - q\frac{\partial\varphi(q)}{\partial q}\right]\right\},$$
$$K = V^* - L - \frac{\lambda\beta}{1+\lambda\beta}V^*\left[1 - \varphi(1) - q\frac{\partial\varphi(1)}{\partial q}\right]. \tag{A4}$$

$H = V^*(1+\lambda\beta)^{-1}[1-\lambda\varphi(q)^2] > 0$. If $q^2V^* \geq L, \partial\varphi(1)/\partial q \geq 0$, and $K > 0$ if $V^* - L - T\cdot V^*[1-\varphi(1)] \geq 0$. The last condition is the same as $[1+\lambda\beta\cdot\varphi(1)]V^* \geq (1+\lambda\beta)$L. Incentive compatibility for issuing equity implies that $[1-\varphi(1)]V^* + (1+\beta)\varphi(1)V^* > (1+\beta)L$, and $V^* > L$; adding λ times the first inequality plus $(1-\lambda)$ times the second yields the desired condition. Thus, $q^2V^* \geq L$ implies $\partial F/\partial q > 0$, proving (b).

If $qV^* \geq L > q^2V^*, \partial F/\partial q = V^* - \gamma L - \Lambda^*/q + T\cdot qV^*\cdot G$, where $G = (1-\gamma)[\partial\varphi(q)/\partial q] + \gamma[\partial\varphi(1)/\partial q]$. $F = 0$ implies $V^* - \gamma L - \Lambda^*/q = [I + m - \gamma L]/q > 0$, so $\partial F/\partial q > 0$ is equivalent to $I + m - L > (\gamma - 1)L + T\cdot qV^*\cdot[-qG] \equiv B(\gamma).L > q^2V^*$ implies $\partial\varphi(1)/\partial q < 0$, so $-\partial G/\partial\gamma > \partial\varphi(q)/\partial q$, and $\partial B(\gamma)/\partial\gamma > L - T\cdot qV^*\cdot[\partial\varphi(q)/\partial q].T\cdot qV^*\cdot[\partial\varphi(q)/\partial q] = [qV^*\varphi(q)]\cdot[(\lambda+\lambda\beta)/(1+\lambda\beta)]\cdot\beta qV^*/[(1+\beta)qV^* - L] < L$, because $qV^*\varphi(q) < L$. Thus $\partial B(\gamma)/\partial\gamma > 0$, so $I + m - L > B(1) = -T\cdot qV^*\cdot[\partial\varphi(1)/\partial q] > 0$ implies $\partial F/\partial q > 0$. ∎

Proof of Corollary 3. Again, I write $V(p,\nu,D)$ as $V(p)$. Λ^* increases with $V(1) = V^*$, so increasing I or m increases V^* (by Corollary 2) and thus increases equilibrium liquidity costs. Similarly, increasing L decreases V^* and increases $V(0) = L$, decreasing equilibrium liquidity costs. Increasing λ or β increases Λ^* both directly through $T = \lambda\beta/(1+\lambda\beta)$ and indirectly by increasing V^*. ∎

Proof of Proposition 4. Again, I write $V(p,\nu,D)$ as $V(p)$. (i) Suppose this pooling equilibrium exists. As noted in the text, a good institution ($p = 1$) without liquidity needs never pools. Suppose an uninformed institution without liquidity needs is willing to pool. Equation (9) for the pooling price P_{pool} is just the average value across the types that pool: institutions that really have liquidity needs (average value $E[V(p)]$, probability λ), and uninformed or bad institutions that are erroneously thought to have liquidity needs (probabilities $\delta(1-\alpha\gamma)$ and $\delta\alpha\gamma(1-q)$, respectively).

An uninformed institution without liquidity needs will pool if and only if $V(q) \leq P_{\text{pool}}$. If $V(q) = V(0)$, then $V(q) \leq P_{\text{pool}}$ because $V(0) < P_{\text{pool}}$, and $V(0) \geq [\delta/(\delta+\lambda)]V(q)$. If $V(q) = qV(1), E[V(p)] = \alpha\gamma(1-q)V(0) + V(q)$; substituting into $V(q) \leq P_{\text{pool}}$ and rearranging gives $V(0) \geq [\delta/(\delta+\lambda)]V(q)$.

Pooling also requires that a good institution with liquidity needs cannot gain by issuing equity $\varphi < 1$. If it issues φ, its change in profits is $(1+\beta)[\varphi P(\varphi) - P_{\text{pool}}] + (1-\varphi)V(1)$. If an uninformed institution without liquidity needs issues φ, its change in profits is $[\varphi P(\varphi) - P_{\text{pool}}] + (1-\varphi)V(q)$. Thus, if $V(q) \geq V(1)/(1+\beta)$, then for any price $P(\varphi)$ such that the good institution prefers to switch, the uninformed institution prefers to switch. Under D1, $P(\varphi) = V(q) \leq P_{\text{pool}}$, and so the good institution prefer to pool rather than switch. If $V(q) < V(1)/(1+\beta)$, the opposite is true; under D1, by issuing $\varphi < 1$, the good institution signals its type, receiving $P(\varphi) = V(1) > P_{\text{pool}}$. For φ close to one, the good institution prefers this to pooling, and so pooling fails.

(ii) The two conditions for pooling are (a) $V(0) \geq [\delta/(\delta+\lambda)]V(q)$ and (b) $(1+\beta)V(q) \geq V(1)$. It is easy to verify that these conditions are always weakly more likely as $V(0)$, λ, or β increases or as $V(1)$ decreases. Next, note that $V(q) < V(1)$, so (a) holds if $V(0) \geq [\delta/(\delta+\lambda)]V(1)$, which holds for δ small. In this case, increasing q does not affect (a) and weakly increases $V(q)$, making (b) more likely.

(iii) In the pooling equilibrium, the institution's expected return equals

$$\begin{aligned}
&\lambda(1+\beta)P_{\text{pool}} + \delta[\alpha\gamma(1-q) + (1-\alpha\gamma)]P_{\text{pool}} + \delta\alpha\gamma qV(1) \\
&\quad + [1-(\lambda+\delta)]\cdot E[V(p)] - (1+\lambda\beta)m\alpha \\
&\qquad = \lambda\beta\cdot P_{\text{pool}} + E[V(p)] - (1+\lambda\beta)m\alpha \equiv (1+\lambda\beta)\{E[V(p)] - \bar{\Lambda} - m\alpha\}, \qquad \text{(A5)}
\end{aligned}$$

where the first equality follows by substituting for P_{pool} from Equation (9). Equation (10) in the text follows easily. $\bar{\Lambda} < \Lambda$ follows from the argument given in the text after the statement of the proposition.

(iv) Substituting for $V(1) - E[V(p)]$ in Equation (10) quickly yields the results on $V(1)$ and $V(0)$. The results on δ are also straightforward from Equation (10).

$\partial\bar{\Lambda}/\partial q$ is proportional to $(\lambda+\delta)[V(1) - E[V(p)]] - (\lambda+\delta-\delta\alpha\gamma q)\cdot q\cdot[\partial E[V(p)]/\partial q]$. When q is close to zero, $V(q) = V(0), V(1) - E[V(p)] = (1-\alpha\gamma q)[V(1) - V(0)]$, $q\cdot[\partial E[V(p)]/\partial q] = \alpha\gamma q[V(1) - V(0)]$, and $1-\alpha\gamma q > \alpha\gamma q$, so $\partial\bar{\Lambda}/\partial q$ is positive. When q is close to one, $V(q) = qV(1)$, $V(1) - E[V(p)] = (1-q)[V(1) - \alpha\gamma V(0)]$, and $q\cdot[\partial E[V(p)]/\partial q] = q[V(1) - \alpha\gamma V(0)]$, so $\partial\bar{\Lambda}/\partial q$ is negative for q sufficiently close to one. (If q is high and δ is not too small, an uninformed institution without liquidity needs may no longer pool; however, using the new pooling price, one can still show that liquidity costs decrease in q for q close to one.) ■

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