Liquidity shortages: theoretical underpinnings

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Liquidity shortages arise when financial institutions and industrial companies scramble for, and cannot find the cash they require to meet their most urgent needs or undertake their most valuable projects. Liquidity problems are compounded when some actors do have excess liquidity, but are unwilling to lend it at the maturities desired by prospective borrowers. The paper revisits the theoretical underpinnings of such liquidity shortages: what drives corporate liquidity demand and supply? How is the latter affected by financial innovation? When does the economy produce enough liquidity for its own needs, and what is the role of public policy? The paper also offers some comments on the recent subprime episode and its implications for prudential regulation, rating agencies and public policy.

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Long before the early-August injections of hundreds of billions of dollars of liquidity by the Fed and the ECB, and ever since, central banks and governments have pondered over how and when to stabilize troubled credit markets. Liquidity is potentially scarce, as actors contemplate the prospect of fire sales of mortgage-backed assets, and to boot it all, actors with available liquidity refrain from lending it to those who are short of it. The USD 11 billion Citigroup write-down of mortgage-related assets and other similar developments at the time of this writing (early November) have raised questions about the effectiveness and timing of the US Treasury backed USD 75 billion "superfund" plan of three large American banks[1] to purchase assets from distressed investments in order to prevent fire sales.

But what is "liquidity"? Does liquidity matter and should governments and central banks do something about it? While trivial to a practionner, these questions surprisingly are not so obvious to an economist trained in the general-equilibrium tradition. Intuitively, an industrial company or financial institution is short of liquidity when a) some (continuation or investment) spending decisions are worthwhile, and b) the firm somehow cannot manage to find the money to finance them. Classical (Arrow-Debreu, Modigliani-Miller) economic theory holds it that a) and b) are inconsistent: if refinancing or financing of new projects is desirable, so goes the argument, the firm can always issue claims on associated future profits, that investors will find sufficiently attractive to be willing to finance the outlay. According to this logic, firms have no reason to plan their liquidity (or for that matter to engage in risk management to avoid bad surprises in their liquidity position): they just can return to the capital market as needs arise.

This paper offers a conceptual framework in which to couch the debate about the recent subprime crisis,[2] and uses this framework to illustrate some of the relevant issues. This conceptual framework at the microeconomic level builds on the existence of agency costs and the concomitant difficulty for firms to access funds (section 1). Costly refinancing leads to a demand for liquidity, with a range of familiar corollaries such as risk and asset-liability management. On the supply side, liquidity is created in several ways: inside liquidity is provided by the firms themselves by issuing securities "backed" by the firm's future income. Outside liquidity stems from the consumer sector, the State, and the international market.

Section 2 first explains why liquidity may be scarce and shows how assets such as Treasury securities command liquidity premia by serving as stores of value. It also discusses the interaction among bubbles, liquidity and investment.

Section 3 draws the implications for public policy.

1| LIQUIDITY: DEMAND AND SUPPLY

An unfortunate habit of economists is the use of the same word, "liquidity", to cover distinct concepts. Consider the common definition: "An asset is liquid if its owner can resell it quickly at a decent price". This definition already recoups the two main and distinct interpretations of the concept:

"Market microstructure or microeconomic liquidity" understanding: an asset is liquid if the transaction costs of buying and selling the asset are small; for example:

"The degree of liquidity of a market is traditionally assessed on the basis of three essential criteria: the tightness of the bid-ask spread, which is a direct measure of transaction costs (excluding other operational costs), and two other criteria that indicate the market's ability to absorb significant volumes without adverse effects on prices : market depth, which corresponds to the volume of transactions that may be immediately executed without slippage of best limit prices, and market resilience, i.e. *the speed with which prices revert to their equilibrium level following a random shock in the transaction flow." (Bervas, 2006).*

In particular, assets with low bid-ask spreads (due to low transaction costs or small amounts of informational asymmetries) are liquid according to this definition. The stock market index, an on-the-run

1 *Bank of America, Citigroup, and JPMorgan Chase.*
2 *The theoretical framework has been elaborated in collaboration with Bengt Holmström (See Holmström and Tirole 1998, 2000, 2001 and 2008).*

Treasury bond, or a mortgage-backed portfolio about which actors would be symmetrically informed, are equally "liquid" according to this definition.

"Aggregate or macroeconomic liquidity" understanding: according to this alternative definition, variants of which date back to Keynes and Hicks, an asset offers liquidity to the corporate world if it can be used by the latter as a cushion to address pressing needs. To be an effective cushion, though, the asset must not lose value in those very circumstances in which the corporate sector does need money. In this respect, the on-the-run Treasury bond is rather distinct from the stock index or the hypothetical mortgage-backed portfolio in that it does not lose value in recessions,[3] while the latter's value is likely to be reduced precisely in case of an industrial or financial recession.

To analyze the subprime crisis, monetary policy and other public interventions geared to adjusting the existing liquidity, the relevant definition is the macroeconomic one, and we will therefore focus on it, even though we will note incidentally that macroeconomic illiquidity makes microeconomic illiquidity more likely.

The demand for liquidity

A basic feature of corporate financial management is that revenues and outlays are not perfectly synchronized. The lack of synchronicity between cash flows and 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.

That strategy however has its limits as both the theory of corporate finance and the daily observation of credit rationing suggest. Due to moral hazard, adverse selection (asymmetries of information about assets in place and projects), or mere transaction costs (we will regroup these three factors under the heading of "financial market imperfections"), cash-strapped corporations find it hard to find financing even for positive net-present-value actions. The current 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 collateralised debt obligation (CDO) market, the corporate credit spread, and the overall credit crunch 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 indirectly (by securing an explicit or implicit credit line from a bank, an insurance company, or a parent company, which hold securities on their own balance sheets to back these lines of credit).

For future reference, we will call *inside liquidity* the amount that can be raised by the corporate sector simply by issuing new claims on its future income. This amount depends on the economic environment; for example, improved corporate governance assuages investors' concern about the prospect of recouping the money they invested; in economic jargon, better corporate governance increases the pledgeability of firm resources to investors. Thus, better corporate governance institutions facilate refinancing by the corporate sector and thereby inside liquidity.

Another strategy for firms to raise money from the capital market is to securitize a portfolio of loans that it has issued. Indeed securitization, often described as an unloading of risk to other parties, is also about the certification of the quality of past activities; indeed asymmetric information about the real value of the returns 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 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.[4] If properly performed (*i.e.* with

3 *In a first approximation. Of course, swings in the interest rate affect the value of longer-term bonds. Let's skip the corresponding discussion here, as it would bring us to a discussion of asset-liability management.*

4 *The securization 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.*

the right incentives in place), this process thereby boosts the volume of inside liquidity.

A key question that will be discussed later on is whether in the aggregate the corporate sector produces enough inside liquidity to cater for its own needs. If not, the corporate sector as a whole must hoard stores of value. But the hoarding of liquidity at the level of the corporate sector supposes the existence in the economy of "stores of value" or "reserves" or *outside liquidity*. We will return shortly to this point when we discuss the supply of liquidity.

Finally, because we will be interested in macroeconomic aspects, we will not discuss the fine points of this liquidity management by individual corporations, although this would in its own sake be worthwhile. Let it suffice to say that liquidity management must adapt to the lack of coincidence between cash flows and needs across states of nature and across time: risk management aims at partially[5] insuring the firm's liquidity position against insurable risks. Similarly, asset-liability management (ALM) 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 15 or 25 years ahead than banks do. Again, these standard functions of financial officers would be hard to rationalize in a classical economics world, in which firms could costlessly return to the capital market to raise funds when they need to.

The supply of liquidity

As we noted, liquidity management pre-supposes the existence of stores of value in the economy. Such outside liquidity in practice can be decomposed into five categories depending on its origin:

• *Rents created by past economic activities*: past activities have created streams of future incomes that can be mobilized as stores of value. Some are directly traded in public or private equity markets (Château d'Yquem); others are not (historical monuments and housing still owned by the State).

• *State-provided liquidity*: States supply liquidity to the corporate sector in various ways. First, they issue securities that can be used as stores of values. As usual, one must ask, what is it that the State can do that the private sector cannot do? These securities are backed by publicly owned assets, and, more interestingly, by the future tax revenue to be collected by the state. Indeed, we argue that the key to public provision of liquidity is the unique/monopoly ability of the State to access consumers' future income through taxation: while consumers can directly provide corporations with credit lines that are unbacked by real assets only in limited amounts (due to the legal or contractual inability to pledge future income-the prohibition of slavery),[6] they can do so indirectly through the State: the future tax revenue is the collateral that backs the payment of interest and principal on Treasury securities. Second, and again using their regalian taxation power, States provide liquidity through various state-contingent injections, with varying implicit liabilities for taxpayers: repos, discount window, banking and industrial sector bailouts. But there are many less obvious ways in which States redistribute money from consumers to firms in bad times (and money the other way round in good times): non-indexed deposit insurance, whose rates don't reflect the enhanced probability of bank default during recessions; non-indexed payroll taxes financing unemployment benefits, and so forth.

• *Stores of value directly created by consumers:* consumers however may directly create stores of value when they borrow instead of financing their homes themselves. Their commitment to reimburse interest and principal on their mortgages represents a claim on their future income; this claim can be securitized and transformed into a store of value through the institution of mortgage-backed securities (MBSs).[7] It is interesting to note in this respect that real estate mortgages of US households have grown from 15% of their net wealth in 1949 to 41% in 2001, due to various factors (financial innovation; increased risk taking through high loan-to-value ratios, teaser rates and lack of refinancing penalties; changes in legislation favoring

5 *The reader will find in Tirole (2006, chapter 5) a review of the considerations that make full coverage of such risks suboptimal. It should be also noted that risk management does not aim at insuring investors as the latter can diversify their risks in other ways.*
6 *The main example of this is consumer credit (which incidentally is the object of securitization).*
7 *There are limits to the creation of liquidity in this manner, though. First, the consumers must consume some of the money they economize today by borrowing; otherwise they invest it into stores of value, and there is no net creation of such stores of value. Note, second, that future mortgage payments compete with taxes, especially if they are tax deductible; that may reduce the State's ability to create liquidity.*

home ownership). An interesting empirical question relates to how much liquidity is really created through the dual process of mortgage borrowing and securitization. And more generally, it is to be seen how much additional liquidity can be harnessed through financial innovation; the analysis here meets that of Hernando de Soto, who argued that the transformation of "dead capital" to "live capital" is a key step in the development process.[8]

• *Foreign sources of liquidity*: corporations can buy foreign stores of value: *e.g.* the stock index or Treasury securities of a foreign country. They can also access lines of credit from the international financial community. The access to foreign stores of value and lines of credit is however limited as they have to be financed in foreign currency, and so, like for sovereign States themselves, the ability to borrow is bounded by the export capacity of the country.[9]

The assertion that a country's ability to borrow is limited by its capacity to export may seem strange in view of the recent American experience. However, the enormous amount of borrowing by the US is a case in point for a discussion of the role of pledgeability in facilitating financing. Corporate governance, the importance of publicly-held corporations, the role of markets and securitization in creating liquid claims, and the political economy of the country (a strong support for investor protection, due in particular to the existence of pension funds) all concur to create a substantial volume of liquidity, which is in high demand in countries producing substantial income, but few pledgeable claims.

• *Bubbles*: bubbles, by inflating the value of financial assets (stocks, real estate), inflate the volume of stores of value. To be certain, bubbles only go so far to boost corporate liquidity if they tend to burst precisely when the economy enters or is in a recession.[10]

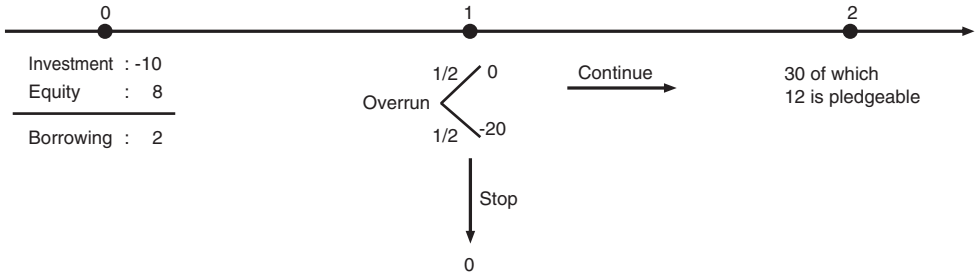
2| LIQUIDITY SHORTAGES AND LIQUIDITY PREMIA

2|1 The concept of inside liquidity in the aggregate

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-Debreu and Modigliani-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 positive NPV re-investments. We therefore investigate the sufficiency of inside liquidity in an example; the conclusions are very general.

An example: consider a representative entrepreneur and three dates (and no discounting between these three dates): $t = 0, 1, 2$ (See figure below for a summary of the timing). At date *0*, the entrepreneur has a project, for which she must invest *10*, but she has wealth only equal to *8*; she must therefore go to the capital market in order to finance this investment. The investment, if made at date *0*, does not generate any revenue at date *1*; actually with probability ½, an overrun (a "liquidity shock") of *20* arises, that must be covered if the project is to go on and produce income at date *2*, otherwise the project is liquidated and yields no income.[11] At date *2*, revenue accrues (provided that the overrun, if any, has been covered at date *1*). The total proceeds, *30*, are shared between investors and entrepreneur; namely, the pledgeable income, that is the maximum amount that can credibly be promised to investors, is only *12*.[12]

8 *De Soto provides the example of giving land ownership rights to land-occupying farmers; property rights give farmers the ability to borrow against this collateral and enable them to buy equipments or new seeds.*
9 *On this see Caballero-Krishnamurthy (2001 and 2003) and Holmström-Tirole (2002 and 2008).*
10 *The popping of the bubble actually triggers a recession. On this, see Farhi and Tirole (2008).*
11 *With probability ½, there is no overrun and therefore no extra expense at date* 1.
12 *For example, the 18 left to the entrepreneur might correspond to an incentive payment provided to the entrepreneur (or more generally the firm's insiders) to curb moral hazard. That amount may also include the entrepreneur's perks and prestige from office. Last, it could also represent money that is diverted toward other activities (affiliated companies, investment in human capital that will be operative in other, future activities).*



Note first that financing the project and covering the overrun if it arises is viable for the investors, even though they cannot put their hands on the entire pie: recalling that the interest rate is by assumption equal to *0*, total (date *0* plus date *1*) investor outlay is equal to date-*2* revenue on investors' claim on the firm: *(10-8)* + *(1/2) (20)* = *12*.

However, the "finance as you go" strategy is not sustainable: suppose that the entrepreneur borrows *2*, against claims on date-*2* income, so as to just be able to cover the investment at date *0*, and counts on returning to the capital market at date *1* in case of overrun. When the overrun arises, the capital market won't be willing to supply more than the maximum revenue, *12*, that investors can grab at date *2* (to obtain *12*, a restructuring of claims through a renegotiation with initial claimholders –who obtain *0* if the firm goes bankrupt at date *1*– is needed if new investors are brought in). Therefore investors aren't willing to bring in the *20* that are necessary to withstand the liquidity shock faced by the firm.

The entrepreneur must therefore plan and hoard liquidity. In this simple example, there are various ways of doing so, but a "reasonable" one may go as follows: the firm contracts with a bank on a line of credit equal to *20*. If this line is drawn, the bank becomes the senior creditor and therefore obtains *12* at date *2*. The bank in exchange demands at date *0* a commitment fee equal to *4* = *(1/2) (20-12)*; it makes money if the credit line is not drawn, and loses money if the firm 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 bank were always happy to provide the funds; it is precisely because lending is a money-losing operation at date *1* that it must be pre-arranged. The other investors must bring in *2* (the investment cost minus the entrepreneur's contribution to it) plus the commitment fee, so *6* in total. They are willing to do so, as they get back *(1/2) (12)* = *6*.

This is all well, but we haven't addressed the "macroeconomic question": where will the bank find the *20* that it has committed to bring in if the credit line is drawn? Imagine that there are lots of such entrepreneurs in this economy. Entrepreneurs are identical at date *0*. As we observed, given that the firm-idiosyncratic events of liquidity shocks are independent and so there is *no macroeconomic uncertainty*, exactly half of the firms face an overrun.

The claim (which is entirely general, and so not specific to this very special example)[13] is that 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 *1* (or *2*, it does not matter), 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 economy wide rate (here *0*): there is no risk-free rate puzzle.

To see this, let the banks invest the 4 they receive in commitment fees in ordinary claims on other firms. If banks are diversified, the per-firm value of the resulting portfolio is *(4/6) (1/2) (12)* = *4* at date *1*. To honor its credit line commitments, the bank needs *(1/2) (20-12)* = *4*, so everything is in order. Note that this arrangement requires some prudential supervision: the bank in general would make more profit by selecting subsets of firms for which liquidity shocks are correlated as this strategy guarantees large profits when such shocks do not arise, and otherwise does not expose the bank, which is protected by limited liability.[14]

13 *See Holmström-Tirole (1998 and 2008). The key assumption for this proposition to hold is that the corporate sector be a net borrower.*
14 *With perfect correlation of shocks in its portfolio, the bank makes* 8 *per firm in the absence of overrun and* 0 *in case of overrun, instead of* 0.

There are other, apparently natural ways of hoarding liquidity that do not work, though. Imagine that instead of centralizing the liquidity within financial intermediaries dispatching liquidity as needed, each firm hoards liquidity in a decentralized way. That is, each firm holds the representative portfolio or index. The value of this portfolio at date *1* is *(1/2) (12) = 6*, which is insufficient to cover the liquidity shortfall (equal to *8*) in the presence of an overrun. To be certain, the firms that do not face an overrun have excess liquidity: the value *6* of the security market holdings, not to mention the possibility of diluting existing claims on their pledgeable income. However, and this is the key point, they have no incentive to lend to and rescue the distressed firms; this situation is certainly reminiscent of the recent subprime crisis, in which those institutions with cash refuse to lend to those without. The efficient outcome does not arise under decentralized liquidity hoarding. There is enough aggregate liquidity in principle, but it is *wasted* by allocating liquidity in a non-contingent manner, so that firms that end up not needing liquidity have plenty of it.

Matters are quite different in the *presence of macroeconomic shocks*. To take an extreme case, suppose that with probability *½* all entrepreneurs face a cost overrun simultaneously; that is, the liquidity shocks are perfectly correlated. Then there is no way investors are going to put in *20* per firm at date *1*: their claims on date *2* income are only *12* per firm, and they cannot be forced to disgorge *20* 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 *8* per firm.

To sum up, meeting liquidity shocks in the absence of outside stores of value requires issuing new securities, *i.e.* digging into inside liquidity, along the way. There is a shortage of inside liquidity when the economy is hit by aggregate shocks. In the absence of macroeconomic shock, by contrast, the corporate sector as a whole in principle produces enough inside liquidity to meet 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 is accomplished by pooling the available liquidity at the level of financial intermediaries, who then redispatch the liquidity through a mechanism akin to credit lines; by contrast, self provision of liquidity, under which each firm hoards liquidity for its own purposes, leads to a waste and therefore a potential shortage of liquidity, as firms that end up awash with cash do not lend it to those with a shortage of liquidity.

Another source of illiquidity is the asymmetry of information about stores of value. This asymmetry of information about assets increases during recessions; for example, a portfolio of mortgage-backed securities may face little risk, and therefore generate little concern about its quality, in good times, and become riskier when things get worse; in the latter circumstances, the MBS assets become illiquid as participants in asset markets are asymmetrically informed: as we announced earlier, macroeconomic illiquidity may generate microeconomic illiquidity.

2|2 Liquidity premia and LAPM

Let us return to the example, in the presence of *macroeconomic uncertainty*. Note first that holding the "stock index" (a portfolio of shares of the firms) does not bring any useful liquidity to firms or financial intermediaries: in the simple-minded example given 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 shock, but this value serves no liquidity purpose as firms don't need liquidity in this circumstances. Put differently, the stock index does not allow firms to diversify and 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 add outside liquidity in a stylized manner to our example. Suppose that at date *0*, there exist stores of value, in quantity x per firm, that the corporate world can purchase and use to meet liquidity needs at date *1*. Namely, each store of value delivers *1* per firm at date *1*.[15] We will call these stores of value the "risk-free assets", and the return they command the "risk-free rate".

15 *Or, indifferently here, at date 2: a long-term store of value delivering 1 at date 2 can be resold at date 1 to consumers at price 1 as consumers are assumed not to discount the future (the rate of interest is equal to 0).*

If x is greater than 8, the shortage of liquidity, then outside liquidity makes up for this shortage. There is sufficient aggregate liquidity: firms can hoard x stores of value each; when they face a liquidity shock they can resell these x stores of value and supplement this sale through a sufficient dilution of initial claimholders: for example, if x is equal to 14, then the firms can double the number of shares in each firm. In so doing, the firms raise cash $(1/2)(12) = 6$, which together with the sale of the risk-free asset allow them to cover the cost overrun (20).[16]

With lower amounts of outside liquidity, outside liquidity complements inside liquidity, but there is still a shortage. Firms compete for the scarce stores of value, raising their price above 1; put differently, the risk-free assets command a return that is below that suggested by the consumers' rate of time preference (here normalized at 0). The higher x, the smaller the liquidity premium (the closer the interest rate is to 0).[17] Like in the less formal accounts of Hicks and Keynes, risk-free securities are held not so much for their return, but rather because they deliver cash when firms need it: they are liquid in the macroeconomic sense.

More generally, the price of assets reflects how much liquidity they bring when it is needed. This property is very much in the spirit of the capital-asset-pricing model (CAPM), which determines security values from the covariance of their return with aggregate activity. There is a difference, though: in the CAPM paradigm, pricing is determined entirely by the consumer sector (technically, the covariance refers to that between the asset's return and the representative consumer's marginal rate of substitution). The liquidity-asset-pricing model (LAPM) adds firms to the picture and states that corporate demand for stores of value also drives the pricing of assets. In the example above, the firms pay a premium over what consumers are willing to pay and so pricing is determined on the corporate side rather than on the consumer side.

In this simple minded example, firms hold *all* risk-free assets, at least if x is less than 8, because consumers have no liquidity needs of their own. More generally and realistically, the "pricing kernel" is determined jointly by consumers and firms with liquidity needs. The key message is therefore that one cannot ignore variations in corporate net liquidity demand when pricing assets.

The "model" described above can, at the cost of increased complexity, be used to study the dynamics of inside liquidity generation and the term structure of interest rates.[18] Yesterday's investments give rise to dividends tomorrow, which if traded, create stores of value today. This creates an investment hysteresis: a higher level of liquidity supports more investment, which in turn creates future dividends that if not transformed into dead capital will create liquidity tomorrow and support new investment, and so forth. The interest rate is procyclical, and the interest rate spread (long rate minus short rate) countercyclical.

2|3 Bubbles

An asset is said to embody a bubble if its price exceeds its fundamental value, namely the value of future dividends, coupons or rentals. It is by no means easy to disentangle bubbles from fundamentals when asset prices reach high levels. For example, the high real estate prices of the first half of this decade in the US can be attributed at least partly to fundamental-boosting low interest rates resulting from Alan Greenspan's deliberate attempt to raise asset values. Shiller however argues that one can detect the existence of a real estate bubble by comparing the evolution of rental and ownership prices. Real estate prices moved in synchronicity with rental rates (the "dividends" on the real-estate assets) until 2000, and afterwards gained 70% relative to rental rates, suggesting the appearance of a bubble.

A policy debate has accordingly emerged, as to whether the central bank should try to prick, or at least lean against the bubble (assuming one succeeds in identifying one). For example, Bernanke (2002) and Bernanke-Gertler (2000 and 2001) argue that the central bank should not be concerned about a bubble unless it is a signal of incoming inflation; others, *e.g.* Bordo-Jeanne (2002) feel otherwise.

16 *Note that the issue of liquidity waste does not arise here: with perfectly correlated shocks, as presumed in this example, a firm needs cash precisely when others also need cash; there is therefore no need to transfer cash from liquidity rich firms to firms with liquidity needs.*
17 *Krishnamurthy and Vissing-Jorgensen (2007) show that the yield spread between AAA rated corporate bonds and US Treasury securities is low when the stock of debt is high, and this even if one controls for default risk on corporate bonds. As they state, changes in the supply of Treasury debt trace out the demand for convenience by investors.*
18 *Ongoing work by Emmanuel Farhi and the author.*

The classic view of asset bubbles[19] has it that a) the existence of a bubble raises interest rates, b) a bubble crowds out productive investment, and c) bubbles can exist only if the economy is "dynamically inefficient", *i.e.* only if the rate of interest lies below the rate of growth of the economy (the productive sector then absorbs more resources than it delivers). While the increase in interest rates is rather uncontroversial, the validity of the other two properties has been questioned. First, while the competition (or crowding out) effect is undeniably there as bubbles inflate the volume of assets proposed to lenders, specific episodes (the Japanese or the American bubbles) suggest that asset bubbles may sometimes go hand in hand with sustained investment. Second, Abel, Mankiw, Summers and Zeckhauser (1989) have argued that there is no evidence that the economy is dynamically inefficient.

In an economy with capital market imperfections, though, bubbles also add to the volume of stores of value. Although they may burst precisely when the economy enters a recession, they still have a residual value in boosting aggregate liquidity. This implies that under certain circumstances,[20] bubbles and investment can be complements, rather than substitutes as predicted by the competition effect. Furthermore, it can be shown that the existence of bubbles is a) more likely in economies with little pledgeable income, and b) consistent with dynamic efficiency (the more so, the higher the agency costs in borrowing).

The burst of a bubble in this context may not be good news: it destroys a store of value and thereby creates a shortage of liquidity, resulting in lower investment.

2|4 The subprime crisis

While it is too early to provide an accurate account of the recent events, a number of factors came into play in the real estate crisis. First, the Fed for a long while kept the cost of borrowing rather low, resulting in high demand for and price of real estate. Second, credit was extended under rather risky terms: high loan-to-value ratios, backloading of reimbursements (teaser rates), low penalties, indexed mortgages.

Third, rating agencies underperformed, giving triple *A* ratings to rather risky portfolios. Commentators have pointed at several deficiencies of the rating process: weakness of models and assumptions on correlations, poor understanding of solvency of issuers and guarantors, flight of key personnel from rating agencies,[21] conflicts of interest (repeated relationship between investment banks-whose involvement in structured finance has become substantial- and rating agencies, bundling of services by rating agencies), etc. Whatever the cause, a key step in the transformation of dead capital into liquidity failed. Ultimate buyers felt unable to assess the value of CDOs and CLOs and relied on the rating agencies' certification, but did not receive an accurate picture of those values.

A modest reduction of real estate prices (3.4% in a year) started creating threats of defaults of, or trouble for those institutions that had purchased portfolios of mortgage-backed securities, or had extended complex, and often hidden liabilities to structured investment vehicles. With it came the prospect of contagion, the stalling of markets and the worry about fire sales, making prudential regulators concerned about banks, insurance companies and pension funds with exposures to MBSs.

The recent events have many ingredients of a standard liquidity crisis. The downturn of the real estate market created the initial aggregate liquidity shock. This shock was magnified by adverse selection, as portfolios became riskier and concerns about quality more pungent. Finally, the shock was further compounded by concerns about fire sales.

3| PUBLIC SUPPLY OF LIQUIDITY

We earlier argued that the State can provide (outside) liquidity 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*.[22] 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.

19 *See Tirole (1985).*
20 *See Farhi-Tirole (2008).*
21 *Hired by investment banks to find out modeling weaknesses.*
22 *Or date 2 for that matter.*

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.

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. We have argued that this is what it does in practice, through a variety of instruments from open market operations to the discount window, from banking bailouts to non-indexed payroll taxes and deposit insurance premia. Ideally, the State should be issuing "state-contingent liquidity", *i.e.* liquidity that delivers 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.

Another suggestion of economic theory 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. 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 funds requirements in the United Kingdom.

Another form of public intervention consists in preventing fire sales by the corporate sector under severe strains in their liquidity position. While economists generally abhor such cartelization activities in general (and rightly so), a case can be made that sellers of assets "over-compete" in periods of liquidity shortages. Namely, the demand curve for these assets (industrial assets or real estate) isn't perfectly elastic. Large sales may lead the price of these assets to plummet, reducing the liquidity available to the corporate sector in bad times. Orderly sales controlled or tolerated by authorities prevent too sharp a drop in the price of the assets; an alternative to avoiding fire sales prices is to offer short-term loans to potential sellers of assets, as in the case of the planned superfund in the US, meant to prevent structure investment vehicles from engaging in fire sales.

A public provision of liquidity may also buy the time needed to proceed to an orderly reallocation of liquidity. Recall that the asymmetry of information about assets increases during recessions. By injecting liquidity, the State may then be able to buy time for the owners of these assets if the latter can use this extra time to convince potential buyers of the assets of their quality.

Finally, we have taken a very normative approach. While the existence of liquidity shortages vindicates the injection of liquidity by the State, there remains a concern that the latter might inject too much liquidity, for several reasons. One, as usual, is capture by those who benefit from an injection at the expense of taxpayers; relatedly, boosting the economy temporarily at a delayed and yet invisible cost may prove tempting. Second, the State, regardless of its benevolence, may be subject to time inconsistency: it may bail out financial institutions who have not properly managed their risk, generating *ex ante* moral hazard.[23] Some of the many tools of aggregate liquidity management (*e.g.* bailouts) are more prone to generate moral hazard than others. Future research ought to provide a better picture of public policy, both in level and in structure.

23 *See Rochet-Tirole (1996) for a model depicting simultaneously corporate liquidity management and the "soft budget constraint".*

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