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Getting the Right Mix of Capital and Cash Requirements in Prudential Bank Regulation*

by Charles W. Calomiris, Columbia Business School

In the context of banking regulation, liquidity requirements have traditionally focused on the minimum proportion of banks' assets held in cash assets (though with varying definitions of cash). More recently, under the Basel III system, liquidity requirements have been broadened to include limits on the *composition* of assets and liabilities that take into account the risk of funding illiquidity—that is, the possibility that a bank's debt will not be rolled over, and that its liquid assets and cash flow will not be sufficient to fund the repayment of those debts at low cost. In other words, Basel III is aimed at reducing the liquidity risk that is created by banks' traditional combination of short-term debts and longer-term, illiquid assets. The problem, however, is that by attempting to reduce banks' liquidity risk, Basel III is also likely to interfere with the production of liquidity by banks, which is generally seen by economists as one of the core functions of the banking system. Furthermore, I will show that the current regulatory focus on limiting bank liquidity risk may distract regulators from broader and more important objectives that motivate a different approach to liquidity regulation. To what extent should liquidity regulation try to limit the longstanding role of banks in creating liquidity? If this is not the main purpose of liquidity regulation, what should it try to do instead, and how?

This article considers the arguments for liquidity requirements from the perspective of both finance theory and the history of banking, and considers the proper role of such requirements alongside capital requirements and the lender of last resort (LOLR). From a theoretical perspective, the central challenge is to explain why a combination of prudential capital requirements and an LOLR that provides assistance to banks is not sufficient—in the absence of liquidity requirements—to address all legitimate regulatory concerns.

Under the simplifying assumptions of the Black-Scholes-Merton framework, which informs many corporate and regulatory discussions of risk management, there is no need for liquidity requirements or the creation of an LOLR to assist banks. But in that framework there is also no need for banks to produce liquidity, or to do anything else, since all assets are assumed to be perfectly liquid. Indeed, in such a "frictionless" world, the simplest way of controlling the default risk of banks is to prohibit banks from issuing any debt, as one economist recently proposed.[1] But in the presence of real-world frictions—particularly information and incentive problems that I discuss below—it is easy to show that 100-percent equity financing is far from optimal. In a world where bank debt finance and bank liquidity creation are necessary for banks to play their role in helping corporate borrowers maximize their value, prudential regulation seeks to control the default risk of banks. Such default risk arises from three sources: the fundamental risk of a bank's assets; the leveraging of that fundamental risk; and the funding illiquidity risk faced by the bank's combination of short-term debts and longer-term illiquid assets. I will show that, in a realistic environment that is fraught with information and incentive problems, regulating banks' liquidity can play an important role alongside equity capital requirements and a LOLR in controlling default risk.

Three kinds of frictions motivate the use of liquidity requirements in controlling default risk: the physical costs of liquidating assets; the adverse-selection costs associated with investing in assets that stem from "asymmetric" information; and the moral hazard (or "incentive") costs associated with risk management. Each of these three kinds of frictions—which I hereafter refer to as the "key frictions" of the financial system—has implications for the relative strengths of capital requirements, liquidity requirements, and LOLR assistance in the control of bank default risk.

Considering the theoretical foundations of liquidity requirements from this perspective can lead to some surprising conclusions. In particular, contrary to popular belief, funding illiquidity risk is not the exclusive, or even the primary, motive for regulating the liquidity of banks. During the recent financial crisis, funding illiquidity problems associated with debtholders' unwillingness to roll over money market instruments—notably, asset-backed commercial paper, interbank deposits and repos—made illiquidity risk a topic of great interest to bankers and policy makers. It is true that liquidity requirements traditionally have been used as part of the solution to address problems

1. See Laurence J. Kotlikoff, *Jimmy Stewart Is Dead: Ending the World's Ongoing Financial Plague with Limited Purpose Banking,* John Wiley & Sons (2010.)

of funding illiquidity in banks—and rightly so, since such requirements can help to limit crisis-related costs of systemic illiquidity. But it does not follow that systemic funding illiquidity risk is the primary reason for liquidity regulation of banks.

In theory, the existence of funding illiquidity risk is neither a necessary nor a sufficient condition to motivate liquidity requirements. Funding illiquidity risk is not a necessary condition because there are other legitimate, and possibly more important, reasons related to the "key frictions" of finance to impose liquidity requirements on banks. Second, funding illiquidity risk generally does not arise in circumstances where default risk is zero. Indeed, the heightened counterparty risks that were associated with the collapse of interbank deposit and repo markets during the financial crisis of September 2008 were the direct consequence of persistent and large losses that reduced banks' true capital ratios (as perceived by the market) to near zero. A focus on keeping default risk low will also limit funding illiquidity risk.

Rather than focus narrowly on funding illiquidity risk when designing liquidity requirements, regulators should consider the tradeoffs among capital requirements, liquidity requirements, and LOLR policies for achieving the broad prudential objective of controlling bank default risk. An understanding of the tradeoffs among capital requirements, LOLR policies, and liquidity requirements for achieving that broader objective is the starting point for designing proper liquidity requirements.

Each of the three primary financial policy instruments (capital requirements, liquidity requirements and the LOLR) suffers from limitations in addressing the challenges for controlling bank default risk that arise from the three key frictions of finance. Only when the strengths and deficiencies of each of the policy instruments are considered together is it possible to identify the optimal combination of the three instruments that should be used in financial policy. An exploration of the deficiencies of each instrument explains why all three are necessary for a properly functioning banking system.

In the pages that follow, I start by identifying the origins of the regulatory problems inherent in managing bank default risk, all of which can be traced to frictions in financial markets that are absent in the Black-Scholes-Merton framework for thinking about the measurement and management of default risk. Second, I provide a brief review of the three key frictions of finance that motivate the use of liquidity requirements, as well as capital requirements and an LOLR. Third, after evaluating the strengths and weaknesses of each of these three regulatory instruments in limiting the effects of these frictions on the safety of the financial system, I conclude that a combination of the three, based on a fairly simple set of rules, provides the most effective protection while preserving banks' proper incentives and ability to make loans. The fourth section provides some empirical evidence in support of my conclusion in the form of a brief history of past U.S. reliance on liquid assets to manage and regulate default risk.

Regulating Default Risk, With and Without Financial Frictions

The focus of prudential regulatory policy is controlling bank default risk. As noted earlier, default risk on bank debt reflects three components of the bank's balance sheet structure: the riskiness of the assets of the bank (the "sigma of assets" in the Black-Scholes-Merton formulation); the leverage of the bank (as measured by the ratio of debt to equity finance); and the maturity structure of bank debts and assets, which together with asset risk and leverage also determine the funding illiquidity risk (sometimes called the maturity transformation risk) of the bank. Prudential regulation is concerned with targeting the default risk arising from these three components, and especially with ensuring that default risk remains sufficiently low.

That is not to say that prudential regulation is, or should be, designed with the single-minded objective of minimizing default risk. That objective could be accomplished easily just by requiring banks to finance themselves with 100% equity (where there is no debt, there can be no default) or, as advocates of so-called "narrow banking" have proposed, by requiring that banks hold only cash as assets (where there is no asset risk, there can be no default). But, of course, neither of those regulatory policies would be desirable because both would prevent banks from performing their primary intermediation function of lending.

Banks earn "quasi rents," or profits in excess of compensation for risk, by investing in building relationships with borrowers. Banks recover the cost of building those relationships through loan spreads that compensate them for playing the role of informed lender, or "delegated monitor." A bank that cannot raise debt finance will find its cost of intermediation rising dramatically, and will have to curtail its relationship formation as well as the lending it provides to existing clients. A bank that holds only cash cannot lend, and therefore cannot provide the essential banking functions of screening would-be borrowers, contracting with them, monitoring their behavior, and enforcing loan contracts. And nor, of course, can such a bank earn the expected "quasi rents" from lending in a competitive market.

Making banks into narrow cash-holding repositories would not abolish lending; instead it would encourage bankers to shift their "delegated monitoring" function to "shadow" banks that operate outside the reach of regulators and rely on alternative sources of funds. Among the most common examples are the "finance companies" that look much like banks and whose main business is funding information-intensive loans with short-term money market instruments, mainly commercial paper.

Requiring banks to finance entirely with equity would be a similarly draconian policy that would also shift lending to

the shadow banking system. Since the origins of banking in Greece in the 6th century B.C., most of banks' financing—that is, in addition to their capital base—has taken the form of short-term debt. According to finance theorists, two financing frictions have driven this preference for debt finance, both of which have to do with "asymmetric information." The first friction arises *ex ante*, or at the time of loan origination in the bank's lending activities. Bankers presumably have a better sense of the prospective payoff structure of their loan portfolios than do those who fund their lending. For that reason, their costs of funding are lower when they raise funds in the form of senior claims like short-term debt. The second friction arises *ex post*, or after the loans have been originated. Loan outcomes (repayment or default) cannot be costlessly verified by the bank's funding sources, and thus equity finance will entail large costs of discovering outcomes and making them observable to third parties (who will enforce the distribution of cash flows to equity holders).[2]

Furthermore, if banks can behave opportunistically to take advantage of the inability of funding sources to observe banks' risks or loan losses, then short-term debt may be particularly desirable as a form of debt finance, either as a means of limiting ex post opportunism or as a means of giving bank executives stronger incentives for better risk management.[3] In sum, bank contracting theory views the maturity transformation of banks, and the funding illiquidity risk that arises because of it, as an efficient response by banks and their investors to information and agency problems between banks and their funding sources.

But that is not to say that funding illiquidity risk—arising from banks' short-term debt financing—is without major costs. In theory, funding illiquidity risk can arise for two reasons: bank funding sources may need to withdraw funds to meet their own needs for cash, or depositors may withdraw funds in response to concerns about insolvency risk. In practice, the latter is by far the more important source of withdrawal risk. Large, sudden withdrawals often reflect increasing asymmetric information about bank default risk during financial crises.[4]

Given the dependence of banks on short-term debt, and their exposure to default risk and illiquidity risk, what combination of prudential tools—liquid assets and capital—will work best in managing those risks? In addressing that question, the costs of imposing higher capital or higher cash requirements must be considered alongside their benefits. Regulators intent on setting draconian standards would find banking activity fleeing to the shadows, leaving little left to

regulate. And if regulators bent on establishing such draconian measures could somehow prevent shadow banks from operating, they could do so only by preventing large parts of the market for credit from operating as well.

That conclusion is not just a matter of theory, nor is it supported only by a centuries-long tendency for banks to rely on short-term debt finance. There is a large body of empirical evidence that shows that when banks are forced to choose between raising more external equity or shrinking their loan supply, loan-supply contraction often bears the brunt of the adjustment.[5] As we saw during the recent crisis, this partly reflects banks' reluctance to raise equity during times when potential equity investors are concerned about the hidden losses in their asset portfolios. In practice, therefore, prudential regulatory policies that raise banks' equity requirements or cash requirements can entail substantial social costs by precipitating credit crunches.

Understanding the potential fallout from imposing strict prudential regulation reinforces the need to identify the optimal mix of cash and capital requirements, which can deliver stability at the lowest social cost. But that's not all. A third policy option must be added to the decision problem of the government—namely, the extent to which and the circumstances under which the government intervenes to limit bank default risk through some form of LOLR assistance (which can take various forms, including discount window lending, ex ante deposit insurance, ex ante asset insurance, ex post government guarantees of bank debts, and contingent government injections of capital in the wake of bank losses). To the extent that the LOLR is aggressive in assisting banks—thereby reducing banks' exposures to liquidity risk, or absorbing banks' losses after the fact—one might expect banks to have less need to maintain the same ratios of cash and equity relative to assets.

That presumption, however, is often false, depending on how LOLR assistance is structured. If it is structured in a way that encourages poor risk management by banks, then the existence of protection may encourage so much "moral-hazard" risk that liquidity and capital requirements may have to be set even higher in the presence of LOLR.

Figure 1 illustrates the prudential regulatory problem faced by the government. The figure presents deposit default iso-risk curves (similar to those that arise in the Black-Scholes-Merton framework), which show the combinations of capital ratios and asset risk that are necessary to maintain a 1 basis point actuarially fair default risk premium, and a 50 basis point premium under two policy regimes: the dotted lines represent

2. See the model of Diamond, Douglas (1984). "Financial Intermediation and Delegated Monitoring," *Review of Economic Studies*, 51, July, 393-414.
3. See Calomiris, Charles W., and Charles M. Kahn (1991). "The Role of Demandable Debt in Structuring Optimal Banking Arrangements," *American Economic Review*, 81, June, 497-513.
4. See Calomiris, Charles W., and Gary Gorton (1991). "The Origins of Banking Panics: Models, Facts, and Bank Regulation," in *Financial Markets and Financial Crises*,

edited by R. Glenn Hubbard, 33-68, University of Chicago Press.
5. See Calomiris, Charles W., and Richard J. Herring (2012). "Why and How to Design a Contingent Convertible Debt Requirement," *Brookings-Wharton Papers on Financial Services*, forthcoming; and Aiyar, Shekhar, Charles W. Calomiris, and Tomasz Wieladek (2012). "Does Macro-Pru Leak: Evidence from a UK Policy Experiment," Working Paper, Bank of England.

Figure 1 LOLR Regimes and Bank Default Risk
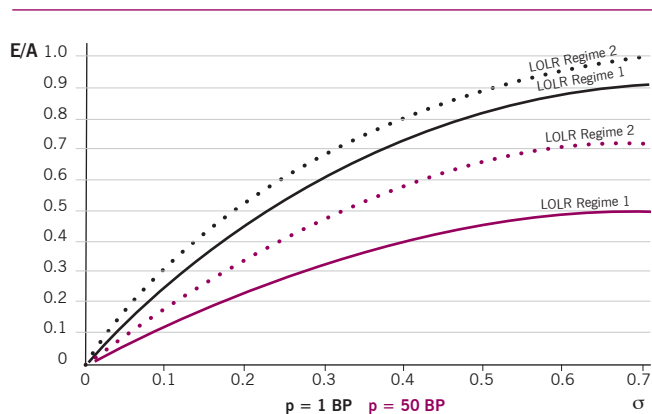
a highly interventionist LOLR prone to substantial moral hazard, while the solid lines represent a more balanced LOLR regime that manages to limit illiquidity risk without creating substantial moral-hazard consequences. Note that, under the assumption that riskless cash and risky loans are the two types of assets banks can hold, asset risk (the sigma of assets) is equal to the sigma of loans (that is, the standard deviation of returns in the loans portfolio) multiplied by the ratio of loans to assets. Greater cash holdings reduce the loan to asset ratio, thereby reducing the sigma of assets. Obviously, the assumptions of the Black-Scholes-Merton model will not be strictly satisfied in the presence of the three sets of financing frictions, but it is reasonable to posit that the shape of the iso-risk lines derived from that model, and depicted in Figure 1, are not very different in shape from those that would obtain under the more complicated assumptions of a more realistic model of risk in the presence of frictions.

As drawn in Figure 1, the dotted-lines LOLR regime increases bank default risk for a given combination of asset risk and equity ratio compared to the solid-lines regime. The solid-lines regime avoids creating much moral hazard. Thus, the solid-lines LOLR regime is welfare improving relative to the dotted-lines regime, since the solid-lines regime manages to reduce net risk (i.e., the moral-hazard risk created by the LOLR is less than the amount of risk that having a LOLR in place avoids). Thus, the combination of capital and liquidity that prudential regulation must require is greater in the dotted-lines regime than in the solid-lines regime.

As Figure 1 illustrates, the best LOLR policy (from the standpoint of efficient and stable banking) is the one that results in a set of iso-risk curves that is shifted as far as possible to the right (permitting banks to minimize their costs of equity finance and cash holdings). We will return to the details of that LOLR design problem at the end of the next section.

After having optimally structured the LOLR, regulators would face two other decisions: (1) the appropriate level of default risk to target (e.g., 1 basis point or 50 basis points), and (2) the optimal (lowest-cost) combination of equity ratio and asset risk that satisfies the default iso-risk constraint. We now turn to those choices.

How Much Risk to Tolerate, and How Much to Rely on Cash or Equity to Control Risk?

The tradeoff between the social value of maintaining higher loan supply for economic growth vs. the value of greater banking stability should play a key role in the public choice determining the target level of expected[6] default risk chosen by the government. For example, if the social costs of banking instability are very high, a lower level of expected risk may be chosen (say, the 1 basis point default iso-risk level), even though the higher combination of capital requirement and cash requirement necessary to achieve that lower risk level reduces loan supply and expected output. When framing the social choice problem of targeting default risk, the equilibrium condition that defines the optimal level of expected default risk should equate the marginal *social* cost of the cost-minimizing means (either an equity increase or a cash increase) of reducing default risk and the marginal *social* gain of reducing default risk. The marginal social cost should include both the banks' cost of satisfying the higher constraint and society's costs incurred from reduced bank lending. The marginal social gain should consider all the potential social costs of targeting higher banking instability (for example, the volatility of the supply of lending, and the implied volatility of output, as well as the potential consequences of taxpayer funding of prospective government LOLR transfers to banks). For the remainder of this paper, I will assume for convenience that the social planner has determined that it is appropriate to target a 1 basis point level of deposit default risk.

Having determined the optimal LOLR policy (more on that at the end of this section) and the optimal level of targeted default risk, what is the optimal combination of cash and capital that should be required to achieve that objective?

To answer that question requires a model that compares the relative effectiveness and costs of capital and cash as prudential tools. Very specific comparisons can be derived from simple models, which simplify bank structure, portfolio choices, outcomes, and other physical aspects of reality. Although those answers cannot be regarded as quantitatively reliable estimates, simple models can be quite useful for illustrating principles that must be taken into account when considering all the influences on this crucial cost-benefit analysis. Drawing from existing theory and experience, we

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6. I refer here to *expected* default risk to emphasize that the sigma of assets is subject to change, as discussed below.

Table 1 Risk Shifting Examples: Balance Sheets of Bank A and Bank B

Panel A: Bank A's Balance Sheet

Assets	Liabilities and Net Worth
Time 0	
100 loans	85 deposits
	15 equity
Time 1 Assuming Bad State	
90 loans	85 deposits
	5 equity

Panel B: Bank B's Balance Sheet

Assets	Liabilities and Net Worth
Time 0	
40 loans	85 deposits
60 cash	15 equity
Time 1 Assuming Bad State	
36 loans	85 deposits
60 cash	11 equity

can at least sketch out some of the factors that should be taken into account.

First, relying more on capital entails incurring greater adverse-selection costs from raising equity (which take the form of the discounting of equity offerings upon announcement of the offering, plus the underwriting costs undertaken to limit that discounting). Second, relying instead on cash also has a cost, namely the opportunity cost to banks (the forgone quasi rents on lending) of holding cash rather than loans. If these two considerations were the only ones that needed to be taken into account, then the optimal combination of cash and capital for a bank would depend only on the bank-specific values of the quasi rents from lending and the adverse-selection costs of raising equity.

But these are not the only relevant considerations. Cash has several other advantages relative to capital. Most importantly, because capital may *disappear in the future* due to a bad outcome in the loan portfolio that remains hidden from outsiders because of ex post asymmetric information, cash can provide both a more transparent buffer against loss, and encourage better risk management by banks in the wake of losses. Banks that have lost significant equity capital may face strong incentives to increase the riskiness of their risky assets. Such increases, which are often accomplished without investor knowledge much less approval, transfer wealth from depositors to bank stockholders (through the effective put option provided by limited liability, the value of which is magnified by the presence of a LOLR).

The incentive to increase risk in the wake of losses is strengthened by the presence of the LOLR in two ways: First, LOLR protection reduces the sensitivity of the cost of debt

finance to the asset risk choices of the bank. Second, in the presence of the LOLR, market participants have reduced incentives to monitor bank outcomes, and typically delegate that monitoring function to government supervisors. Government supervisors, however, lack incentives to identify bank losses or increased bank risk taking in a timely fashion; indeed, they often face strong incentives to overvalue bank loans for political purposes. When banks know that they can increase asset risk with impunity in the wake of losses, they can anticipate a transfer of wealth from depositors (or from the LOLR) to bank stockholders as the result of doing so.

This moral-hazard incentive problem in risk management is sometimes called the "asset substitution" or "risk shifting" problem. From the standpoint of this moral-hazard problem, cash requirements can have special benefits relative to capital requirements: cash is observable, especially if it is held in the form of reserves at the central bank; the presence of cash as a component of bank assets not only reduces asset risk through the direct effect of cash's risklessness, it also reduces risk by limiting moral-hazard incentives related to risk management.[7]

To see how cash limits banks' incentives for risk shifting, consider the simple example that is illustrated in Table 1. The example involves a bank making loans over just two periods. In the first period, loans that were made at time zero either rise in value to 110 or fall in value to 90 with equal probability; the initial value of loans is 100. When the first-period outcome occurs, banks can choose to either leave their portfolio in a similar risk profile for the second period (which will produce either a rise of 10 or a fall of 10 in its value for that period with equal probability); or at the end of the first period they can—without their investors' knowing—shift their portfolio to new loans that will either grow in value by 20 or decline in value by 21 with equal probability.

Although shifting to higher risk in the second period is clearly value destroying, in some circumstances the bank will choose to do so. Panel A of Table 1 illustrates why. As shown in the panel, Bank A begins with all of its assets in loans, financed 85% by deposits and 15% by the banker's equity. Assume that all parties are risk-neutral. If the bad outcome occurs in the first period, the banker will shift to the higher risk portfolio because his expected payoffs as a stockholder in the second period are higher when he does so (0.5 x 25, which equals 12.5, as opposed to 0.5 x 15, which equals 7.5).

Panel B illustrates how Bank B, by holding a sufficient quantity of cash in period 0, eliminates this moral hazard problem. In this example, Bank B initially holds 60% of its assets in cash, and finances itself 85% in deposits as before. In period 1, if the bad state occurs, Bank B will now decide not to shift to the high-risk portfolio (which rises by 8 or falls by

7. See Calomiris, Charles W., Florian Heider and Marie Hoerova (2012). "A Theory of Bank Liquidity Requirements," Working Paper.

Figure 2 **LOLR Regimes and Bank Default Risk**
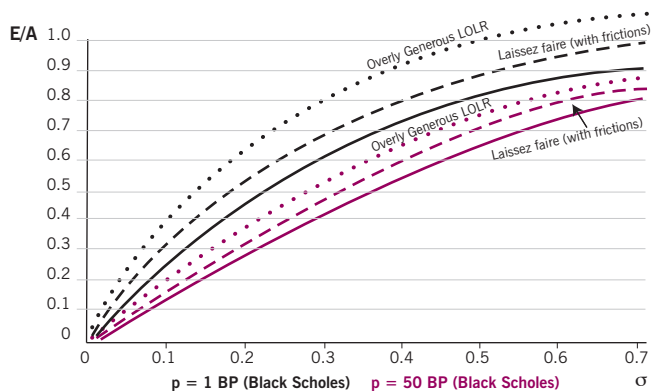
9 with equal probability) since his expected payoff is higher from not doing so, which implies staying with a portfolio that either rises by 4 or falls by 4 with equal probability. The expected payoff to the banker from the low-risk choice are 0.5 x 15 plus 0.5 x 7, which equals 11, as opposed to the payoff from the risky strategy, which is 0.5 x 19 plus 0.5 x 2, which equals 10.5. In other words, as this example is meant to show, cash not only reduces risk directly by reducing a bank's exposure to risky assets, it also affects the "state-contingent" preferences toward risk by the bank in the future. More generally, as my recent work with Florian Heider and Marie Hoerova shows, one effect of substituting cash for riskier holdings (at the outset) is to encourage banks to expend more effort on risk management. More cash raises the lower bound of the bank's asset value in bad times and lowers the upper bound of the bank's asset value in good times, which limits the gains to stockholders of risk shifting and encourages better risk management. Without the cash, banks would face weaker incentives to invest in risk management.

Thus far, we have considered several factors that affect the optimal combination of liquidity requirements: (1) adverse-selection (or information) costs associated with raising equity (which favors the use of cash), (2) the opportunity cost of forgone lending (which favors the use of capital), (3) potentially wasteful risk-shifting in bad states (which favors the use of cash). It is also important to note that the relative effectiveness of liquidity requirements is especially pronounced under weak supervision or an overly generous LOLR, since in those environments the opportunities for profitable risk-shifting are especially pronounced. In other words, cash requirements have a notably bigger "bang for the buck" than capital requirements in circumstances where risk-shifting opportunities call for greater reliance on cash as a way to limit the incentives to abuse the safety net.

Figure 2 illustrates these points. The solid lines in the figure represent the default iso-risk map derived from the

Black-Scholes-Merton model. The dashed lines represent a hypothetical default iso-risk map in the presence of financial frictions, which takes into account the relative advantages of cash for mitigating default risk in an environment where risk-shifting is possible. The dashed lines are drawn under the assumption of a laissez faire LOLR regime (meaning the absence of any LOLR protection). The dotted lines in Figure 2 show the effect of an overly generous LOLR regime (e.g., complete deposit insurance, easy discount window lending, no effective timely verification of loan outcomes, and no effective means of accurately measuring portfolio risk). Figure 2 shows that, to counteract the moral hazard of overly generous LOLR policy, capital and cash requirements need to be higher than under laissez faire because on balance the LOLR regime creates more risk than it avoids.

As Florian Heider, Marie Hoerova and I show in our study, because of the greater incentive for risk-shifting under deposit insurance (because deposit insurance discourages the monitoring of outcomes or risks), cash has even greater relative effectiveness than capital for limiting default risk in the presence of deposit insurance. This is illustrated in Figure 2 by the steeper slope of the default iso-risk curves under an overly generous LOLR regime. In other words, as the sigma of assets rises, moral hazard problems imply that more capital per unit of initial asset risk is needed to target the same level of default risk.

The Option Value of Cash in Dealing with Changes in Risk
Finally, let's add one more real-world complication, which also favors a reliance on cash rather than capital. The riskiness of assets is not constant. In the context of our modeling framework, the sigma of assets primarily reflects the sigma of loans, as well as the liquidity risk that arises from exogenous or endogenous withdrawal demands by depositors. These risks are time varying, and subject to jumps (especially during financial crises). Therefore, another important dimension on which to compare the relative efficacy of cash and capital requirements has to do with their robustness to changes in those risks.

From the perspective of the possibility of asset sigma jump risk, the key difference between relying on capital requirements and liquidity requirements as prudential instruments is that cash has greater *option value* in dealing with shifts in fundamental risks. Consider two banks, X and Z. Bank X targets a 1 basis point level of expected default risk primarily by maintaining low leverage without holding any cash (operating at a point far to the right on the 1 basis point iso-risk line in Figure 1), while Bank Z targets the same default risk primarily with a combination of moderate leverage and significant cash holdings (operating at a point far to the left on the 1 basis point iso-risk line).

First, consider the effects on the two banks of a jump in the sigma of loans. A rise in the sigma of loans creates more of an adjustment problem for Bank X than for Bank Z for the simple reason that Bank X is holding a higher propor-

tion of loans to assets. That implies that Bank X will have to adjust some combination of its capital (by cutting dividends or raising new capital) or its cash holdings (by liquidating or not renewing some of its loans) in response to the risk jump by a greater amount, implying larger adjustment costs for Bank X than for Bank Z.

Second, consider the effects on the two banks of an increase in withdrawal demands by depositors. Exogenous increases in withdrawal demand may reflect depositors' consumption or portfolio management needs. Endogenous increases in withdrawals by uninsured depositors may reflect concerns about increases in default risk—for example, that result from a jump in the sigma of loans, or a noisy signal about the risk management practices or portfolio quality of banks.[8] Bank X will find it harder to adjust to these withdrawal demands because it is maintaining less cash relative to deposits than Bank Z. Thus, Bank X will suffer greater liquidation costs with respect to its loan portfolio than Bank Z.

These examples point to a further advantage to cash relative to capital in managing default risk—namely, its resilience in response to changes in the risk environment. In short, a strategy of relying relatively more on cash to manage default risk provides option value, making it less costly to adjust to increased risks.

Proper Design of the LOLR

As discussed above, from the narrow perspective of prudential banking policy, the LOLR regime should be chosen to shift the iso-risk map in Figure 2 as far as possible to the right, since doing so economizes on the social costs of either raising capital or holding cash to achieve the targeted level of default risk. Of course, the LOLR may have objectives other than stabilizing the banking system (e.g., it may be designed to stabilize the financial sector or the economy defined more broadly). Nevertheless, from the perspective of the crucial objective of bank stabilization, pushing the iso-risk map to the right (achieving lower default risk with a combination of lower capital and less cash) is the measure of design success.

In essence, the LOLR policy design problem is constructing a regime that optimally balances the cost of protection (moral-hazard induced increases in default risk, which destabilizes banks ex post, wastes resources ex ante, and creates distortions from whatever taxes are used to finance government bailouts) with the benefits of protection. The main benefits of LOLR protection, which reduce bank default risk for any combination of cash and equity, are two: (1) access to the discount window and other forms of bank assistance reduce funding illiquidity risk; and (2) assistance to banks in various forms prevents adverse portfolio shocks from raising bank default risk, which thereby mitigates bank credit supply

crunches in the wake of bank loan losses that would otherwise occur under a laissez faire regime.

What sort of LOLR arrangements are likely to properly balance the costs and benefits of LOLR assistance? A wide variety of policy interventions can be said to be part of the LOLR toolkit, including central bank lending, government capital injections of preferred or common stock, and credit guarantees to intermediaries or to classes of securities offered in the market. It is beyond the scope of this paper to consider all these, but a few principles are worth mentioning.

First, "nothing ventured, nothing gained." A LOLR that takes the form of a discount window that exchanges cash for riskless securities cannot do much good, and may even do harm. Banks experiencing withdrawal pressures stemming from debt holders' concerns about their solvency do not need a central bank to convert riskless securities into cash; they need it to convert risky assets into cash. If the central bank collateralizes its loans with riskless securities, it effectively subordinates depositors, which can actually encourage runs on banks, and indeed, this has sometimes been the outcome of excessively conservative LOLR policy.[9] For the LOLR to be effective, it must absorb some risk and thereby leave depositors in a superior (lower) default risk position than before the LOLR intervention. This can be done by lending on moderately risky collateral or by means of guarantees or capital injections.

Second, despite the need for some risk absorption, in the interest of minimizing moral hazard, LOLR interventions should take as senior a position as possible relative to the intermediaries or assets that are the object of their interventions. There does come a point where lending alone will not be an appropriate tool to mitigate default risk. For example, when a bank lacks appropriate collateral or when it is already very highly levered, additional leveraging can promote risk-taking—thanks to the same asset substitution problem discussed earlier. If the problem is just the absence of appropriate collateral, preferred stock injections may be desirable (since they maintain a relatively senior risk position for the LOLR), but if the bank is very highly levered, additional debt-like finance (including preferred stock), even on subsidized terms, can have perverse incentive consequences. At that point, guarantees that place lower bounds on asset values or equity injections may be better ways to provide effective assistance.

Third, the long-term moral-hazard costs of mitigating default risk are real, and must be weighed against the short-term advantages of avoiding the costly adjustment to higher default risk (especially loan-supply contraction). A permanent shift in risk-taking behavior that either produces long-term waste of resources through excessive risk taking, or that necessitates permanent increases in cash reserves or capital to mitigate the effects of LOLR generosity (as depicted in

8. Calomiris and Kahn (1991) show that a buffer of reserve holdings can serve a useful role as a buffer against noisy signals, permitting banks to avoid unwarranted and costly liquidation.

9. See Joseph R. Mason (2001). "Do Lender of Last Resort Policies Matter? The Effects of Reconstruction Finance Corporation Assistance to Banks During the Great Depression," *Journal of Financial Services Research*, 20, September, 77-95.

Table 2   NYC Banks' Loans/Cash, Risk, Equity, Dividends

	Loans/(R+T)	Ass. Risk	Equity/Ass.	p	Dividends
1923	2.2	1.9	0.20	0.0	
1929	3.3	17.5	0.33	33.5	$392m
1933	1.0	6.1	0.15	41.7	
1936	0.6	4.3	017	1.3	
1940	0.3	2.0	0.10	2.1	$162m

Definitions: Loans/(R+T) is loans and discounts divided by reserves plus Treasury securities. Ass. Risk is defined as the implied standard deviation of returns to assets held by banks. Equity/Ass. is the ratio of the market value of equity to the market value of assets. "p" is the actuarily fair default risk premium on deposits derived from the Black-Scholes model.

Source: Calomiris and Wilson (2004).

Figures 1 and 2) can be very costly, and often is not worth the short-term gains that politicians and bankers find it convenient to emphasize.

Three broad conclusions emerge from this discussion. First, the exclusive focus on capital requirements as a prudential tool in many countries is misplaced. In many respects, liquidity requirements are a superior tool.

Second, that is not to say that liquidity requirements should be used instead of capital requirements. From the perspective of achieving the central prudential objective of controlling default risk at a minimum social cost, capital requirements have some limitations that favor liquidity requirements, and vice versa. Given that marginal costs are generally increasing along any one cost margin, the optimal policy generally will be a combination of liquidity and capital requirements.

Third, capital and cash requirements are not the only policy tools that are used to influence bank default risk. In particular, LOLR policy also affects default risk, and its specific design affects the efficacy of capital and liquidity for managing default risk. If LOLR policy is designed wisely, it can reduce the need for costly capital and cash requirements. But if designed poorly, it can result in the need to offset the moral hazard produced by the policy itself with costly increases in capital and liquidity requirements.

Historical Perspectives on Liquidity Requirements

The emphasis on capital as the primary or exclusive regulatory instrument of choice for controlling bank default risk is a very recent phenomenon. The use of bank capital ratios as a prudential tool by U.S. bank regulators did not start until around 1980, and for many countries operating in accord with the Basel standards, the beginning was 1988 or later.

Prior to recent times, however, liquidity requirements were the primary prudential instrument used to manage default risk.

Take the case of the New York Clearing House, which, as a private self-regulating coalition of U.S. banks formed in the 1850s, was among the first forms of central banking and LOLR policy in the U.S. The Clearing House established a cash reserve requirement equal to 25% of member banks' deposits. In his 1873 report, George Coe, then president of the Clearing House, explained the importance of reserve requirements for ensuring the ability of the banking system to respond to financial crises. Similarly, cash reserve requirements against bank liabilities—not capital ratio requirements—were adopted under the National Banking System that began in the 1860s, and which continued under the Federal Reserve System.

Cash Reserves vs. Capital, 1920-1940

The experience of U.S. banks during the interwar period provides a striking illustration of the importance of banks' reliance on cash as a tool for limiting default risk and maintaining the confidence of depositors during risky and uncertain times. From the perspective of the iso-risk lines depicted in Figures 1 and 2, my 2004 study with Berry Wilson shows that New York City banks were targeting a consistently low level of default risk throughout the period.[10] As Table 2 shows, the "p value" of default risk on deposits began and ended the period at a similar level, although the shocks of the Depression era and the recession of 1937-1938 temporarily raised average default risk.

During the expansionary mid-1920s, banks expanded their capital ratios and minimized their cash-to-asset ratios, given the large opportunities to make profitable loans available in the loan market. Many New York banks raised equity on more than one occasion during the 1920s. When the Great Depression hit, banks suffered large losses, and as their default risk rose, banks that were unable to respond adequately lost depositors to other banks or to postal savings. The primary tool banks used to restore depositor confidence was to reduce loans, and convert maturing loans into cash assets (cash plus Treasury securities). As Table 2 shows, the ratio of cash assets to loans rose dramatically throughout the 1930s. And as Joseph Mason and I showed in a 2003 study,[11] cash assets reduced the risk of failure by U.S. banks during the Depression. Banks that experienced greater than average risk of failure saw their retail deposits decline more than other banks, and saw their reliance on high-cost, interbank "borrowed funds" increase.

What's more, when Joseph Mason, David Wheelock and I recently (2011) explored the demand for cash assets by U.S. banks during the mid-1930s, we found that regulatory reserve requirements were not binding on most banks.[12] Instead, banks were holding substantial excess reserves voluntarily on the basis

10. Calomiris, Charles W., and Berry Wilson (2004). "Bank Capital and Portfolio Management: The 1930s Capital Crunch and Scramble to Shed Risk," *Journal of Business*, 77, July, 421-56.

11. Calomiris, Charles W., and Joseph R. Mason (2003). "Fundamentals, Panics, and Bank Distress During the Depression," *American Economic Review*, 93, December,

1615-47.

12. Calomiris, Charles W., Joseph R. Mason, and David C. Wheelock (2011). "Did Doubling Reserve Requirements Cause the Recession of 1937-1938? A Microeconomic Approach," NBER Working Paper No.16688, January.

of a well-defined prudential demand for reserves as a risk control in response to market discipline. In particular, we found that banks with lower capital held higher ratios of cash assets. But if cash and capital clearly substituted as prudential devices during the interwar period, very few banks raised any capital during the 1930s, except through internal sources (retained earnings). As Table 2 shows, banks did cut dividends significantly to help bolster their positions. But increased cash asset holdings were the primary instrument used by banks to respond to shocks and maintain depositor confidence during the 1930s.

Conclusion

The literature on the optimal mix of capital and liquidity requirements in prudential regulation is in its infancy. Still, there are several points to be made about the desirability of combining the two instead of focusing exclusively on capital regulation.

Theory identifies several distinct categories of costs and benefits associated with relying either on cash or on capital as prudential tools. Given the increasing marginal costs and diminishing marginal benefits of any one of these categories of costs or benefits, some combination of reliance on cash, capital, and appropriate LOLR interventions is surely optimal from the standpoint of targeting default risk at the least social cost. The theoretical discussion emphasizes that liquidity requirements are useful as a *broadly conceived prudential tool, not as a narrow tool for dealing with illiquidity risk*. Indeed, illiquidity risk is neither a necessary nor a sufficient condition for establishing bank liquidity requirements.

There is substantial historical precedent for believing that liquidity, and liquidity requirements, are an important prudential tool in banking. Liquidity requirements were the first prudential requirements used in U.S. banking; capital ratio requirements were not part of U.S. bank regulation until the 1980s. The accumulation of cash assets in response to economic distress has traditionally been the primary tool used by banks to restore depositor confidence under difficult circumstances. Liquidity requirements continue to be used to great effect currently in many countries.

What, then, are the regulatory implications of these observations, and what lessons do they imply for the new liquidity requirement initiative under Basel III? There are many, but three observations are particularly salient.

First, in considering the extent to which regulators should rely on liquidity requirements, it should be recognized that requirements not only substitute for capital requirements as a buffer against loan loss, they also help protect the financial system by *encouraging good risk management.* Moreover, because of their option value, cash requirements are likely to be more effective than capital requirements in maintaining low default risk in the face of uncertainty about risks.

Second, the Basel III approach to regulating liquidity seems fundamentally misguided. A large part of the appeal of liquidity relative to capital as a prudential tool is its *simplicity* and *transparency.* Cash assets are uniquely useful as a regulatory tool because their value is easily observable, they are riskless, and their value is not subject to risk shifting. A simple cash requirement (say, 20% of assets) held continuously at the central bank (to avoid window dressing), on which interest is paid at the treasury bill rate (to avoid distortionary taxation of reserves), would be an excellent start in the direction of adding liquidity requirements to the prudential toolkit. Instead, the Basel committee has created a new Rube Goldberg morass. They have devised two separate liquidity requirements, the "liquidity coverage ratio" and the "net stable funding ratio," neither of which is regarded as predictable or observable by bank analysts, since both require substantial regulatory discretion in their definitions.

Not only does Basel III's complexity and discretion create potential costs and fail to realize important prudential regulatory opportunities, there is also substantial evidence that the Basel committee is willing to play politically motivated games when deciding what banks need to do to satisfy their liquidity requirements.

Furthermore, Basel III's pursuit of the narrow goal of reducing bank liquidity risk may itself be undesirable. The need to preserve the liquidity production role of banks may shift resources to the shadow banking system. Or, if shadow banking is not feasible, reductions in bank liquidity creation may unnecessarily reduce the level of liquidity and credit in the economy.

Finally, as the evolving conversation over regulatory reform proceeds, the substitutability between cash and capital will have to take into account the new forms of capital that are being proposed, particularly contingent capital (CoCos). CoCos, if properly designed, have unique properties that make them quite different from equity capital as prudential tools. In a recent article, cited earlier, Richard Herring and I show that a properly designed CoCo requirement has many of the positive incentive features for risk management that are also present in proper liquidity requirements. Thus, the discussion here—which focuses on book equity requirements when considering the substitutability between capital and liquidity requirements—should be expanded when applied to more complex and carefully conceived capital instruments. This last point reinforces the need for additional research that considers prudential regulatory tools in *combination*. Capital, liquidity, and LOLR policies all interact in their effectiveness, and they must be analyzed jointly for that reason.

CHARLES CALOMIRIS is Henry Kaufman Professor of Financial Institutions, Columbia Business School, and Research Associate, National Bureau of Economic Research.