Journal of Economic Literature 2011, 49:2, 287–325
http:www.aeaweb.org/articles.php?doi=10.1257/jel.49.2.287

Illiquidity and All Its Friends

Jean Tirole*

The recent crisis was characterized by massive illiquidity. This paper reviews what we know and don't know about illiquidity and all its friends: market freezes, fire sales, contagion, and ultimately insolvencies and bailouts. It first explains why liquidity cannot easily be apprehended through a single statistic, and asks whether liquidity should be regulated given that a capital adequacy requirement is already in place. The paper then analyzes market breakdowns due to either adverse selection or shortages of financial muscle, and explains why such breakdowns are endogenous to balance sheet choices and to information acquisition. It then looks at what economics can contribute to the debate on systemic risk and its containment. Finally, the paper takes a macroeconomic perspective, discusses shortages of aggregate liquidity, and analyzes how market value accounting and capital adequacy should react to asset prices. It concludes with a topical form of liquidity provision, monetary bailouts and recapitalizations, and analyzes optimal combinations thereof; it stresses the need for macro-prudential policies. (*JEL* E44, G01, G21, G28, G32, L51)

1. *Introduction*

The recent crisis, we all know, was characterized by massive illiquidity. Various markets (money, corporate debt, securitization, collateralized debt obligations (CDOs), etc.) ground to a halt. Investors ran on a variety of institutions, including Bear Stearns, Lehman Brothers, and Northern Rock, before authorities guaranteed a substantial fraction of the financial system. Financial institutions and industrial companies scrambled for cash by selling assets at fire sale prices. Central banks injected unprecedented amounts of liquidity into the system.

Much of the current thinking on regulatory reform focuses on how to avoid a repeat of this episode. Regulators strive to homogenize their measurement of liquidity and to improve their stress tests. The Financial Stability Forum[1] (2009) calls for "a joint research program to measure funding and liquidity risk attached to maturity transformation, enabling the pricing of liquidity risk in the financial system" (Recommendation 3.2) and recommends that "the BIS and IMF

*Toulouse School of Economics. An earlier version of this paper was prepared for the 8th BIS Annual Conference on "Financial Systems and Macroeconomic Resilience: Revisited" (Basel, June 2009). The author is grateful to Emmanuel Farhi, Bengt Holmström, and Jean-Charles Rochet for joint work and extensive discussions on the topics of this paper, and to Franklin Allen, Mathias Dewatripont, Roger Gordon, participants at the BIS conference and at meetings at the Banque de France, and three anonymous referees for very helpful comments.

[1] Now the Financial Stability Board in its revamped version.

could make available to authorities information on leverage and maturity mismatches on a system-wide basis" (Recommendation 3.3). Fair value accounting, once a darling of the financial community, has been at least temporarily relaxed on the grounds that it creates excess supply of liquidity in booms and (more relevant to the decision) shortages thereof when asset prices fall.

But what is liquidity? Relatedly, why do firms and financial institutions fear illiquidity? Why can't they return to the capital market whenever they need to finance worthwhile (understand: "positive net present value") undertakings, be they new projects or the continuation of existing ones? What determines the overall amount of liquidity in the economy? What implications do economic analyses of liquidity have for financial regulation?

This paper reviews what we know and don't know about illiquidity and all its friends: market freezes, fire sales, contagion, and ultimately insolvencies and bailouts. Viewing liquidity as stores of value or real claims,[2] and building on the familiar notions of funding and market liquidity, section 2 explains why liquidity cannot easily be apprehended through a single statistic. Section 3 reviews the determinants of corporate liquidity management and, given that prudential regulation traditionally has focused on the measurement of solvency, asks whether liquidity should be regulated when a capital adequacy requirement is already in place. After these preambles, sections 4 through 7 form the core of the paper. Section 4 first analyzes market breakdowns due to adverse selection and why such breakdowns are endogenous to balance sheet choices and to information acquisition, and then points at the role of financial muscle and limits to arbitrage. Section 5 looks at what economics can contribute to the debate on systemic risk and its containment. Section 6 takes a macroeconomic view and discusses shortages of aggregate liquidity. It then analyzes how market value accounting and capital adequacy should react to asset prices and it enunciates some principles for an optimal policy of public supply of liquidity. Section 7 focuses on a topical form of liquidity provision, monetary bailouts and recapitalizations, and analyzes optimal combinations thereof. It describes a rationale for macro-prudential policies. Section 8 concludes.

[2] Like most of the literature on liquidity, I abstract from nominal issues.

2. *Liquidity Comes in Many Guises . . . or the Elusive Concept of Liquidity*

For the sake of illustration, consider a bank and its starkly simplified balance sheet depicted in figure 1, and suppose that this bank needs new cash in order to finance an expansion or an acquisition, or to withstand an unexpected loss in earnings or asset value. Alternatively, its wholesale depositors may have run away.

2.1 *Funding and Market Liquidity*

To meet its liquidity shortfall, the bank may count on either funding or market liquidity.[3]

Funding liquidity. Funding liquidity traditionally refers to the liability side of the balance sheet. The bank may issue new wholesale deposits, long-term bonds, preferred stocks, straight equity or still other securities. By so doing, it dilutes its existing investors.

[3] The role of these two forms of liquidity has been emphasized in particular by Markus K. Brunnermeier and Lasse Heje Pedersen (2009). The dichotomy between funding liquidity (liability side of the balance sheet) and market liquidity (asset side of the balance sheet) is primarily for convenience and is not as sharp as one would wish. Indeed, some cash infusions, such as the securitization of a loan portfolio with a contingent promise of liquidity support to the corresponding conduit, involve both sides of the balance sheet (a conduit is an organizational structure that pools various loans into a single entity and issues securities, such as collateralized debt obligations or residential mortgage-backed securities, that are backed by the underlying assets).

A	L
✓ T-bills, quasi-cash	✓ retail deposits
✓ other securities	✓ wholesale deposits
✓ "illiquid assets"	✓ MT/LT debt, hybrid securities
	✓ equity

Figure 1. Bank's Simplified Balance Sheet

How much can be raised on the liability side depends on the economic environment; for example, improved corporate governance assuages investors' concern about the prospect of not recouping the money they invested; in economics jargon, better corporate governance increases the pledgeability of corporate resources to investors. Thus, better corporate governance institutions facilitate refinancing by the corporate sector and thereby boost funding liquidity.

Another determinant of funding liquidity is the ease with which existing claims can be renegotiated. Funding liquidity involves diluting existing claimholders and therefore may require their consent. A large literature has discussed debt overhang, the idea that some claimholders, usually debtholders, attempt to free ride in a restructuring of the liability side. When the institution needs new cash to refinance itself, each claimholder would like others to make concessions (accept to be diluted, to bring in new cash) while keeping the full value of his claim for himself. The free riding issue has for example been prominently discussed in the context of sovereign debt restructuring. A unanimity rule clearly fosters free-riding while a qualified majority rule enhances funding liquidity.[4]

Finally, funding liquidity may be prearranged for reasons that we will shortly elucidate. The institution can secure a credit line or more generally some form of liquidity support from another institution.

Market liquidity. To generate cash over and beyond the yield accruing from assets on its balance sheet, the bank can also sell easily-tradable assets such as T-bills, or alternatively use these as collateral in borrowing operations such as repos. Another strategy for banks to raise cash on the asset side is to securitize a portfolio of loans that it has issued. We will return to securitization later on. Assets like T-bills are usually said to be liquid in that they are traded in deep markets under limited asymmetries of information, and therefore sold with low haircuts or discounts. But so do stock market indices such as the S&P500. The distinguishing feature of T-bills, as we will later discuss, is that unlike stock indices, one can pretty much count on their delivering cash when cash is needed.

That the liquidity of assets is driven not only by market micro-structure, but also by macroeconomic considerations is actually an old theme in economics. Borrowing from Marshall and Pigou, John Maynard Keynes

[4] This is correct only in the short run. In the long run, the ease with which debt claims can be renegotiated may deter investors from acquiring them. This is an instance of the trade-off between leverage and liquidity that we will later emphasize.

(1936) and John Hicks (1967) emphasized liquidity preference for transaction and precautionary purposes (associated with foreseen and ill-foreseen needs, respectively), and made a distinction between running and reserve assets on the one hand, and speculative or investment assets on the other hand, where the latter are held for their yield.

Funding and market liquidity tend to be correlated, as we have seen in the recent crisis. When potential buyers have difficulties raising funds and may even be in the process of downsizing, it becomes hard for sellers to part with their assets. Conversely, market illiquidity may make investors reluctant to bring funds to a bank that, they know, will have trouble selling assets.

2.2 *Other Determinants of Liquidity*

But liquidity depends on other factors as well:

Risk Management and Financial Structure

The flip side of liquidity management is risk management, namely the extent to which the bank's returns are insulated against shocks that are not under the control of the bank. This takes the form of interest rate, exchange rate, and credit default swaps, or other derivative contracts; such contracts can be viewed as prearranged, contingent liquidity support arrangements. Thus, one cannot assess a bank's liquidity position without also considering its hedging policy.[5]

Relatedly, the bank can also make the occurrence of liquidity shortfalls less likely by issuing equity, long-term debt and preferred stocks (a form of debt which allows the institution to delay the payment of coupons as long as dividends on ordinary shares are not paid), or by including covenants allowing debt–equity swaps in certain circumstances;[6] it thereby reduces calls for cash, especially in hard times.

Reputation Risk

Some institutions may be tempted (as Bear Stearns was a couple of months before its collapse) to rescue vehicles toward which they have no legal obligations. The private rationale for this is to attempt to restore a tarnished reputation by signaling strength, thereby "speculating on one's franchise value" (Darrell Duffie 2009). This risk unfortunately has not been properly accounted for, as the corresponding "obligations" do not carry any capital charge under current regulations.

One possible approach in this respect consists in trying to measure such implicit liabilities and in imposing a capital charge on them. Finding the right capital charges is likely to be complex. Given that the rationale for honoring such implicit obligations is signaling, and that signaling is often wasteful, I would rather suggest that regulators do not allow banks to honor (at least without a large penalty) obligations they have no legal obligation to honor. This prohibition would eliminate the supplemental reputation risk (the reputational damage done by a failing conduit is there anyway) associated with not honoring implicit commitments.

[5] This observation of course does not imply that full hedging is desirable; indeed it may not be advisable to fully cover one's risks for a number of reasons: transaction costs, serially-correlated profits, CAPM-style arguments, asymmetric information, incentives, market power, and strategic considerations. For a review of these reasons, see Jean Tirole (2006, pp. 216–20); and see Thomas-Olivier Léautier and Jean-Charles Rochet (2009) for an analysis of hedging in oligopoly markets.

[6] In this spirit, the recent debate on regulatory reform has discussed the possibility of mandating issues of "Coco" (contingent convertible) bonds, which convert into equity if the bank's capital gets too low. The issuance of such bonds faces several problems, although the stigma usually associated with their introduction would be removed by the compulsory feature in the case of regulated banks. One of the worries about Coco bonds is the discretion involved in the definition of solvency.

And especially it would prevent banks from taking on contingent liabilities without allocating sufficient capital to them; put differently, the prohibition would eliminate a channel of regulatory evasion.[7]

2.3 *Measuring Liquidity*

These considerations explain why capturing the notion of an "illiquid balance sheet" in a single statistic is a difficult exercise. It is no wonder that prudential measurements of liquidity ratios are many, even though their approach usually consists in measuring some mismatch between short-term liabilities (making some assumptions on the fraction of those that could be called and therefore not rolled over) and liquid assets (again, building on hypotheses on market liquidity). Recently, the Reserve Bank of New Zealand has added another liquidity requirement based on the "core funding ratio" that forces banks to fund at least 75 percent of total lending through sticky liabilities such as retail deposits and wholesale borrowing maturing in more than a year.[8] More recently still, new Basel (III) regulations, besides raising solvency requirements, will impose two minimum liquidity ratios, a thirty-day one and a longer-term "net stable funding ratio."

A complementary approach reflects the idea that "you know it when you stress it"; that is, one can formulate some hypotheses as to the coevolution of key variables and the operation of markets and look at the implications of various scenarii on the available cash for the bank. Such stress tests are only as good as the statistical data they are fed with (recall the wrongful use of short and favorable time series in the assessments of risk prior to the crisis). But they nonetheless convey information about the liquidity of the balance sheet.[9]

3. *Demand for Liquidity*

3.1 *Basics*

3.1.1 *The Need for Financial Planning: Transformation and Maturity Mismatches*

The raison d'être of corporate financial management is that revenues and outlays are not perfectly synchronized. The lack of synchronicity between cash flows and cash needs implies that firms and financial institutions must find ways of covering their needs in periods of shortfall. Two broad strategies are available to this purpose: "finance as you go" and "liquidity hoarding."

"Finance as you go" consists in returning to the capital market and borrowing from investors and other corporations when needs arise. Note that markets would satisfactorily bridge the temporal gaps between revenues and expenditures in a world of perfect (understand "agency-cost free") capital markets.

"Finance as you go" however has its limits. Financial market imperfections, which encompass moral hazard, adverse selection (asymmetries of information about assets in place and projects), and mere transaction costs, make it hard for cash-strapped corporations to raise financing even for positive net-present-value actions. The subprime crisis is a case in point: the lending to the ECB rather than to cash-strapped banks by banks with excess liquidity, the stalling of the securitization and CDO markets, the corporate credit spread, and the overall credit crunch

[7] On this topic, see the Basel Committee on Banking Supervision consultative document (2009), which offers to address reputation risk through pillar 2 of the Basel II accords.

[8] *The Economist*, September 5, 2009.

[9] The Basel club of regulators proposed in December 2009 to require banks to be able to withstand a thirty-day freeze in credit markets. It also called for less reliance on short-term wholesale funding.

despite the injection of liquidity by central banks all illustrate the difficulty of relying on markets for refinancing.

For this reason, corporations must complement the recourse to the financial market by some planning of their own. That is, they must hoard liquidity either directly (by holding securities on their own books, or by taking on limited short-term debt so as not to be forced to pay back their entire short-term income to investors) or indirectly (by securing credit lines from banks, insurance companies, or parent companies, which hold securities on their own balance sheets to back these lines of credit).

3.1.2 *A Simple Model*

Let us now develop a simple framework that illustrates liquidity management and the concepts of funding and market liquidity and stresses the existence of a basic trade-off between scale and insurance: insurance is always costly, and reduces the investment equity multiplier.[10]

There are three periods: $t = 0, 1, 2$. Investors demand a (normalized) return equal to 1 per unit invested between dates 0 and 2, and to R between dates 1 and 2.

Illiquid Assets

At date 0, a representative banking entrepreneur has wealth (equity) a and invests i in "illiquid assets." If resold at date 1, illiquid assets yield p per unit. So a higher p means that the asset is less illiquid. One can think of p as technologically determined, that is as the value of the asset in an alternative use at date 1. Or else p might be market determined, like in the fire-sales literature discussed later. The parameter p therefore is a measure of market liquidity. Illiquid assets yield r per unit at date 1.

If brought to completion (i.e., to date 2), a unit of illiquid asset yields ρ_1, of which only ρ_0 is pledgeable to investors, where $\rho_0 < \rho_1$. That $\rho_1 > \rho_0$ ("investors cannot grab the entire cake") is the essential difference of this framework with the Arrow–Debreu model. The wedge $\rho_1 - \rho_0$ can be motivated by private benefits of control, perks, verifiability problems or required incentive payments paid to the entrepreneur (or more generally the insiders) to curb moral hazard. The wedge could also represent money that is diverted toward other activities (affiliated companies, investment in human capital that will be operative in other, future activities). The pledgeable income parameter ρ_0 is a measure of the quality of governance. We assume that $R > \rho_0$, since otherwise (and as we are going to observe) the bank would never have any refinancing problem.

Liquidity Shock

At date 1, with probability α the bank does not face a liquidity shock and can proceed to reap the benefits from investment at date 2. With probability $1 - \alpha$, the bank faces a liquidity shock at date 1 and must then reinvest 1 unit per unit of investment to be brought to completion at date 2. Let j, $0 \leq j \leq i$, denote the size of the continuation. The ratio $(i - j)/i$ measures the extent of downsizing in case of an adverse shock.

Liquid Assets

Finally, the banking entrepreneur can invest at date 0 in an asset that yields 1 per unit at date 2 (and nothing at date 1). The date-0 price of this store of value is $q \geq 1$ (it must exceed 1 since otherwise investors would increase their demand for it). Liquidity is costly if $q > 1$ (recall that consumers demand to recoup 1 at date 2 per unit invested at date 0). Let xi denote the date-0 investment in this store of value. The number x is akin to a liquidity ratio. I rule

[10] This follows Emmanuel Farhi and Tirole (forthcoming-b), and is straight in the spirit of the model in Bengt Holmström and Tirole (1998).

out for the moment liquidity pooling, that is I do not allow banking entrepreneurs to centralize their provision of liquidity and to redispatch it to those who end up needing it; this assumption is justified if the liquidity shortage events are correlated across banks.

I assume for the moment that investors can monitor the bank's liquidity position and therefore condition their lending on it.

Feasible Continuations

In case of a liquidity shock, the bank can use:

- its hoarded liquidity, with value xi at date 2
- its market liquidity, with value $p(i-j)$ at date 1
- its date-1 income, ri
- its funding liquidity, with value $\rho_0 j$ at date 2.

The last term deserves some explanation: the most that the bank can obtain by diluting its existing investors, i.e., the total value of the securities it issues, is the pledgeable income. So feasible continuations must obey the liquidity condition:

$$(1) \quad j \leq \frac{\rho_0 j + xi}{R} + p(i-j) + ri.$$

Note that low-interest rate conditions at date 1 (a low R) favor continuation, and so expectations of low interest rates make liquidity hoarding less necessary. Similarly, and unless the bank refuses to sell assets, market liquidity (as measured by p) makes it easier to refinance.

A liquidity need (i.e., a need for hoarding stores of value $x > 0$ if one wishes to fully withstand the liquidity shock) arises if

$$(2) \qquad \frac{\rho_0}{R} < 1 - r$$

i.e., if the net per unit cash demand $1 - r$ exceeds the funding liquidity, a condition that we will assume.

Borrowing Capability (Solvency Ratio)

At date 0, the bank needs to borrow

$$i - a + qxi,$$

an amount that investors must recoup later on. In the absence of liquidity shock, there is no reason to downsize and the latter receive $(\rho_0 + x)i$ at date 2 and ri at date 1.

In case of a liquidity shock, the bank either continues at scale j given by (1):

$$(3) \qquad j = \frac{(x + Rr + Rp)i}{R(1 + p) - \rho_0}$$

(at the optimum, the RHS of (3) will never exceed i, as hoarding liquidity is costly); or it resells all its assets at price p—this extreme outcome stems from the linearity of the model. Furthermore, and again from linearity, it can easily be shown that in this model it is optimal to hoard liquidity so as to continue at full scale ($j = i$) or not at all ($j = 0$).[11]

To shorten the analysis, let us assume that $r = 0$ (the asset's return is fully backloaded) and $p = 0$ (the asset is completely illiquid).

Then, if the bank decides to hoard liquidity so that $j = i$ even in case of a shock, from (2):

$$x = R - \rho_0.$$

Its borrowing capacity is then given by

$$(4) \quad i - a + qxi = \alpha(\rho_0 + x)i \Leftrightarrow$$

$$i = \frac{a}{1 + q(R - \rho_0) - \alpha R},$$

[11] Partial downsizing arises naturally when one considers a continuum of shocks.

and the banking entrepreneur's utility is

$$U = (\rho_1 - \rho_0)i.$$

If the bank chooses to be illiquid ($x = 0$ and therefore $j = 0$ in case of a shock, and $R > \rho_0$), the new investment I is given by

$$I - a = \alpha\rho_0 I \Leftrightarrow I = \frac{a}{1 - \alpha\rho_0} > i.$$

There is therefore a *trade-off between liquidity (capital insurance) and scale*.

Hoarding liquidity is really about buying costly insurance from investors. It is optimal if and only if

$$(5) \qquad (\rho_1 - \rho_0)i \geq \alpha(\rho_1 - \rho_0)I,$$

or

$$\frac{(1-\alpha)^2}{\alpha} \geq (q-1)(1-\rho_0) - (1-R)(q-\alpha)$$

Obviously hoarding liquidity is optimal if it is cheap (q close to 1) and shocks are not unlikely (α is not close to 1). Liquidity hoarding is also more attractive when the pledgeable income (ρ_0) is high: hoarded liquidity is then easily complemented by funding liquidity.

3.2 *Discussion*

3.2.1 *Asset–Liability Management*

Liquidity management must respond to the lack of coincidence between cash flows and needs across states of nature and across time: as we already discussed, risk management aims at partially insuring the firm's liquidity position against insurable risks. Similarly, asset–liability management techniques try to restore some coincidence between the timing of receipts and expenditures; thus, pension funds or life-insurance companies have higher demands for securities delivering coupons fifteen or twenty-five years ahead than banks do. Again, these standard functions of financial officers would be hard to rationalize in a classical economics world,[12] in which firms could costlessly return to the capital market to raise funds when they need to.

While banks have always transformed short-term borrowing into long-term loans, an important precrisis development has been the financial sector's dramatic increase in transformation. Commercial banks, investment banks and a number of other economically or politically influential economic agents made themselves heavily exposed to refinancing in the wholesale market and thereby to variations in interest rates. I will return to this phenomenon in detail in section 7.

Increased maturity transformation is only very indirectly captured in the Basel I (1988) capital adequacy rules. The accord in appearance focused entirely on solvency. Yet it touched on liquidity issues through the concepts of tier 1 (equity) and tier 2 (debt over five year maturity, certain hybrid instruments). As we noted, medium- and long-term debt do not drain cash the way short-term debt does; similarly, preferred equity provides the institution with flexibility in meeting its liquidity demands. In this sense, the capital adequacy requirements defined in 1988 mixed solvency and liquidity considerations.

3.2.2 *"Last Taxi at the Station"*

The conceptual framework makes it clear that liquidity, which is necessarily expensive (otherwise all assets would be liquid assets and there would be no transformation), is meant to be used up in case of important need. Or, as Charles Goodhart would put it, liquidity must be usable liquidity:

> The most salient metaphor and fable in prudential regulation is of the weary traveler who arrives at the railway

[12] Unless markets are incomplete.

> station late at night, and, to his delight, sees a taxi there who could take him to his distant destination. He hails the taxi, but the taxi driver replies that he cannot take him, since local bylaws require that there must always be one taxi standing ready at the station. Required liquidity is not true, usable liquidity. Nor might I add, is required minimum capital fully usable capital from the point of view of a bank. Principles of liquidity management, (and in my view of capital adequacy also), ought to be applied in a much more discretionary manner, pillar 2 rather than pillar 1. (Goodhart 2008, p. 41)

The discussion above however only half-responds to Goodhart's point. The dynamic management of liquidity must account for the fact that drawing down one's liquidity position leaves the institution exposed to a subsequent liquidity shock that could occur in the near future (and so, that would not leave the institution with enough time to replenish its reserves).

Economic theory has not yet offered much guidance regarding the repeated-liquidity-shock conundrum. Nonetheless, very interesting contributions by Bruno Biais et al. (2007, 2010) and by Peter M. DeMarzo and Michael J. Fishman (2007a, 2007b) shed some light on Goodhart's puzzle.[13] Biais et al., for example, show that liquidity is not meant to be fully depleted even though it is indeed reduced after an adverse shock. Discipline is ensured by downsizing when things go wrong, not by a complete exposure to liquidity risk. The spirit of proportionality (for compulsory reserves as well as for capital requirements) should therefore be interpreted as a commitment of supervisors to promptly scale down the activities of banks that do not comply with these regulations, unless shareholders are willing to recapitalize them.

[13] See also Ilhyock Shim (2006).

3.2.3 Does a Leverage/Solvency Ratio Suffice?

Capital adequacy requirements, as we noted, have traditionally emphasized solvency, although their use of maturities in the definition of capital embodies some liquidity considerations beyond priority ones (there is a close relationship, but no equivalence between maturity and priority). An important regulatory issue is whether one should append a liquidity measure to the solvency one. Put differently, can one trust the institutions to properly manage their liquidity, once excess leverage has been controlled by the solvency requirement?

The answer to this question is not as straightforward as one would expect. As we shortly demonstrate, theory tells us that, even in the absence of externalities among institutions (these externalities are considered in sections 4, 5, and 7), institutions left on their own may well under- or over-hoard liquidity, although I will later argue that the former is more likely in general, and especially so in the banking context.

Underhoarding may result from a form of asset substitution, sacrificing insurance for size. The institution may dispose of its liquid assets in order to expand the scale of its illiquid investments. It thereby obtains less insurance, but it still receives some, due to the "soft-budget-constraint" phenomenon: If the shock to be met is not too large, investors will be willing to bring in new funds and bail out the institution. The availability of funding liquidity for self-financing continuations can lead the bank to overinvest and underinsure.

Conversely, it may also be the case that the institution hoards large amounts of liquidity in order to make sure that it will be able to finance even mediocre reinvestments in the future. This reverse form of

asset substitution is linked to the anticipation of poor governance in the future, in which investors will let management finance wasteful continuations.

To most regulators, and certainly to observers of the current crisis, this overhoarding of liquidity and associated excessive initial restraint in the investment in illiquid assets probably feels like a theoretical nicety and a rather remote possibility. Yet, it is related to Michael C. Jensen's (1986) famous condemnation of free cash flows and his prediction of an eclipse of the modern corporation. Jensen's view was that firms often reinvest in wasteful activities if they have available liquidity. He argued that firms should be loaded up with debt, especially short-term debt, whose coupons or principal's reimbursement would force them to disgorge its available cash and to return to the capital market and justify new investments in order to obtain new funds. Jensen thereby counted on abundant funding liquidity and assumed away liquidity problems.

Let us return to the basic model and investigate whether, when left unmonitored, the bank would want to underhoard liquidity when certain continuation is optimal, or to overhoard liquidity when liquidation in case of an adverse shock is optimal.

Temptation to Underhoard?

Suppose that condition (5) obtains and so capital insurance is optimal. Let the banking entrepreneur deviate from the agreement and invest all his date-0 money into illiquid assets. The investment level is then:

$$\mathcal{I} = [1 + q(R - \rho_0)]i.$$

When the bank is intact, the investors cannot credibly punish the banking entrepreneur for this departure from their agreement, since they get $\rho_0\mathcal{I}$ in case of continuation and 0 in case of closure. Thus, a form of soft budget constraint obtains. By contrast the bank is closed down when distressed.

The banking entrepreneur's expected net utility becomes:

$$\hat{U} = \alpha(\rho_1 - \rho_0)\mathcal{I}.$$

Underhoarding occurs if liquidity is left unmonitored if and only if $\hat{U} > U$, or $\alpha\mathcal{I} > i$. Thus underhoarding is a concern whenever

$$\alpha[1 + q(R - \rho_0)] > 1. \tag{7}$$

Ceteris paribus, underhoarding is thus more likely, the lower the probability of a shock (α large), the more expansive the stores of value (q high), and the higher the cost of refinancing (R). Of course, to obtain a complete picture, we should not forget that underhoarding is possible only if hoarding liquidity is optimal in the first place, that is, $i \geq \alpha I$. Thus underhoarding also requires $\mathcal{I} > I$, or

$$\frac{1 + q(R - \rho_0)}{1 + q(R - \rho_0) - \alpha R} > \frac{1}{1 - \alpha\rho_0},$$

which can be shown to be equivalent to

$$\rho_0 < \frac{1}{q}. \tag{8}$$

To sum up, underhoarding may occur if (7) and (8) (which are not inconsistent) are satisfied.

Note the nature of the externality on investors: when economizing on liquidity to increase size, the banking entrepreneur deprives the investors of the value $(R - \rho_0)i$ of the store of value when unneeded (i.e., when the bank is intact); on the other hand, the investors also make a large profit, due to the large size, when the bank is intact. In order for the banking entrepreneur to benefit from underhoarding, it must be the case that investors lose in net terms. This is not always the case, and indeed condition (7) is required to obtain underhoarding.

Temptation to Overhoard?

Suppose that, to the contrary (5) is violated and so it is optimal not to have capital insurance. The banking entrepreneur, when deviating from the agreement and allocating some of the date-0 cash to stores of value, can invest at level k given by:

$$I = k + q(R - \rho_0)k.$$

Let us assume that at date 1, $(R - \rho_0)k$ is then some "free cash flow" (à la Jensen) that the banking entrepreneur can use in case of distress (note that the investors have no incentive to let him do so, as they prefer to pay themselves $(R - \rho_0)k$ rather than reinvest this sum into a negative NPV project).

Overhoarding yields expected net utility

$$\hat{U} = (\rho_1 - \rho_0)k$$

and benefits the entrepreneur if and only if $k > \alpha I$, or

$$1 > \alpha[1 + q(R - \rho_0)], \tag{9}$$

that is if (7) is violated.

The nature of the externality on investors can again be described in terms of size versus availability of the store of value: When the bank is intact, the claimholders obtain a lower profit due to a lower size, but can seize the hoarded liquidity $(R - \rho_0)k$, that they were not expected to be available.

As earlier, we must not forget that capital insurance was suboptimal in the first place, i.e., that $\alpha I > i$. Thus overhoarding may arise if and only if $k > i$, or

$$\frac{\rho_0}{R} > \frac{1}{1 + q(R - \rho_0)},$$

which is equivalent to

$$\rho_0 > \frac{1}{q}. \tag{10}$$

Note that (10) holds when (8) is violated. The overhoarding analysis thus perfectly mirrors that of underhoarding!

3.2.4 *Other Considerations*

To sum up, our discussion so far tells us only that the liquidity choices cannot be completely left to the bank, but, unless one is prepared to calibrate the theoretical analysis, it does not indicate whether the surveillance of liquidity positions should take the form of a minimum-liquidity ratio, a maximum-liquidity ratio, or both. Yet, I feel that the focus ought to be mostly on the definition of a minimum liquidity requirement. First, overhoarding requires poor corporate governance, enabling management to make a discretionary use of the free cash flow. While free cash flow problems do occur in practice, the case for underhoarding requires no such assumption. Second, and in the specific context of banking regulation, I *venture* into three possible extra reasons for focusing on minimal liquidity requirements, all related to the idea that low liquidity positions sacrifice insurance for scale and therefore represent an increase in risk:

- *Regulatory mandate*. Banking regulators are particularly concerned about the debt part of the balance sheet, and in particular about the welfare of retail depositors or the deposit insurance fund. In this respect Mathias Dewatripont and Tirole (1994) developed the "representation hypothesis," according to which a major objective of regulation is to make up for the inability (and suboptimality) of small depositors—insurees in insurance companies, future pensioners in pension funds—to monitor and exercise control over the institutions in which they invest their money. The banking regulator, according to this view, represents the interests of the retail depositors or, if the latter are insured, of the

deposit insurance fund. This naturally gives regulators a rather conservative (risk-averse) slant, as they may not care much about the upside. Put differently, a lack of cushion is particularly hazardous for debtholders.

- *Systemic risk*. Potential domino effects of a banking failure have become very prominent lately, and have inspired a number of bailout decisions (for example, AIG's). Accordingly, there is an externality-based rationale for insisting on banks' holding enough liquidity so as not to expose the rest of the financial system to a widespread crisis. This argument is appealing but is not without its own limitations; for, one may wonder whether liquidity hoarding is the most efficient instrument to address systemic risk (I will discuss others), or even part of an optimal package of instruments to control that risk. We will return to domino effects in section 5. Section 4 will investigate another "fire sales" externality created by illiquidity.

- *Macroprudential regulation*. As I will discuss in section 7, authorities should protect themselves against widespread maturity mismatches. This offers a clear rationale for minimum liquidity requirements.

4. *Market Liquidity Breakdowns*

Market liquidity presumes that there are buyers (of assets, of securities) on the other side. As the recent crisis has demonstrated, this need not be the case. Commentators have accordingly mentioned the possibility of a "buyers' strike," a surprising concept for economists used to the notion that prices will adjust downward to the level at which buyers will be willing to acquire the assets.

For simplicity, I will couch much of the discussion in terms of the securitization market. It is clear that similar insights apply to the interbank market,[14] which also froze substantially during the recent crisis. Lending in interbank markets, like purchases in the securitization market, rests inter alia on trust about the quality of the borrower's/issuer's assets (remaining on the balance sheet, and securitized, respectively),[15] and on the ability of prospective buyers to raise cash to finance purchases.

This section considers three reasons why market liquidity may break down: adverse selection (doubts about the quality of the assets), insufficient financial muscle of prospective buyers, and regulatory arbitrage.

4.1 *Securitization Freezes and Stigmas*

4.1.1 *Securitization: The Fundamentals*

Securitization has recently, and understandably, come under attack. If it has been vastly abused, one should not forget that securitization is a useful institution for three reasons: first, it allows issuers to raise new cash and thereby undertake new projects. Securitization is then about the certification of the quality of past activities; asymmetric information about the real value of the return streams attached to the loans makes it difficult to offer the loan portfolio as collateral against further borrowing. The securitization process, if it is accompanied by careful

[14] The interbank market has recently received much theoretical and empirical attention, see, e.g., Viral V. Acharya, Denis Gromb, and Tanju Yorulmazer (2009), Acharya and Ouarda Merrouche (2009), and Florian Heider, Marie Hoerova, and Cornelia Holthausen (2009).

[15] But of course, the borrower's choice between selling an asset and issuing new securities hinges on a number of other considerations. For instance, keeping the assets on the balance sheet may facilitate the management of these assets by the borrower. It also gives a wider access to collateral to the lender (as in the case of covered bonds). But it is probably more information-intensive for the lender.

scrutiny by buyers, rating agencies or credit enhancers, certifies the quality of the portfolio to the market and transforms otherwise illiquid assets into tradable ones.[16] If properly performed (i.e., with the right incentives in place), this process thereby boosts the institution's solvency position, a view reflected in the lower capital requirement for banks when the assets they securitize qualify as sales.

Second, and in an economy in which stores of value are in high demand, securitization creates new stores of value[17]; this effect is not to be neglected, as the demand for American stores of value stemming from China and other countries with underdeveloped financial markets or more generally a shortage of stores of value relative to their savings, increased the scarcity of stores of value in the United States and made it particularly profitable to issue new ones.[18]

These two reasons (bank-level and macroeconomic level) fit well with Hernando de Soto's (2003) view that a major role of a financial system is to transform "dead capital" into "live capital." Third, securitization may in some cases allow the institution to diversify its risk.

Securitization of assets is fraught with asymmetric information hazards: moral hazard to the extent that issuers have little incentive to create high-value instruments if they anticipate selling a major stake in them; and adverse selection whenever the issuer is able to cherry pick the loans to be put on the market. There is increasing evidence that asymmetric information has played a key role in securitization of loans, e.g., Benjamin J. Keys et al. (2010).

Of course, these hazards are sharply reduced (and therefore the fraction to be securitized can increase) if monitoring occurs at the securitization stage. At least two monitors play a substantial role:

- *Rating agencies*' mandate is to assess the quality of the assets. We now understand too well that the rating agencies did not play that role successfully in the case of structured finance. Conflicts of interest, advice on how to structure portfolios (which created marginal AAA claims where the market was expecting average AAA tranches) and prerating assessments all conspired to mislead the market. The realization that rating agencies were not doing their job raised new doubts about forthcoming issuances, and contributed to the freeze of the securitization market. Rating agencies are auxiliaries of regulation; their being part of the regulatory process, and the strong appetite for AAA-rated securities associated with the regulation of banks (since Basel II), insurance companies and pension funds, boosts their earnings. It is therefore logical that they be accountable to the prudential regulators if their ratings are used for regulatory purposes.[19]

- Second, *buyers* themselves are meant to assess the quality of the claims. In an IPO (which is a form of securitization),

[16] The securitization process is very similar to the exit mechanism in venture capital deals. This exit mechanism enables the venture capitalist to mobilize illiquid capital (part or all of his/her share in the venture), certify it through an initial public offering or a sale to a knowledgeable buyer, and thereby avail himself/herself of new funds to undertake new deals.

[17] These assets can also act as stores of value when remaining on the balance sheet of the bank and being funded by deposits. The reduction in capital requirements associated with securitization implies that stores of value are created when the assets are transferred, though.

[18] See Ricardo J. Caballero, Farhi, and Pierre-Olivier Gourinchas (2008).

[19] One may be concerned that the same rating agencies (S&P, Moody's and Fitch) also rate sovereign debt, and thus cannot be regulated thoroughly by governments if the quality of sovereign debt may be called into question. In the absence of structural separation between corporate and sovereign debt ratings, the best safeguard against such collusion is probably regulatory independence vis-à-vis politicians.

this is achieved through the issuance of equity—an information-intensive claim—and by creating enough volume—for example through the institution of drag-along rights[20]—so as to attract interest in the issue. In the case of Mortgage Backed Securities in the recent crisis, buyers did not monitor very carefully the claims that they were acquiring. The reason for this is that they may have been more interested in acquiring highly rated securities (which carry only small capital charges) than concerned about a low-probability, but large default.

This brings us to the regulation of securitization. The adverse selection and moral hazard problems mentioned above are well understood, and we would expect markets to adapt to them and determine the optimal level of "skin in the game" that issuers must keep.[21] When regulated institutions are involved as issuers or buyers, though, the regulator may need to monitor that depositors' or taxpayers' money not be jeopardized by an improper securitization process. In my view, the problem arises more when a regulated entity is on the buying side: when it is on the selling side and provided that the sale is final (no possible recourse), then it is the buyer's responsibility to exercise due diligence and to demand a lower price if little skin in the game is maintained. By contrast, when the regulated institution is on the buying side, careless purchases may endanger its solvency, as the recent crisis demonstrated.

What is the optimal level of skin in the game? On the theoretical front, a mechanism design analysis of optimal securitization illustrates the trade-off between the benefits of securitization—say the transformation of illiquid claims into cash—and its cost—the reduction in accountability. The optimal retention rate is highly asset-dependent, making it hard to specify in a "one-size-fits-all" regulation a minimum amount to be kept by the issuer—in 2008 the European Union required its banks to keep at least 5 percent (as opposed to 15 percent in the initial proposal) of their securitized assets on their balance sheets. A claim on a reliable local government can be almost entirely resold without creating moral hazard, while a claim on a highly risky borrower or project may be fraught with moral hazard and adverse selection. This makes it hard to design good, across the board regulations that preserve proper incentives for the issuer while safeguarding the benefits of securitization.

4.1.2 *Securitization Breakdowns*

The process of market breakdown was well explained by George A. Akerlof (1970) four decades ago. In a market in which the quality of items for sale is known only to sellers, highest-quality sellers are the first to withdraw from the market when doubts about asset quality lead to a reduction in the market price. Their exit further lowers the price and triggers another exit wave by sellers with slightly lower quality assets, and so on. The market can quickly shift from an efficient, high-volume one to a transactionless market.

Frédéric Malherbe (2009) goes one step further and points out that market liquidity is affected not only by news about the overall quality of assets (for example the likelihood that subprime borrowers reimburse their loans, or the integrity of rating agencies),

[20] Drag-along rights allow for example a majority shareholder to force minority shareholders to sell their shares to a buyer (at the same price and conditions). They thereby facilitate the sale of 100 percent of the rights to a buyer; or they increase volume and thereby raise investor interest in an IPO.

[21] An approach related to, but different from securitization is the issuance of covered bonds. The pool of assets serving as collateral for such a bond remains on the issuer's balance sheet; in case of default, the investors have recourse to both the pool and the issuer, who therefore keeps substantial skin in the game.

but also by the market's perceived motives for selling. His theory is based on the idea that liquidity-driven sales disguise information-driven ones: Suppose that banks' exact liquidity positions are not known by the market (presumably because of the difficulties involved in apprehending these liquidity positions and reviewed in section 2). If it expected that banks hoard substantial liquidity, then the market is subject to much adverse selection and breaks down: The motive for selling assets must be that they are of low quality, not that the banks really need cash. Liquidity hoarding is then self-fulfilling, as banks cannot count on securitization to raise cash and must hoard liquid assets. Conversely, a situation in which banks are expected to hoard little liquidity reduces the adverse selection (banks need to raise cash and are expected to also sell high-quality assets), and thus the prospect of a well-functioning securitization market dispenses banks from hoarding costly liquidity.

A corollary of Malherbe's theory is that banks that want to part with some of their assets benefit from appearing fragile. This behavior resembles that of students' insisting in ads for selling their car that they are graduating and moving out of town ("moving sale"), or that of homeowners who go at great length to explain that they have exogenous reasons to sell their house. But how can this prediction that ceteris paribus a bank would like to convey the impression of illiquidity be reconciled with the widespread observation that banks strive to avoid the stigma of looking fragile? For example, banks, whenever feasible, try to avoid borrowing at the discount window to avoid the associated stigma (in the same way that the IMF's contingent credit lines have never been used by countries by fear of being stigmatized). There is actually no contradiction between the two, due to the following suggestion:

"*Topsy-turvy principle*": Appearing illiquid is a plus for a bank that looks for market liquidity, and a handicap for one that wants to tap funding liquidity.

The idea that banks that expect the securitization and interbank markets to freeze will increase their hoarding of liquidity either as an insurance device (as in Malherbe's paper) or for predatory purposes (as in the literature on financial muscle discussed below) resonates with the recent crisis, which saw a huge amount of hoarding by financial institutions.[22]

4.1.3 *Endogenous Information about Asset Quality and Market Breakdown*

An interesting point of Malherbe's analysis is that adverse selection and market breakdowns are highly endogenous. In this respect, imperfect information about underlying liquidity positions is only one of several drivers of this endogeneity. Another driver is endogenous information acquisition about asset quality, the topic of recent contributions by Marco Pagano and Paolo Volpin (2009) and by Tri Vi Dang, Gary B. Gorton, and Holmström (2009).

It is often assumed that more information (increased transparency) reduces the competitive advantage that sophisticated investors have over unsophisticated ones. This reasoning is correct if what differentiates sophisticated investors is the ability to go and collect facts. It is flawed if sophistication refers to a higher ability to figure out what a given information actually means (Pagano and Volpin 2009). Thus if what is at stake is the differential ability to process information, more public information means higher asymmetries of information and therefore more concern for unsophisticated buyers. Consequently, the seller of securities may not want to disclose too much information in order to "reach" the

[22] For example, Acharya and Merrouche (2009) document that after August 2007 liquidity buffers of U.K. banks increased by 30 percent. Another illustration is the dramatic increase in parking at the ECB after September 2008 (Heider, Hoerova, and Holthausen 2009).

unsophisticated buyers and obtain a higher price for the securities in the primary market (as Pagano and Volpin show, conclusions are different for the secondary market).

To discuss Dang, Gorton, and Holmström's (2009) contribution, it is useful to start with some reminders about the impact of the information sensitivity of financial claims. It has long been understood (Jack Hirshleifer 1971) that, in a world in which parties cannot contract on trades before receiving information, the possibility of acquiring information jeopardizes the provision of otherwise desirable insurance. This idea plays an important role for example in the debates on genetic testing or mandatory health insurance coverage. That private information acquisition may impact transactions was developed in financial economics in celebrated contributions by Steward C. Myers and Nicholas S. Majluf (1984) and Gorton and George G. Pennacchi (1990), which share the notion of "low-information-intensity security."[23] A low-information-intensity security is one for which the value of information about the quality of the underlying asset is small. The security is in a sense a "no-brainer."

Myers and Majluf, and a sizable subsequent literature on security design, have argued that issuers endowed with private information about the value of underlying assets will want to follow a pecking order in the type of securities they issue. Safe debt is an instrument of choice, as it does not give rise to adverse selection; with larger cash needs the issuer ought to go for more and more "information-intensive" securities, even though the corresponding markets are fraught with adverse selection: risky debt, hybrid securities, and, in the last resort, equity. The same idea explains why the collateral posted in repos has historically (although not lately, with assets such as CDOs being used as collateral prior to the crisis) been safe securities such as Treasury securities.

Information intensity refers to the gain that a seller or buyer of this security can secure by acquiring costly information about its value; for example, there is no gain acquiring information about the value of a debt claim sufficiently covered by high-quality collateral, but there are substantial gains in acquiring information about the value of shares in an initial public offering.[24] While this concept is context dependent (it depends on the price of the security and therefore, inter alia, on whether other investors are acquiring information), it is a very useful tool to understand the working of financial markets.

Analyzing security design as well, but focusing on future rather than current adverse selection, Gorton and Pennacchi make the point that different clienteles may be interested in securities with different information intensities. Safe debt is very attractive to investors with short horizons (in the sense of a high probability of turnover), as they will not "lose their shirt" when they need to resell their securities; by contrast, an investor holding shares in a corporation is likely to face better informed traders when he resells his stake and will on average lose money to them.[25] This theory,

[23] See chapters 6 and 12 in Tirole (2006) for a review of this literature. A recent literature (Thomas Philippon and Vasiliki Skreta forthcoming and Tirole forthcoming) adds a government which would like to restart a market marred by adverse selection. In these papers, institutions may anticipate the market rebound and not participate in the government scheme.

[24] Note that Myers and Majluf's pecking order is reversed in an IPO, as information-intensive securities are issued so as to provide investors with incentives to acquire information about the value of assets in place and thereby enable exit by the venture capitalist and possibly the managerial team without impairing their initial incentives. On this see Philippe Aghion, Patrick Bolton, and Tirole (2004).

[25] For the same reason, stock market indices are more attractive than individual stocks for short-horizon investors, as it is widely believed that there is less adverse selection on a large number of securities than on individual ones: see Gorton and Pennacchi (1993) and Avanidhar Subrahmanyam (1991).

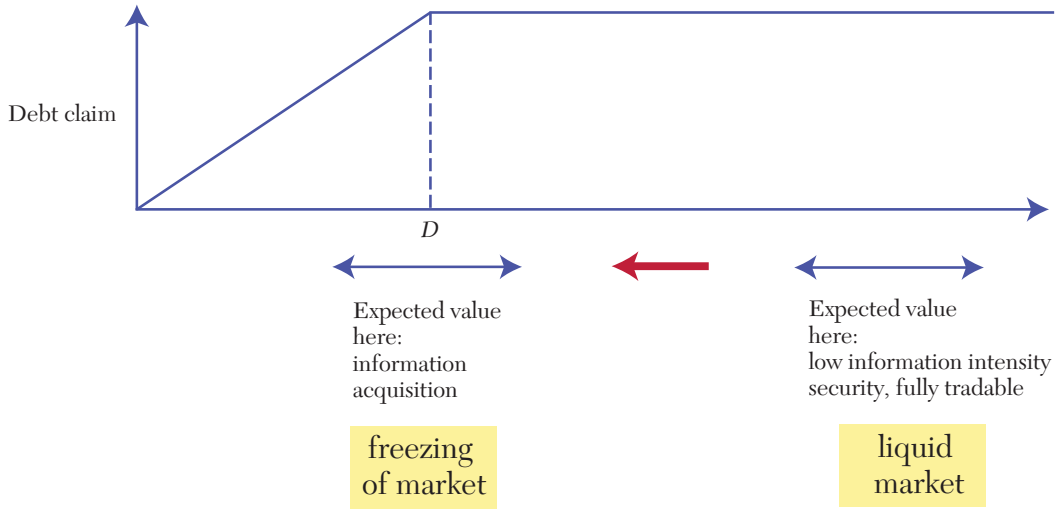

Figure 2. Dang–Gorton–Holmström's Double Whammy Argument

which incidentally predicts an equity premium, also resonates with common wisdom, as main street bank employees usually recommend bonds to investors with short horizons and stocks for their retirement savings.

Dang, Gorton, and Holmström (2009) make a simple, but important observation: a security's information intensity varies with news accruing about the quality of the underlying asset or borrower. Consider for instance a debt claim. As long as the underlying assets pay off nicely or the borrower remains solvent, the ex post return on the debt claim is constant. So additional ex ante information about the quality of the underlying asset (or about the borrower's solvency) is almost useless; that is, the return on a debt claim is relatively insensitive to additional information when (publicly known) prospects are favorable and so its reimbursement is pretty secure (the option is well into the money). By contrast, when doubts about the quality of assets or the borrower's solvency are raised, it becomes profitable for potential sellers and buyers of the security to go and collect information about the real value. In a nutshell, the market for the security switches from a liquid, symmetric information market to an illiquid, low-volume one in which adverse selection and suspicions about the motives for trade are paramount.

Dang et al.'s analysis, which is depicted in figure 2, implies that institutions should be wary of market liquidity (the option to resell assets) as a means to cover their liquidity needs. Not only is it the case that bad news about the quality of assets may lower the resale price; but precisely in that event, the secondary market will be fraught with adverse selection and will dry up. This double whammy prediction fits well with the recent episode, in which the securitization market, the repo market and a number of other collaterized markets froze.[26]

[26] It also responds to the possibility—related to the previous discussion of Malherbe—that asset markets should become more liquid when lots of institutions are in distress and so the motive for selling is unlikely to be adverse selection (Harald Uhlig 2011). Uhlig proposes an alternative theory for why markets may freeze when bad news accrues; this theory is based on the assumption that investors are "uncertainty averse"—they are only willing to pay the value corresponding to the lower bound of the support of possible distributions.

4.2 *Local Liquidity, Financial Muscle, and Fire Sales*

Common sense suggests that asset prices are likely to be low when lots of assets are for sale in the market. Standard (market microstructure) theory explains this through the presence of adverse selection: a high volume of sell orders suggests that sellers/speculators are pessimistic about prospects.[27] Thus, the demand curve for securities is not perfectly elastic.

This theory does not seem to account for fire sale episodes such as the one we just witnessed. Somehow, one feels that, beyond the adverse selection problem discussed in section 4.1, there is also a limit to arbitrage. Potential buyers don't have enough financial muscle to acquire the assets. Or, to use a term coined by Holmström, "local liquidity" is limited.

Thus, a now sizable literature has investigated institutions' incentives to hoard liquidity for the purpose of acquiring assets in distress from other institutions in the future. A simple, but important point is that, if liquidity is costly, then assets must be expected to trade in the secondary market at a price below their fundamental value at the date of secondary trading; for, the wedge between fundamental value and price in the secondary market is what gives institutions ex ante incentives to hoard liquidity. Otherwise, institutions would sacrifice return and would be better off investing only in illiquid assets and not hoarding liquidity.

An important early analysis of fire sales is due to Franklin Allen and Douglas Gale (e.g.,1994, 1998). Their analysis is couched in a Douglas W. Diamond and Philip H. Dybvig (1983)-style model of consumer liquidity demand. Imagine that today investors separately invest in liquid (short-term) assets, that yields a safe return at the intermediate date, and higher-yield illiquid (long-term) assets. Tomorrow a fraction of consumers will want to consume; to this purpose, they will use the returns on the short-term assets and also will resell their long-term assets. The focus of the 1994 paper is on how much these long-term assets will fetch in the secondary market. There is aggregate uncertainty, in that the number of consumers who desire to consume early is random. The clearing condition in the secondary market for the long-term asset is that consumers who desire to consume late use the proceeds of their short-term assets to purchase the long-term assets unwanted by the consumers who desire to consume early. The former—the buyers—have limited cash on hand, and so the asset price decreases when more consumers—the sellers—want to dispose of their long-term assets in the market. This phenomenon is called "cash-in-the-market pricing" by Allen and Gale.

Allen and Gale later allow intermediaries to pool liquidity and to offer noncontingent deposit contracts. The lower the resale price, the more long-term assets the intermediary needs to sell in order to honor its commitment toward depositors. This, together with the intermediaries' limited liability, adds a discontinuity in the resale price of the secondary asset. If the resale price is too low, the intermediary goes bankrupt and then its entire holdings of long-term assets are dumped on the market, creating a "crisis."

The literature on financial muscle more generally emphasizes the role of contract incompleteness (the absence of ex ante pooling arrangements for sharing liquidity) and ex post secondary markets for assets. Caballero and Arvind Krishnamurthy have in a series of papers (for example 2003, 2004)

[27] This idea, due to Albert S. Kyle (1985), does not conflict with Malherbe's theory (reviewed above). In the market-microstructure story, sell-orders are large and prices are low when news about the asset is bad and unobservable. In Malherbe's story, sell orders and price increase when public information accrues that potential sellers need cash. In either case, liquidity-driven sales disguise information-driven ones and sustain the price of the asset.

emphasized the scope for under hoarding of liquidity in environments where intact institutions' financial muscle exerts positive externalities on distressed institutions. Similarly a number of recent papers on fire sales externalities have shown that pecuniary externalities matter when agents are liquidity constrained: individual institutions do not internalize the fact that their maturity mismatch will depress the market price of assets in the secondary market in case of an adverse macroeconomic shock and thereby hamper the other institutions' ability to refinance.

But liquidity may also be *over* hoarded for rent seeking purposes. In Holmström and Tirole (2011, chapter 7), institutions hoard costly liquidity in order to overbid rivals in the market for distressed assets. A reinterpretation of such "vulture behaviors" has institutions with cash playing a waiting game and refusing to buy distressed assets at fire-sale prices in order to buy them at a still lower price in the future. This behavior may have taken place in the recent crisis, when cash-rich institutions accumulated reserves at the central banks rather than lending their extra cash to, or buying assets from distressed institutions.[28]

4.3 *Regulatory Arbitrage*

The notion of market breakdown hinges on the idea that some gains from trade are not realized. But what if there are actually no gains from trade between the two sides of the transaction? Diamond and Raghuram G. Rajan's "asset substitution theory" (forthcoming), applying the theory of debt overhang and risk shifting, offers an alternative perspective for the recent freeze of some markets. In a nutshell, a transfer of assets from distressed institutions to deep-pocket ones would enable the former to refinance and would benefit the society as a whole; it may however not be in the interest of the two protagonists in the transaction, the buyer and the seller. Diamond and Rajan's idea is that a third party not involved in the transaction, the taxpayer, would benefit from the trade, which would make the government's stake in the distressed bank (for example, the deposit insurance fund's stake) more secure. But the buyer and the seller do not internalize this gain. In the absence of bilateral gains from trade, the management of the distressed bank refuses to sell assets at a low price in the hope of good news.

To illustrate such "gambling for resurrection" in a rather stark way, suppose that the distressed bank owes a liability of 8 to depositors (or the deposit insurance fund). It owns an asset of nominal value 10. However bad news accrues, that indicates that this asset will pay off 10 with probability ½ and 0 otherwise. Information is symmetric, and so buyers would be willing to buy at price $p = 5$. But the intact bank is better off holding on to this asset in the hope that it recovers and enables it to make a profit of $10 - 8 = 2$. Because the depositors' claim is a debt claim, the distressed bank prefers to keep its call option. This example of course is too simplistic; to make it more interesting one can add a benefit from the distressed bank's enjoying some liquidity, such as refinancing new projects. But as long as the distressed bank benefits substantially from hanging on to its call on asset recovery, the asset market will remain inactive.

This example illustrates the more general point that regulatory arbitrage may interfere with markets. Another illustration is provided by the recent relaxation of accounting standards, enabling financial institutions to return to historical cost accounting under certain circumstances. When historical levels are allowed as measures of asset values, institutions are incentivized to sell winners (and then record them at their market value) and to keep losers so as to avoid recognizing

[28] It is hard, of course, to know whether this behavior was motivated by a waiting game or by the fear that they themselves might need cash in the near future.

losses.[29] This reluctance to sell losers can lead to a freeze of markets that would operate normally in the absence of regulation.

5. *Economics of Domino Effects*

An institution's liquidity and solvency may be jeopardized if the solvency of other institutions it has lent to is compromised. This section reviews what we know and don't know about systemic risk.

5.1 *Centralized versus Decentralized Trading*

One of the major regulatory failures of this decade has been the lenient attitude of regulators toward OTC markets, or more precisely toward the involvement of strategic players (players whose stability is crucial to the economy) in these markets. For instance, AIG's holding company, an investment bank which was involved in $440 bn in protection contracts, was rescued by fear that a large-scale domino effect would result from bankruptcy. The traditional view of prudential regulation, the protection of depositors, has recently left center stage, and systemic risk has become by far authorities' main concern.

It is natural for financial institutions to lend to each other. Such lending may smooth liquidity positions; for example, a bank or mutual fund may have incurred substantial withdrawals or redemptions while others have not and thereby hold excess liquidity. Similarly, risk management necessitates entering into interest rate and foreign exchange swap agreements, or CDS contracts.[30] This pooling of risk and handling of asynchronicities however gives rise to a new type of risk, the counterparty risk associated with cross exposures. Accordingly, mutual exposures raise concerns for the system's financial stability.

There are two polar views on how cross exposures are to be handled. In a *centralized* approach, transactions between two parties involve a clearinghouse acting as a counterparty to the trade. In a *decentralized* approach, epitomized by the OTC markets, no one interferes with the cross-exposures and the two parties are free to take as much counterparty risk and/or require as little collateral requirement (i.e., low haircuts on the collateralized assets) as they like.

Hybrid systems combine centralization with cross exposures. For example, a large value intraday payment system may be centralized, but let each participant set bilateral overdraft ceilings, which are akin to bilateral credit lines. The bilateral overdraft ceilings are then aggregated by the system to define an individualized overall cap on each member's intraday overdraft. In case of default of a participant at the end of the day, a loss sharing formula has members share the losses of the failing bank proportionally to the overdrafts granted to the failing bank. See the analytical framework in Rochet and Tirole (1996a), which combines the properties of the Clearing House Interbank Payments System (CHIPS) and the Federal Reserve Banks' gross-settlement system Fedwire.[31] The latter is centralized and involves no cross exposures among participants but allows overdrafts (priced and subject to a net

[29] See, e.g., Dewatripont and Tirole (1994) for a discussion of gains trading.

[30] Shin (2009) further argues that mutual exposures arise naturally in long chains of intermediation, such as mortgage pool–ABS issuer–securities firm–commercial bank–money market fund.

[31] CHIPS is a privately held net settlement system. It has a smaller membership than Fedwire (only 47 very large institutions participate, while Fedwire has 9,289 members), and nets payments at the end of the day. CHIPS opens at 9 AM. Between 9 AM and 5 PM, banks send payments to each other; they must maintain a positive net balance up to the credit limits that were arranged among banks before 9 AM. CHIPS requires banks to fund their negative closing positions by 5:15 PM; payment orders are then sent through Fedwire. Fedwire is a real-time gross settlement system. The payment of a transaction is processed at the time of the transfer (say 11 AM) rather than at the end of the day (say 5:30 PM). Payments are final and irrevocable.

debit cap) with respect to the Fed. The former by contrast allows its members to give each other intraday credit facilities.

Conversely, in some extreme cases, decentralization may not imply cross exposures. The recent regime of government guarantees on interbank lending is a case in point. Under guaranteed interbank lending, a loan from bank *A* to bank *B* is de facto a loan from the government to bank *B*. This raises the question of why the government does not lend directly.

Centralization should be encouraged, as the benefits of decentralization can be duplicated on centralized platforms, and the latter have further benefits:

- *Transparency.* In a decentralized system, parties know their cross-exposures with their counterparties, but they have little clue about their counterparties' exposures to third parties. Although the fall 2008 disruption may have other causes, the Lehman Brothers episode is a case in point, which later led the U.S. authorities to rescue some other key financial players by fear of propagation. By contrast, the collapse of the large hedge fund Amaranth in 2006 had very little impact on financial markets, as the hedge fund was trading in well-organized (mainly energy) centralized markets.[32] Transparency is important also for the regulators, as interconnections currently make it almost impossible to figure out what the real solvency of individual institutions is.

To be certain, regulators could demand transparency of positions even in decentralized markets. However, the complexity posed to regulators by this solution is daunting. OTC products are often very complex objects whose covenants and implications thereof are understood by only a handful of experts. Furthermore, the chain of counterparty risks remains rather opaque. Centralization of trades through a central clearing counterparty of course is no panacea. Poorly monitored, a central clearing counterparty might take on substantial direct or indirect counterparty risk vis-à-vis the members. It might thereby become yet another "too-big-to-fail institution." It is therefore important to apply careful prudential regulation to such parties. This brings me to a second desirable move.

- *Standardized products.* There are substantial social benefits to the trading of financial products in liquid markets. The existence of market prices in particular allows the central clearing counterparty to be more accurate in the dynamic adjustment of its margin calls. And, crucially, it allows supervisors to better monitor the solvency of central clearing counterparties and therefore to reduce the likelihood of a bailout of such institutions. The standardization of products, which could be promoted through a sufficiently strong differentiation in capital charges for regulated entities, comes at a cost as regulated entities will find it more expensive to provide their customers with finely tailored (bespoke) products. [33] But many useful derivative products (exchange and interest rate

[32] In September 2006, Amaranth lost $6 bn out of the $9 bn it was managing. By contrast, the direct losses from Lehman's failure were relatively modest (net payouts on its CDS contracts amounted to $5 bn); but that failure had a major macroeconomic impact and completely changed the IMF global growth prospects (Andrew G. Haldane 2009). Stephen G. Cecchetti (2007) compares the failure of Amaranth with that of LTCM (1998), whose interest rate swaps were not traded on an exchange.

[33] There is no reason to prevent nonregulated entities from trading in nonstandard products or for that matter in nontransparent markets.

swaps, commodity insurance, credit default swaps, etc.) can be or already are standardized. The loss in granularity in my view is second order compared to the externality currently inflicted upon society by current arrangements.

- *Multilateral netting.* Decentralized markets allow netting between two institutions. By contrast, centralized ones enable multilateral netting, thereby reducing collateral requirements. If *A* owes money to *B*, who owes money to *C*, who owes money to *A*, bilateral netting won't save on collateral as each pair's relationship involves a large net exposure. Centralized systems are a priori superior to decentralized ones, as they can mimic the benefits of bilateral deals while not exhibiting their flaws. I have already mentioned the possibility of embodying transparent mutual overdraft (exposures) in a centralized system. Duffie and Haoxiang Zhu (2009) analyze potential costs of central clearing platforms. The first is the proliferation of platforms (for example there are currently two approved CDS central clearing counterparties in the United States and five in Europe); unless these institutions are connected through cross-margining agreements,[34] the resulting outcome may be very costly in collateral if cross-exposures are widespread and so players must be active on multiple platforms. Second, the desirability of netting also applies cross-products. One may net a CDS contract with an interest-rate swap contract. The challenge then is to allow competition between well-organized and secure clearinghouses without losing the benefits of netting and collateral pooling.

5.2 *Regulatory Reforms*

The recent explosive growth of OTC derivative markets has added much opacity and can be viewed as a form of regulatory evasion in which cross-exposures were underpriced in terms of capital requirements. "Too interconnected to fail" unregulated institutions were rescued at the expense of the taxpayer; although this was not the first time,[35] the magnitude of the recent bailouts of unregulated institutions is alarming. Such institutions were able to have their cake and eat it too. They were unregulated and at the same time could avail themselves of an access to a safety net built on taxpayer money, which allowed them to borrow from other parties without being carefully monitored by the latter. Relatedly, and importantly, both markets and regulators have little information about the consequences of pulling the plug on an institution. The bankruptcy of Lehman is widely believed to have had major consequences on the functioning of the markets worldwide. Opacity thus has a major cost for markets and not only for taxpayers.

Is the solution to enlarge the scope of regulation? Some oversight will be imposed on hedge funds, or more generally "tier 1 institutions" that are deemed to expose the financial system to systemic risk. This however is likely to prove very insufficient for two reasons. First, regulators are understaffed and have a hard time overseeing institutions (retail banks, insurance companies, pension funds) with small depositors. Extending the scope of regulation will require a substantial upward adjustment in their budget. Second, and before you know it, Pacific Gas and Electric, General Electric and Boeing will become hedge funds if the existing hedge funds and other institutions in the tier 1

[34] Under cross-margining, a market participant can take excess collateral/margin on one account to meet the collateral requirement on another account.

[35] Recall the rescue of the LTCM hedge fund in 1998. The Fed then coordinated an injection by the creditors of LTCM. The fund was liquidated in 2000.

group are subject to a strict regulation. The lack of clear critera for defining tier 1 institutions and the potential migration of risk taking could imply that the entire private sector would need to be subject to regulatory reporting.

In my view, a better approach is to return to the standard rationale for micro-prudential regulation and to delineate a regulated sphere (retail banks, insurance companies, pension funds, broker-dealers) in which the regulators defend the interests of unsophisticated investors. Interaction between this regulated sphere and the rest of the economy should take place in standardized products and on approved clearinghouses, or else should be subject to substantial capital charges.[36] There is of course a cost to this solution, as OTC markets allow contracts to be finely tailored to individual circumstances. However, it has become clear that contracts in OTC markets often have been motivated more by the prospect of fees and by underpriced capital requirements than by first-order hedging benefits. Innovation in financial markets could in part migrate to the development of standardized products beyond the existing ones, so that most of the participants could cover their major risks. The loss in terms of market completeness then seems dwarfed by the misbehavior and huge bailouts that resulted from OTC markets.

5.3 *Economics of Contagion*

A large literature (e.g., Allen and Gale 2000a, Nobuhiro Kiyotaki and John Moore 1997) describes how a small shock to one institution or to the economy may propagate in a financial system with given cross-exposures. For example, domino effects are shown to be related to the completeness of the structure of claims (Allen and Gale). This literature also illustrates the opaqueness associated with bilateral exposures. As Caballero and Alp Simsek (2009) note, in order to know the health of its counterparties, a participant in financial markets must also know the health of its counterparties' counterparties, and so on. Becoming well informed about the solvency of the entire financial system is daunting for participants regulators.[37] Caballero and Simsek show how deteriorating conditions may make information processing unmanageable to banks and result in a panic (a generalized withdrawal/flight to quality equilibrium).

While this literature obtains a number of useful insights, my view is that one should still build on it in order to derive policy implications. A "Lucas critique" of this literature is that one cannot assume that the network of cross exposures is unaffected by the regulatory environment or by the underlying risk structure. Different environments will give rise to different mutual exposures and contagion possibilities. Recall our discussion of intraday payment systems. There, the possibility of domino effects has been taken on board for decades, and centralized systems with very visible and limited cross exposures have been put in place. Put differently, the parties (institutions, regulators) are cogniscent of the possibility of domino effects and have accordingly limited cross exposures and made them transparent. Conversely, the private sector has quickly identified regulatory loopholes in the treatment of OTC markets and has reacted accordingly by developing bilateral exposures.

[36] This view is gaining traction (Basel III will create incentives to move contracts to platforms will central clearing counterparty), although it is still unclear whether the higher capital charges that will apply to customized contracts will reflect the price of risk.

[37] Furthermore, from the Dang, Gorton, and Holmström analysis mentioned earlier, we know that participants' information acquisition will in general respond to market circumstances.

Relatedly, one must ask what bilateral exposures are all about. There are two potential rationales with rather distinct normative implications: regulatory evasion, as discussed above, and mutual monitoring. By "mutual monitoring" I have in mind mutual monitoring of the quality of assets or the solvency of institutions more than investments in learning the bilateral exposures of various participants in the financial systems (such investments are socially wasteful, as the exposures could be cheaply read from positions in centralized exchanges, if the latter exist). Ignoring regulatory evasion, bilateral exposures can be motivated only by the existence and the use of decentralized information not held by a central agent (say a central bank or a regulator). As I noted above, one can wonder about the decentralized nature of government guaranteed interbank loans, when the latter reflect no decentralized information due to the guarantee. In the absence of government guarantee or of a prospect of government bailout, a bilateral exposure should really be about saying: "I have information that makes me trust you, and so I'm willing to accept the corresponding counterparty risk." As argued in Rochet and Tirole (1996b), this monitoring view has implications for capital adequacy rules (or margining rules in exchanges). Finally, it bears emphasizing that, as some payment systems illustrate, the use of decentralized information is not inconsistent with a centralized approach.

6. *Aggregate Liquidity*

6.1 *Is There Sufficient Inside Liquidity?*

Let us start with a basic question, that of the sufficiency of inside liquidity at the aggregate level. We have seen that, in the presence of agency costs, the (Arrow and Debreu and Modigliani and Miller) feasibility of "financing as you go" by resorting to the capital market does not hold at the individual firm level; because investors cannot grab the entire benefits associated with their investment, they tend to ration the financing they extend to the firm. However, "financing as you go" might hold "on average" at the macroeconomic level, and so the corporate sector might not need outside stores of value to finance desirable reinvestments. I therefore investigate the sufficiency of inside liquidity in the example described in section 3.1 and specialized to $p = r = 0$; the conclusions however are very general.[38]

Recall that the representative entrepreneur invests i at date 0 and thus borrows $i - a$; he also spends qxi to invest xi in liquid assets, each of which yields 1 unit at date 2. With probability α, the entrepreneur does not need to reinvest at date 1. With probability $1 - \alpha$, he must reinvest one unit per unit of investment to be brought to completion at date 2. Feasible continuation scales $j \leq i$ are given by condition (1′):

$$(1') \qquad j \leq \frac{\rho_0 j + xi}{R},$$

where $R > \rho_0$ is the rate of interest between dates 1 and 2.

As I noted in section 3.1, "finance as you go" ($x = 0$) is not sustainable if the entrepreneur wants to withstand the shock: in case of a shock, diluting date-0 investors yields at most $\rho_0 j$ while date-1 investors demand a return $Rj > \rho_0 j$. So no reinvestment is doable.

6.1.1 *No Aggregate Shock*

Let us first assume that there is a continuum of ex ante identical entrepreneurs and that at date 1, a fraction $(1 - \alpha)$ of these

[38] See Holmström and Tirole (1998 and 2011).

face a liquidity shock. I make the following claim:[39]

> *Even in the absence of other stores of value, liquidity is cheap* ($q = 1$). *The private sector produces enough inside liquidity to efficiently withstand liquidity shocks that it should withstand; another way of rephrasing the same point is that if one introduces a store of value* (*a Treasury bond, say*) *delivering* 1 *at date* 2, *this store of value will trade at price* 1 *at date* 0: *it won't embody any liquidity premium for supplying liquidity services, or equivalently, its interest rate will be equal to the economywide rate* (*here* 0); *there is no risk-free rate puzzle*.

Suppose that indeed $q = 1$, that is, that liquidity is priced by the consumers' marginal rate of substitution; we will later need to check that the securities issued by the private sector provide enough liquidity so as to induce no shortage of it. There are many ways for entrepreneurs to plan and hoard liquidity. A "reasonable" one may go as follows: the entrepreneur contracts with a financial institution for a line of credit equal to i. The financial institution must then hoard $(1 - \alpha)\ Ri$ on average to be able to meet its obligations. If this line is drawn, the financial institution becomes the senior creditor and obtains $\rho_0 i$ at date 2. The financial institution in exchange demands at date 0 a commitment fee equal to $f = (1 - \alpha)(R - \rho_0)i$; it makes money ($f$) if the credit line is not drawn, and loses money $((R - \rho_0)i - f)$if the entrepreneur faces an overrun. This is indeed the nature of a credit line: there would be no reason to contract in advance on a credit line if at date 1 the financial institution were always happy to provide the funds; it is precisely because lending is a money-losing operation at date 1 that it must be prearranged.

The other investors must bring in $i - a$ (the investment cost minus the entrepreneur's contribution to it) plus the commitment fee, so $i - \alpha + f$ in total. They are willing to do so, as they get back $\rho_0 i$ with probability α and:

$$i - a + (1 - \alpha)(R - \rho_0)i = \alpha \rho_0 i$$

(which is nothing but (4) with $q = 1$).

This example is straightforwardly reinterpreted in terms of a choice of maturity structure. Keep the same numbers, except that the investment cost for a project of size i is now $ci (c > 1)$ instead of i and that the investment returns a safe short-run profit equal to ri, where $c - Rr = 1$ at date 1. A per unit of investment short-term debt $d = r$ forces the firm to disgorge the short-term profit and makes up for the increased investment cost from the point of view of investors. Alternatively, the entrepreneur can now do without a credit line, but secure liquidity through a longer maturity structure, in which the short-term per unit debt is only $d = r - (R - \rho_0)$ provided that the firm can commit not to misinvest its liquidity when it does not need it.[40]

This is all well and good, but I haven't addressed the "macroeconomic question": where will the financial institution find the $(R - \rho_0)i$ that it has committed to bring in if the credit line is drawn? Given that the firm-idiosyncratic events of liquidity shocks are independent and so there is no macroeconomic uncertainty, exactly a fraction $1 - \alpha$ of the entrepreneurs face an overrun.

[39] The key assumption for this proposition to hold is that the corporate sector be a net borrower. Michael Woodford (1990) analyzed the case of a corporate sector that is a net lender; there is then always a shortage of inside liquidity, even in the absence of macroeconomic shock.

[40] See Holmström and Tirole (2011, chapter 3) for an analysis of optimal contracting when the firm may reinvest unneeded liquidity into less profitable projects.

Let the financial institution cover the investment shortfall $i - a$ and invest the $(1 - \alpha)(R - \rho_0)i$ it receives in commitment fees in ordinary claims on other entrepreneurs. If a financial institution is diversified, the per-firm value of the resulting portfolio is $\alpha\rho_0 i$ at date 1. To honor its credit line commitments, the financial institution needs $(1 - \alpha)(R - \rho_0)i = \alpha\rho_0 i - (i - a)$, so everything is in order if firms are net borrowers ($i \geq a$). Note that this arrangement requires some prudential supervision: the financial institution in general would make more profit by selecting subsets of entrepreneurs for which liquidity shocks are correlated as this strategy guarantees a large profit when such shocks do not arise, and otherwise does not expose the financial institution, which is protected by limited liability.[41]

To sum up, in the absence of macroeconomic shock, the corporate sector as a whole in principle produces enough inside liquidity to meet the liquidity shocks it wants to withstand, even though there is insufficient inside liquidity at the firm level. We have stressed that the adequacy of inside liquidity in the aggregate hinges on an efficient dispatching of available liquidity toward those firms in (moderate) need of cash. This can be accomplished for instance by pooling the available liquidity at the level of financial intermediaries, who then redispatch the liquidity through a mechanism akin to credit lines.

6.1.2 *Macroeconomic Shock*

Matters are quite different in the presence of a macroeconomic shock. To take an extreme case, suppose that with probability $1 - \alpha$ all entrepreneurs face a cost overrun simultaneously; that is, the liquidity shocks are perfectly correlated.[42] Then there is no way investors are going to put in 1 per unit of investment and they cannot be forced to disgorge even if their portfolios of claims on the firms are seized. Somehow for the efficient allocation to be sustainable there must exist stores of values in quantity at least equal to $(R - \rho_0)i$ per firm.

There is a shortage of inside liquidity when the economy is hit by an aggregate shock. Holding the "stock index" (a portfolio of shares of the firms) does not bring any useful liquidity to firms or financial intermediaries: in the example above, the value of this stock index falls to 0 when the economy is hit by a shock: all firms are then valueless. The stock index has value in the absence of a shock, but this value serves no liquidity purpose as firms don't need liquidity in this circumstance. Put differently, the stock index does not allow firms to diversify as it does not create a store of value that can be resold in case of liquidity needs. Thus, the stock index is not a liquid security in the macroeconomic sense, even though it is perfectly liquid in the microeconomic sense.

Let us now determine the liquidity yield discount and illustrate how a boom–bust cycle may emerge in this framework.

Suppose that there is a limited volume L_S of outside stores of value in the economy. Equation (5), taken with equality, establishes an upper bound $q^{\max}$ on how much banking entrepreneurs are willing to pay for these stores of value. This upper bound increases with the probability $1 - \alpha$ of a shock and with the pledgeability of returns ρ_0 and decreases with R (recall that $R \geq \rho_0$).

[41] With perfect correlation of shocks in its portfolio, the financial institution makes $\rho_0 i$ per firm in the absence of overrun and 0 in case of overrun.

[42] Acharya, Heitor Almeida, and Murillo Campello (2009) look at the intermediate case in which there is aggregate risk, but firms are heterogeneous with respect to their exposure to this aggregate risk. They predict, and confirm empirically, that firms with high aggregate risk have a higher ratio of cash reserves to lines of credit.

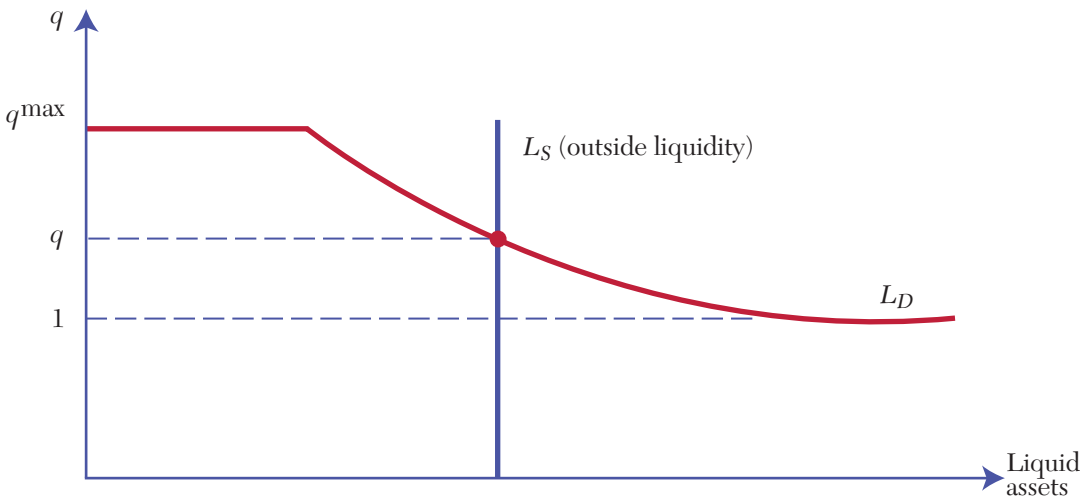

Figure 3. Equilibrium in the Market for Liquidity

Let L_D denote the demand for liquidity whenever $1 < q \leq q^{max}$:

$$(11) \quad L_D = (R - \rho_0)i = \frac{(R - \rho_0)a}{1 + q(R - \rho_0) - \alpha R}.$$

Figure 3 depicts the equilibrium in the market for stores of value.

6.1.3 *Boom–Bust Episodes*

Suppose that the banks' equity a increases at date 0. Then investment grows. If we keep the interest rate R constant, the increase in bank equity, ceteris paribus, leads to an increase in investment, and therefore to an increase in liquidity demand (see equation (11)). Consequently, the price q of liquid assets adjusts so as to clear the market for stores of value. For a large enough boom, the increase in equity leads to an actual increase in investment and a lower liquidity ratio $x = L_S/i$, which later creates a bust in bad times.

6.2 *Public Supply of Liquidity*

The state can provide (outside) liquidity by issuing Treasury securities and by using the future tax income to back up the reimbursements. In our stylized example for instance, the state can issue bonds at date 0 and promise to pay out at date 1.[43] There are of course limits on what the state can do: first, the reimbursement through taxation introduces both substantial deadweight losses and credibility problems when national debt reaches high levels. Second, the taxation of consumers generates social costs when consumers have liquidity needs of their own. In particular, as employees of the firms, they may face hardships precisely when firms are in need of liquidity.

[43] Or date 2 for that matter.

The fundamental feature of public provision of liquidity is that the state should redistribute from consumers to corporations when the latter face pressing liquidity needs. So it does in practice, through a variety of instruments from open market operations to the discount window, from fiscal policies to nonindexed payroll taxes and deposit insurance premia. The recent events have illustrated this large-scale support: monetary bailout, banking recapitalizations, asset repurchases (as proposed, but not realized, by the Paulson and Geithner plans), relaxation of accounting standards (suspension of fair value accounting), underpriced state guarantees in interbank and other markets, and so forth. I am not necessarily approving of each and every countercyclical policy, but their general thrust is sound.

Ideally, the state should be issuing "state-contingent liquidity," i.e., liquidity that delivers cash only during recessions. Contingent claims of this kind are usually implicit rather than explicit; an exception is the sale by the Federal Reserve of contingent access to the discount window in the context of the potential Y2K computer bug; in this case, a well-defined event of liquidity shortage (the potential problems with computers at the turn of the millennium) was identified and contingent claims accordingly issued by the central bank. But defining precisely a liquidity shortage in advance is rather hard and injections of liquidity remain for that reason by and large discretionary.

The state has a comparative advantage in providing support in low-probability events. The private sector's self provision of liquidity (the production of stores of value) takes place before the state of nature is revealed. If macroeconomic shortages of liquidity are rare, then private provision of liquidity is very costly. By contrast, the state can bring in funds ex post on a contingent basis.

Another theoretical suggestion is that liquidity premia attached to risk-free rate assets are signals of the scarcity of aggregate liquidity at the various maturities and therefore are a useful guide for the issuing of government securities, both in level (total public debt) and in structure (choice of maturities); for example, a very low long rate signals substantial shortages of long-term stores of value, and therefore social gains to issuing long-term Treasury securities.[44] A case in point is the issuing by HM Treasury of long-term bonds in reaction to the low rates triggered by the 2005 reform of pension fund requirements in the United Kingdom.

The public provision of liquidity is motivated by a missing contract between consumers and the corporate sector (or more generally by missing contracts between entities that turn out to need cash and those who turn out to have sufficiently). A similar idea is exploited by Guido Lorenzoni (2008), who analyzes fire sales. Suppose that the corporate sector invests in assets (say real estate), that it can sell to consumers in a macroeconomic downturn, when it needs cash. If it has to sell to consumers at a low price, it won't be able to generate enough cash in bad states of nature. A Pareto improvement could be achieved in which consumers would "agree" to pay higher prices in recessions in exchange of some insurance premium paid in booms; put differently some asset price stabilization would be desirable.

6.3 *Asset Overvaluation and Fair Value Accounting*

The overall shortage of stores of value sheds some interesting light on the role of asset bubbles on macroeconomic activity. In a standard rational bubble framework, bubbles compete with securities issued by corporations for the consumers' savings and

[44] See Holmström and Tirole (2001).

thereby crowd out productive investment (Tirole 1985) in the same way public debt also crowds out private investment (Peter A. Diamond 1965). This need no longer be the case if corporations need stores of value to adjust to the asynchronicity between cash availability and cash needs (Farhi and Tirole forthcoming-a). An asset bubble, by inflating the volume of stores of value, fuels growth. It is more likely to exist, the wider the gap between value and pledgeable income, that is the less developed financial markets are (one polar case is the neoclassical model, with its perfect financial markets, i.e., the absence of gap between value and pledgeable income). When the bubble crashes, the economy contracts.[45]

This analysis shows that bubbles, if they boost investment by increasing corporate access to stores of value, still are a very imperfect form of liquidity for two reasons. The first is obvious: bubbles may burst, so their owner cannot fully count on realizing their full value. Second, and more interestingly, bubbles burst "at the wrong time." The burst of the bubble creates a recession and lowers interest rates. Conversely, an otherwise generated recession makes it more difficult to sustain a bubble. Overall, the picture is one of a negative correlation between asset values and liquidity demand. So it is precisely when the corporate sector wants the money most that it is not available. Consequently, bubbles trade at a (liquidity) discount relative to the value embodying only the probability that the bubble burst.

[45] Another worthy point is that bubbles are consistent with dynamic efficiency in the presence of nonpledgeable income. For independent work on the impact of asset bubbles on economic activity, see Narayana Kocherlakota (2009). Kiyotaki and Moore (2008) develop a monetary economy framework in which the issuance of money to satisfy the economic agents' demand for easy-to-resell stores of value improves welfare.

This discussion is related to the current debates on asset price stability mandates, on the one hand, and on fair value accounting, on the other hand. The dominant view, associated with Greenspan and Bernanke in particular, has been that even if one could recognize an asset price bubble, monetary policy should not react to it unless there is a concern for inflation (e.g., Ben S. Bernanke 2002, Bernanke and Mark Gertler 2000, 2001). This view has been called into question in the wake of the recent crisis, in which an asset price bubble combined with fair value accounting boosted the institutions' solvency and encouraged investment (fair value accounting has been perceived to be an amplifying mechanism in the downturn as well, forcing institutions to resell assets in reaction to reduced solvency, triggering further asset price decreases and thereby further sales).

It is hard to rejoice over the recent tinkering with reclassification, a relaxation of fair value accounting, even if one understands its motivation. Fair value accounting, despite its drawbacks, has clear benefits. In case of losses ("ex post"), it forces a bank to recognize their losses and to engage in deleveraging. "Ex ante," the prospect of having to downsize if assets lose some of their value reduces the attractiveness of bad investments. In a nutshell, fair value accounting is an important disciplining device.

But, for all its merits, fair value accounting requires some adjustments in our regulatory context. To see this, let's return to asset bubbles. We saw that bubbles are a very imperfect store of value because they may burst and furthermore they tend to burst at the wrong time. This "double whammy" makes a case for not using market value accounting, as the corresponding assets hardly serve as a cushion.

This discussion is also linked to the debate on countercyclical capital adequacy requirements. Until recently, it was admitted in

regulatory circles that capital requirements should not vary with the cycle; the fear has always been that regulators would face intense lobbying by the industry if they had discretion to adjust the Cooke ratio or any other regulatory rule. If anything, capital requirements lately have been procyclical with the advent of fair value accounting. Yet economic theory provides arguments in favor of countercyclical capital adequacy requirements, that would increase during booms in order to constitute a stronger cushion for bad times.[46]

One rationale for countercyclical capital adequacy requirements (CARs) is the *loanable funds effect.* It stems from the fact that regulated institutions are central to the provision of credit to the real sector, and in particular to small and medium size enterprises. In a banking boom, such as the one experienced before the subprime crisis, the higher availability of loans to the real sector driven by the high level of bank capital lowers the banks' markup on inframarginal loans and induces a shift toward marginal and less profitable loans. These shifts call for a bigger cushion, i.e., a higher equity over assets ratio. Conversely, adverse macroeconomic shocks deplete banks' capital position and, under invariant CARs, impose deleveraging upon them. As a consequence, the spread between interest rates faced by consumers and those demanded by banks increases. While this "capital scarcity rent" allows banks to slowly reconstitute their capital, the shortage of loanable funds also creates a credit crunch, which hits the financially most fragile firms, often the smaller ones (Holmström and Tirole 1997). Adjusting the CAR to the overall capital condition of the banking sector stabilizes interest rates and access to credit.

Another potential rationale for contercyclical CAR is the *insurance effect* (Dewatripont and Tirole 1994). It is related to the fact that the Basel rules make no distinction between idiosynchratic shocks, for which the bank's management should be held partly accountable, and macroeconomic shocks, for which the bank bears no responsibility. Based on a well-known principle (due to Holmström 1979) according to which economic agents should be held accountable only for outcomes over which they have control, it can therefore be argued that the Basel rules are excessively tough on (lenient with) banks in recessions (booms). This suggests some automatic recapitalization process in banking recessions and some tax on banking leverage during booms (the combination of the two amounting to an insurance scheme provided by the government).

7. *A Call for Macroprudential Regulation*

As we noted earlier, an important recent trend has been the sharp increase in financial institutions' reliance on short-term, market liabilities. For example:

- Commercial banks have pledged substantial liquidity support to the conduits. According to Acharya and Philipp Schnabl (2009), the ten largest conduit administrators (mainly commercial banks) had a ratio of asset backed commercial paper to equity ranging from 32.1 percent to 336.6 percent. See table 1.
- The increase in the market share of investment banks mechanically increases the financial sector's interest rate fragility, as investment banks rely on repo and commercial paper funding much more than commercial banks do. See figures 4 and 5.
- Primary dealers have increased their overnight to term borrowing ratio. See figure 6.

[46] A variant of this countercyclical rule is dynamic provisioning, which was used by Spain before the subprime crisis.

TABLE 1
TEN LARGEST CONDUIT ADMINISTRATORS BY SIZE

	Conduits		Administrator			
	#	CP (in bn)	Assets	Equity	CP/Asset	CP/Equity
Citibank	23	93	1,884	120	4.9%	77.4%
ABN Amro	9	69	13,000	34	5.3%	201.1%
Bank of America	12	46	1,464	136	3.1%	33.7%
HBOS	2	44	1,160	42	3.8%	105.6%
JPMorgan Chase	9	42	1,352	116	3.1%	36.1%
HSBC	6	39	1,861	123	2.1%	32.1%
Societe Generale	7	39	1,260	44	3.1%	87.2%
Deutsche Bank	14	38	1,483	44	2.6%	87.8%
Barclays	3	33	1,957	54	1.7%	61.5%
WestLB	8	30	376	9	8.0%	336.6%

Notes: January 2007, administrator merged for all subsidiaries associated with bank administator not necessarily liquidity/credit risk provider, Bank variables from Bankscope, selected largest bank with banking groups (usually bank holding company), dropped nonbanks and corporates.

Source: Chapter 2 in Acharya and Richardson (2009).

- LBOs have become more levered. See figure 7.

Overall, there has been a tremendous increase in the proportion of short-term liabilities in the financial sector. See figure 8. Accordingly, there is a widespread feeling that maturity mismatches have played a prominent role in the crisis and that monetary policy and financial stability are closely linked (Tobias Adrian and Hyun Song Shin 2008).

The recent crisis unveiled the dire consequences of a widespread maturity mismatch. This section, based on the analysis in Farhi and Tirole (forthcoming-b), argues that there is a two-way relationship between maturity mismatches and the massive bailout that we have witnessed.

The public bailout of the financial sector has taken many forms, but can be roughly decomposed into a monetary bailout and a fiscal one. The former consists in keeping extremely low short-term rates so as to allow institutions that have chosen to depend on the wholesale market not to go under. The latter takes the form of recapitalizations, liquidity support and asset repurchases.

Let us start with *monetary bailouts*. Although there are obviously relevant nominal features of monetary policy (most prominently, the risk of inflation), we capture a key aspect of this policy while assuming away the price stability issue and positing that liquidity corresponds to claims on real resources. It reduces borrowers' cost of short-term liabilities. This impact amounts in the model to a reduction in the date-1 interest rate R. The benefit of a loose monetary policy is, as we have seen, that it rescues institutions that rely on the wholesale market for their funding. The costs associated with keeping interest rates low are

Figure 4. Repo Funding of Investment Banks

Source: Flow of funds (percentage of total assets).

several.[47] First, low interest rates establish a wedge between marginal rate of substitution and marginal rate of transformation.[48]

Second, they induce an implicit subsidy from consumers to the corporate sector (hence the use of the term "bailout," which in common language takes the more neutral form of "support to the banking system" or of "transmission mechanism"); the lower yield on savings transfers resources from consumers to borrowers, but unlike a direct recapitalization the money does not transit through the state. Suppose, in the model of section 3, that the natural rate of interest is equal to 1 (consumers have preferences $\sum_{t=0}^{2} c_t$). Then the implicit subsidy is equal to $(1 - \rho_0)i$ as the investors must bring in some manner i in case of a shock and get back only $\rho_0 i$. Although it does not flow through the Treasury's accounts and is usually perceived as a countercyclical policy rather than as a transfer, this subsidy is real and has definitely contributed to the large profits made by some banks in the aftermath of the crisis.

Third, they sow the seeds for the next crisis: low short-term interest rates boost

[47] See Farhi and Tirole (forthcoming-b) for more detail.

[48] One may object that monetary policy impacts the short-term rates and so the divergence between MRS and MRT is a second-order effect. However, monetary policy kept the rates extremely low between 2001 and 2004, and has been setting negative real rates since 2007 and will keep doing so for a while.

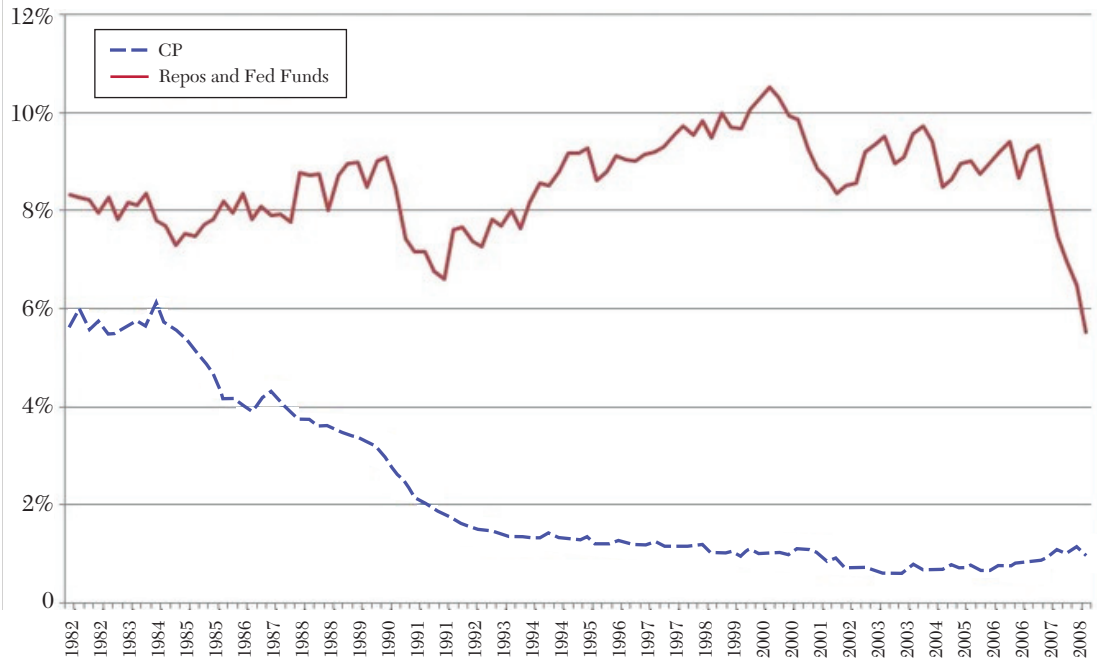

Figure 5. CP and Repo/Funds Funding of Commercial Banks

Source: Flow of funds (percentage of total assets).

investment by lowering the overall cost of capital; they also encourage institutions to borrow short and thereby to adopt an illiquid balance sheet. This effect too is captured by the basic model: a decrease in R increases investment by reducing the cost of capital (equation (3)).[49] Adrian and Shin (2008) document the relationship between low interest rates and maturity mismatches in the case of investment banks. This third cost also fits with the idea of a "risk-taking channel" in the transmission mechanism, i.e., of an impact of changes in policy rates on risk perception and risk tolerance (Claudio Borio and Haibin Zhu 2008).

Fourth, a loose monetary policy creates inflation and distorts money demand, and, in New-Keynesian models, induces price dispersion.

The key observation is that, except for the (more or less proportional) implicit subsidy component, the costs of a loose monetary policy are economywide; they resemble a "fixed cost." Consequently, the central bank is willing to incur these costs if there are enough (strategic) fragile

[49] This framework does not capture the manipulation of the rate of interest between dates 0 and 1. If R_0 denotes this rate and R (as before) the interest rate between dates 1 and 2, it can be shown that the entrepreneur will choose to hoard enough liquidity to withstand a crisis ($x = R - \rho_0$) if

$$\frac{\alpha(R-\rho_0)}{1-\alpha} \leq \frac{1-\frac{\alpha\rho_0}{R_0R}}{1-\frac{\alpha}{R_0R}}$$

and no liquidity ($x = 0$) otherwise. It is easy to see that the right-hand side of this equation is increasing in R_0 so that a lower date-0 interest rate R_0 discourages liquidity hoarding and increases the maturity mismatch problem.

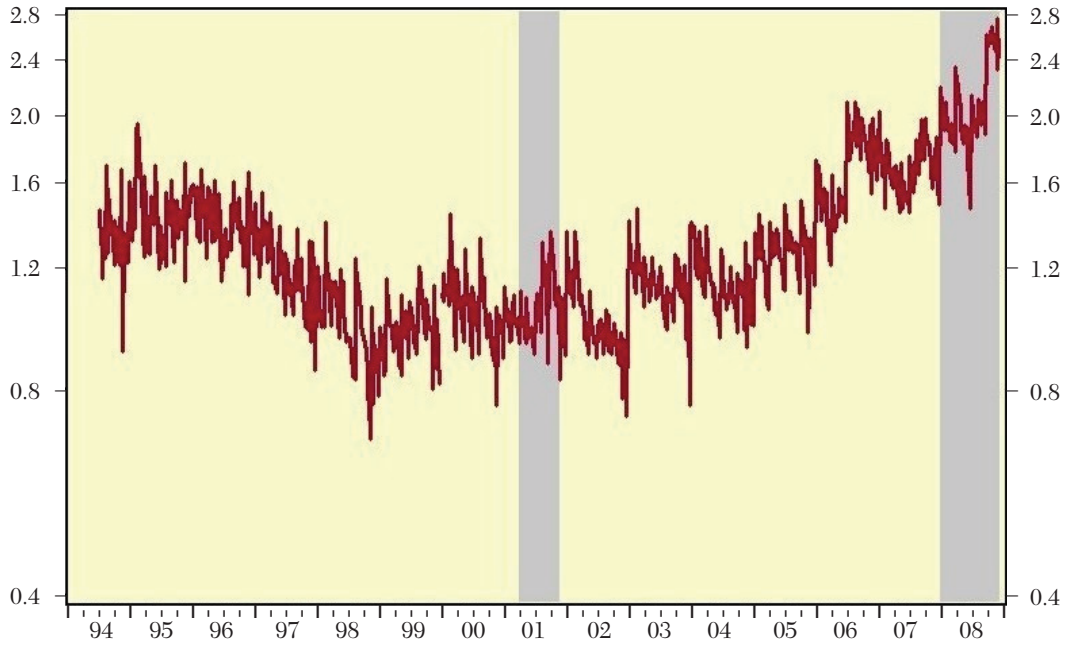

Figure 6. Primary Dealers' Overnight to Term Borrowing Ratio (FDFRV/FDFRA)

Source: Haver Analytics.

players. Put differently, the policy response makes balance-sheet risk choices *strategic complements.* The more other institutions (especially ones that a central bank will be eager to rescue, such as large banks or too-interconnected-to-fail institutions) gamble on the yield curve and adopt an illiquid balance sheet, the more an individual bank is expecting to face a low interest rate and thus favorable refinancing conditions, and so the more it benefits from sacrificing capital insurance for scale.

To sum up, when everyone engages in maturity transformation, authorities have little choice but facilitating refinancing, and so refusing to adopt a risky balance sheet lowers the return on equity. This simple observation has several corollaries:

- There may be multiple equilibria.
- In contrast with CAPM, which predicts that banks, if endowed with the freedom to select the states of nature in which they face financial difficulties, will choose positions that, whenever feasible, makes them negatively correlated with the market portfolio, it is in the interest of each bank to be illiquid in the same states of nature as other banks. The prediction is then one of a joint concentration on the same high tail risk and of an endogenous macroeconomic uncertainty.
- While corporate finance theory predicts that an increase in the probability of needing cash increases the demand for capital insurance (i.e., more hoarding of liquidity), the endogenization of the policy response shows that an increase in the probability of distress may reduce

Figure 7. Leverage Ratio for LBOs (1999–2007)

Notes: This figure graphs the average total debt leverage ratio for LBOs in both the United States and Europe with EBITDA of 50 million or more in dollars or Euros, respectively. The chart covers the period from 1999 to 2007.

Source: Standard & Poor's LCD.

the incentive to hoard liquidity. The reason for this surprising result is that the increase in the probability of distress may imply that more institutions are indeed in distress, forcing the central bank to implement a loose monetary policy.

- The central bank faces a time-inconsistency problem. It would want to commit to a tough monetary policy, but when push comes to shove and if enough key institutions choose to rely on wholesale markets, it will lower interest rates.
- This offers a rationale for macro-prudential regulation, i.e., regulation that does not just look at the liquidity and solvency positions of individual banks, but also looks at the overall maturity mismatch.[50]
- The analysis suggests imposing a minimum liquidity requirement, at least for those actors that authorities will be keen to rescue. By contrast, subsidizing liquidity often reduces welfare: institutions' cost of financing then decreases, inducing them to increase their leverage, making ex post bailouts even more necessary.
- When banks are subject to a minimum liquidity requirement, they may choose to substitute cheaper, but potentially toxic assets for more expensive and

[50] For preadmonitory work on the need to engage on macro-prudential oversight, see Borio (2003) and Borio and Shim (2007).

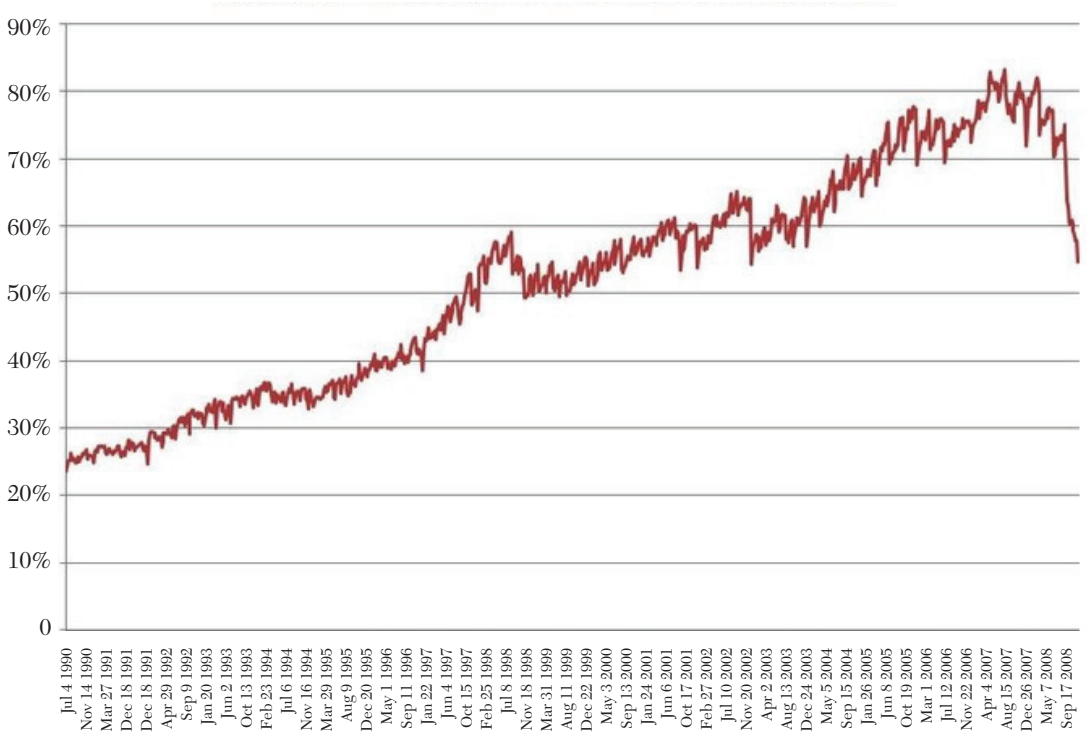

Figure 8. Primary Dealer Repos and Financial Commercial Paper as a Fraction of M2

Source: Adrian and Shin (2009).

safer stores of value. Furthermore, the choices of liquid asset quality often exhibit strategic complementarities as well. Thus the regulator should also monitor the quality and not only the quantity of liquid assets.

Monetary bailouts are an important, but not the unique, component of rescue packages. Typically, authorities also engage in loan guarantees, asset repurchases, and recapitalizations. One may wonder whether monetary policy should be part of a rescue package since its effects are diffuse and targeted rescues would seem to be a more appropriate response to banking problems. The paper applies mechanism design to obtain the optimal rescue package. The first conclusion is that monetary policy, because it benefits those institutions that really need cash, is always part of a rescue package despite the fact that it is less targeted than direct recapitalizations. Actually, it is the only form of bailout over a range of parameters. In general, though, monetary policy is complemented by a recapitalization, perhaps involving a deleveraging request in order to screen out banks that would want to benefit from subsidized public support, but don't really need the money. The bottom line is that monetary and fiscal bailouts, if different in their working and effects, work toward the common objective of restoring

the institutions' liquidity and solvency positions and cannot be conceived separately.

8. *Concluding Notes*

Liquidity mismatches and the overreliance on wholesale funding were at the core of failures and rescues in the recent crisis. Despite much progress in our understanding of what drives liquidity shortages at the individual and aggregate levels, academic knowledge still has some way to go in order to provide satisfactory inputs into the design of regulatory and monetary policies. Achieving this will require further convergence between micro- and macroeconomics. Microeconomists interested in financial regulation and markets can no longer ignore macroeconomic factors leading to the simultaneous freeze in markets that are central to the institutions' market and funding liquidity; they must develop better models of systemic risk; and they can no longer look at institutions in isolation and not consider the overall maturity mismatch and the allocation of financial muscle.

Conversely, macroeconomists need to account for arcane details of prudential regulation, corporate finance and market microstructure if they are to develop a better understanding of countercyclical monetary policies and the transmission mechanism; Keynes's and Hicks's emphasis on liquidity called for an integrated view of micro and macro treatments of the financial system. I hope that the crisis will encourage the pursuit of the corresponding research agenda and accelerate the convergence between the two fields.

Listing the many other open questions exhaustively lies outside the scope of this paper. As we have noted, though, extending the theory to account for the nominal dimension of liquidity stands high on the research agenda. So does the analysis of the multicountry version of the model, as international bailouts of the financial system raise serious questions in a world still dominated by home-based regulations and deposit insurance schemes. Finally, while three-period models (the most common in the literature) tractably capture many relevant insights, infinite-horizon versions are required for the analysis of important topics, such as the linkage between bailouts and dynamic public finance, or (as we already noted) the evolution of liquidity ratios over time.

References

Acharya, Viral V., Heitor Almeida, and Murillo Campello. 2009. "Aggregate Risk and the Choice between Cash and Lines of Credit." Unpublished.

Acharya, Viral V., Douglas Gale, and Tanju Yorulmazer. Forthcoming. "Rollover Risk and Market Freezes." *Journal of Finance*.

Acharya, Viral V., Denis Gromb, and Tanju Yorulmazer. 2009. "Imperfect Competition in the Interbank Market for Liquidity as a Rationale for Central Banking." New York University Working Paper FIN-09-031.

Acharya, Viral V., and Ouarda Merrouche. 2009. "Precautionary Hoarding of Liquidity and Inter-bank Markets: Evidence from the Sub-prime Crisis." Unpublished.

Acharya, Viral V., and Matthew Richardson, eds. 2009. *Restoring Financial Stability: How to Repair a Failed System*. Hoboken, N.J.: Wiley.

Acharya, Viral V., and Philipp Schnabl. 2009. "How Bank Played the Leverage Game." In *Restoring Financial Stability: How to Repair a Failed System*, ed. Viral V. Acharya and Matthew Richardson, 83–100. Hoboken, N.J.: Wiley.

Adrian, Tobias, and Hyun Song Shin. 2008. "Financial Intermediaries, Financial Stability and Monetary Policy." Paper presented at the Federal Reserve Bank of Kansas City Symposium, Jackson Hole, WY.

Adrian, Tobias, and Hyun Song Shin. 2009. "Money, Liquidity, and Monetary Policy." *American Economic Review*, 99(2): 600–605.

Aghion, Philippe, Patrick Bolton, and Jean Tirole. 2004. "Exit Options in Corporate Finance: Liquidity versus Incentives." *Review of Finance*, 8(3): 327–53.

Akerlof, George A. 1970. "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism." *Quarterly Journal of Economics*, 84(3): 488–500.

Allen, Franklin, and Douglas Gale. 1994. "Limited Market Participation and Volatility of Asset Prices." *American Economic Review*, 84(4): 933–55.

Allen, Franklin, and Douglas Gale. 1998. "Optimal Financial Crises." *Journal of Finance*, 53(4): 1245–84.

Allen, Franklin, and Douglas Gale. 2000a. "Bubbles

and Crises." *Economic Journal*, 110(460): 236–55.
Allen, Franklin, and Douglas Gale. 2000b. "Financial Contagion." *Journal of Political Economy*, 108(1): 1–33.
Basel Committee on Banking Supervision. 2009. *Proposed Enhancements to the Basel II Framework*. Basel: Bank for International Settlements.
Bernanke, Ben S. 2002. "Asset-Price 'Bubbles' and Monetary Policy." Remarks before the New York Chapter of the National Association for Business Economics, New York.
Bernanke, Ben S., and Mark Gertler. 2000. "Monetary Policy and Asset Price Volatility." National Bureau of Economic Research Working Paper 7559.
Bernanke, Ben S., and Mark Gertler. 2001. "Should Central Banks Respond to Movements in Asset Prices?" *American Economic Review*, 91(2): 253–57.
Biais, Bruno, Thomas Mariotti, Guillaume Plantin, and Jean-Charles Rochet. 2007. "Dynamic Security Design: Convergence to Continuous Time and Asset Pricing Implications." *Review of Economic Studies*, 74(2): 345–90.
Biais, Bruno, Thomas Mariotti, Jean-Charles Rochet, and Stephane Villeneuve. 2010. "Large Risks, Limited Liability, and Dynamic Moral Hazard." *Econometrica*, 78(1): 73–118.
Bolton, Patrick, Tano Santos, and Jose A. Scheinkman. 2011. "Outside and Inside Liquidity." *Quarterly Journal of Economics*, 126(1): 259–321.
Bordo, Michael D., and Olivier Jeanne. 2002. "Boom-Busts in Asset Prices, Economic Instability, and Monetary Policy." National Bureau of Economic Research Working Paper 8966.
Borio, Claudio. 2003. "Towards a Macroprudential Framework for Financial Supervision and Regulation." Bank for International Settlements Working Paper 128.
Borio, Claudio, and Ilhyock Shim. 2007. "What Can (Macro-)prudential Policy Do to Support Monetary Policy?" Bank for International Settlements Working Paper 242.
Borio, Claudio, and Haibin Zhu. 2008. "Capital Regulation, Risk-Taking and Monetary Policy: A Missing Link in the Transmission Mechanism?" Bank for International Settlements Working Paper 268.
Brunnermeier, Markus K., and Lasse Heje Pedersen. 2009. "Market Liquidity and Funding Liquidity." *Review of Financial Studies*, 22(6): 2201–38.
Caballero, Ricardo J., Emmanuel Farhi, and Pierre-Olivier Gourinchas. 2008. "An Equilibrium Model of 'Global Imbalances' and Low Interest Rates." *American Economic Review*, 98(1): 358–93.
Caballero, Ricardo J., and Arvind Krishnamurthy. 2003. "Excessive Dollar Debt: Financial Development and Underinsurance." *Journal of Finance*, 58(2): 867–93.
Caballero, Ricardo J., and Arvind Krishnamurthy. 2004. "Smoothing Sudden Stops." *Journal of Economic Theory*, 119(1): 104–27.
Caballero, Ricardo J., and Alp Simsek. 2009. "Complexity and Financial Panics." Unpublished.
Cecchetti, Stephen G. 2007. "A Better Way to Organize Securities Markets." *Financial Times*, October 4.
Dang, Tri Vi, Gary B. Gorton, and Bengt Holmström. 2009. "Financial Crises and the Optimality of Debt in Liquidity Provision." Unpublished.
DeMarzo, Peter M., and Michael J. Fishman. 2007a. "Agency and Optimal Investment Dynamics." *Review of Financial Studies*, 20(1): 151–88.
DeMarzo, Peter M., and Michael J. Fishman. 2007b. "Optimal Long-Term Financial Contracting." *Review of Financial Studies*, 20(6): 2079–2128.
De Soto, Hernando. 2003. *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else*. New York: Basic Books.
Dewatripont, Mathias, and Jean Tirole. 1994. *The Prudential Regulation of Banks*. Cambridge and London: MIT Press.
Diamond, Douglas W., and Philip H. Dybvig. 1983. "Bank Runs, Deposit Insurance, and Liquidity." *Journal of Political Economy*, 91(3): 401–19.
Diamond, Douglas W. and Raghuram G. Rajan. Forthcoming. "Fear of Fire Sales, Illiquidity Seeking, and Credit Freezes." *Quarterly Journal of Economics*.
Diamond, Peter A. 1965. "National Debt in a Neoclassical Growth Model." *American Economic Review*, 55(5 Part 1): 1126–50.
Duffie, Darrell. 2009. "The Failure Mechanics of Dealer Banks." Unpublished.
Duffie, Darrell, and Haoxiang Zhu. 2009. "Does a Central Clearing Counterparty Reduce Counterparty Risk?" Unpublished.
Farhi, Emmanuel, and Jean Tirole. Forthcoming-a. "Bubbly Liquidity." *Review of Economic Studies*.
Farhi, Emmanuel, and Jean Tirole. Forthcoming-b. "Collective Moral Hazard, Maturity Mismatch, and Systemic Bailouts." *American Economic Review*.
Faure-Grimaud, Antoine, and Denis Gromb. 2004. "Public Trading and Private Incentives." *Review of Financial Studies*, 17(4): 985–1014.
Financial Stability Forum. 2009. *Report of the Financial Stability Forum on Addressing Procyclicality in the Financial System*. Basel: Financial Stability Board.
Froot, Kenneth A., David S. Scharfstein, and Jeremy C. Stein. 1993. "Risk Management: Coordinating Corporate Investment and Financing Policies." *Journal of Finance*, 48(5): 1629–58.
Goodhart, Charles. 2008. "Liquidity Risk Management." *Banque de France Financial Stability Review*, 11: 39–44.
Gorton, Gary B., and George G. Pennacchi. 1990. "Financial Intermediaries and Liquidity Creation." *Journal of Finance*, 45(1): 49–71.
Gorton, Gary B., and George G. Pennacchi. 1993. "Security Baskets and Index-Linked Securities." *Journal of Business*, 66(1): 1–27.
Haldane, Andrew G. 2009. "Rethinking the Financial Network." Unpublished.
Heider, Florian, Marie Hoerova, and Cornelia Holthausen. 2009. "Liquidity Hoarding and Interbank Market Spreads: The Role of Counterparty Risk." European Central Bank Working Paper 1126.

Hicks, John. 1967. *Critical Essays in Monetary Theory*. Oxford and New York: Oxford University Press.
Hirshleifer, Jack. 1971. "The Private and Social Value of Information and the Reward to Inventive Activity." *American Economic Review*, 61(4): 561–74.
Holmström, Bengt. 1979. "Moral Hazard and Observability." *Bell Journal of Economics*, 10(1): 74–91.
Holmström, Bengt, and Jean Tirole. 1997. "Financial Intermediation, Loanable Funds, and the Real Sector." *Quarterly Journal of Economics*, 112(3): 663–91.
Holmström, Bengt, and Jean Tirole. 1998. "Private and Public Supply of Liquidity." *Journal of Political Economy*, 106(1): 1–40.
Holmström, Bengt, and Jean Tirole. 2001. "LAPM: A Liquidity-Based Asset Pricing Model." *Journal of Finance*, 56(5): 1837–67.
Holmström, Bengt, and Jean Tirole. 2011. *Inside and Outside Liquidity*. Cambridge and London: MIT Press.
Jensen, Michael C. 1986. "Agency Costs of Free Cash Flow, Corporate Finance, and Takeovers." *American Economic Review*, 76(2): 323–29.
Keynes, John Maynard. 1936. *The General Theory of Employment, Interest and Money*. London: Macmillan.
Keys, Benjamin J., Tanmoy Mukherjee, Amit Seru, and Vikrant Vig. 2010. "Did Securitization Lead to Lax Screening? Evidence from Subprime Loans." *Quarterly Journal of Economics*, 125(1): 307–62.
Kiyotaki, Nobuhiro, and John Moore. 1997. "Credit Chains." Unpublished.
Kiyotaki, Nobuhiro, and John Moore. 2008. "Liquidity, Business Cycles, and Monetary Policy." Unpublished.
Kocherlakota, Narayana. 2009. "Bursting Bubbles: Consequences and Cures." Unpublished.
Kyle, Albert S. 1985. "Continuous Auctions and Insider Trading." *Econometrica*, 53(6): 1315–35.
Léautier, Thomas-Olivier, and Jean-Charles Rochet. 2009. "On the Strategic Aspects of Risk Management." Paper presented at IDEI/CSIO Conference, Toulouse.
Lorenzoni, Guido. 2008. "Inefficient Credit Booms." *Review of Economic Studies*, 75(3): 809–33.
Malherbe, Frédéric. 2009. "Self-Fulfilling Liquidity Dry-Ups." Unpublished.
Myers, Stewart C., and Nicholas S. Majluf. 1984. "Corporate Financing and Investment Decisions When Firms Have Information That Investors Do Not Have." *Journal of Financial Economics*, 13(2): 187–221.
Pagano, Marco, and Paolo Volpin. 2009. "Securitization, Transparency and Liquidity." Unpublished.
Philippon, Thomas, and Philipp Schnabl. 2009. "Efficient Recapitalization." Unpublished.
Philippon, Thomas, Vasiliki Skreta. Forthcoming. "Optimal Interventions in Markets with Adverse Selection." *American Economic Review*.
Rochet, Jean-Charles, and Jean Tirole. 1996a. "Controlling Risk in Payment Systems." *Journal of Money, Credit, and Banking*, 28(4): 832–62.
Rochet, Jean-Charles, and Jean Tirole. 1996b. "Interbank Lending and Systemic Risk." *Journal of Money, Credit, and Banking*, 28(4): 733–62.
Shim, Ilhyock. 2006. "Dynamic Prudential Regulation: Is Prompt Corrective Action Optimal?" Bank for International Settlements Working Paper 206.
Shin, Hyun Song. 2009. "Financial Intermediation and the Post-Crisis Financial System." Paper presented at the Eighth Bank for International Settlement Annual Conference, Basel.
Subrahmanyam, Avanidhar. 1991. "A Theory of Trading in Stock Index Futures." *Review of Financial Studies*, 4(1): 17–51.
Tirole, Jean. 1985. "Asset Bubbles and Overlapping Generations." *Econometrica*, 53(6): 1499–1528.
Tirole, Jean. 2006. *The Theory of Corporate Finance*. Princeton and Oxford: Princeton University Press.
Tirole, Jean. 2008. "Liquidity Shortages: Theoretical Underpinnings." *Banque de France Financial Stability Review*, 11: 53–63.
Tirole, Jean. Forthcoming. "Overcoming Adverse Selection: How Public Intervention Can Restore Market Functioning." *American Economic Review.*
Uhlig, Harald. 2010. "A Model of a Systemic Bank Run." *Journal of Monetary Economics*, 57(1): 78–96.
Woodford, Michael. 1990. "Public Debt as Private Liquidity." *American Economic Review*, 80(2): 382–88.