

Liquidity Crises*

BY RONEL ELUL

Financial markets have experienced several episodes of “liquidity crises” over the past 20 years. One prominent example is the collapse of the Long Term Capital Management hedge fund in 1998. The recent market disruption brought about by the downturn in subprime mortgages also shares many features with liquidity crises. What is liquidity? Why does it sometimes seem that the market’s supply of it is insufficient? Can anything be done about it? In this article, Ronel Elul outlines some theories of market liquidity provision, how it breaks down in times of crisis, and some possible government responses.

Over the past 20 years, financial markets have experienced several episodes of “liquidity crises.” Among these are the 1998 collapse of the Long Term Capital Management hedge fund and the disruption in financial markets that began in the summer of 2007, sparked by the downturn in subprime mortgage markets.

In many of these cases, the market’s supply of liquidity seemed to be insufficient, and moreover, liquidity does not always appear to be allocated to those who need it

most. Lack of liquidity also sometimes forces “fire sales,” actions that, in turn, push down asset prices, thus making liquidity problems worse. Economists have sought to understand the nature of market liquidity provision, how it breaks down in times of crisis, and possible government responses.¹

ANATOMY OF A LIQUIDITY CRISIS

What Is Liquidity? One author has pointed out that “liquidity, like pornography, is easily recognized but

not so easily defined.”² For understanding liquidity crises, however, it may be useful to think of liquidity as the ease of selling an asset at its “true,” or fundamental, value. This fundamental value may be defined as the present value of the asset’s future cash flows. Alternatively, liquidity can be viewed as the extent to which it is possible for the holder of an asset to borrow against these future cash flows.

The Collapse of LTCM. The events of the summer and fall of 1998 provide an illustration of many of the main features of liquidity crises. These events revolve around the collapse of the Long Term Capital Management (LTCM) hedge fund.³

During the summer of 1998, LTCM took large losses on many of its trades; these losses were intensified when Salomon Smith Barney’s arbitrage group, which had positions very similar to LTCM’s, was broken up and its positions liquidated. But LTCM’s position became much more precarious on August 17, 1998, when the Russian government devalued the ruble and declared a moratorium on repaying 281 billion rubles (\$13.5 billion) of its Treasury debt. The fact that the IMF had allowed a major economy to default shocked the markets.⁴



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at www.philadelphiafed.org/econ/br/.

¹ I use the term “government intervention” broadly. In principle, this might include fiscal policy or central bank monetary policy. In this paper, I will focus on monetary policy.

*The views expressed here are those of the author and do not necessarily represent the views of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.

² See the book by Maureen O’Hara.

³ Much of this account is drawn from Roger Lowenstein’s book.

⁴ In addition, a further surprise occurred when Russian banks and securities firms exercised *force majeure* clauses and refused to honor the derivatives contracts they had sold to foreign customers. These clauses, which are common in many contracts, are intended to free a party from liability when an extraordinary event prevents him from fulfilling his obligation.

LTCM had indeed invested in Russian bonds and lost money following this default. However, the resulting *flight to quality* had an even bigger effect on the value of LTCM's portfolio. Investors who had become nervous as a result of these events pulled out of risky assets and rushed to assets considered safe. For example, the yield on the 30-year U.S. Treasury bond (a safe security) fell to its lowest level up to that time. Many of LTCM's strategies had involved betting that the spread between safe and risky assets would actually decline; thus, the flight to quality caused it to lose substantially more. Finally, in addition to a flight to quality in security markets, there was a broad-based drying up of liquidity as banks chose to preserve their liquidity and cut back on lending.⁵

As a result of declines in prices on the risky assets in its portfolio, LTCM breached collateral agreements with its lenders and was forced to sell assets to meet these margin calls.⁶ These asset sales had ramifications for other markets and other hedge funds. Mark Mitchell, Lasse Pedersen, and Todd Pulvino recount an example: "When LTCM incurred large losses on macroeconomic bets, the firm was forced to liquidate large convertible bond positions.⁷ These sales led to depressed valuations of convertible bonds despite

the fact there was little change in overall fundamentals.⁸ As a result, other hedge funds incurred large losses and were also forced to sell their convertible bond holdings." The authors show further that prices of convertible bonds fell far below their "fair" value, as calculated by mathematical models.⁹

Because of concerns that the forced liquidation of LTCM's huge

The events of the summer and fall of 1998 provide an illustration of many of the main features of liquidity crises.

portfolio would cause further upheaval in financial markets, the Federal Reserve helped coordinate a private-sector bailout of the fund in September 1998.¹⁰ The Fed also cut its fed funds rate target by 75 basis points during the fall of 1998, in part because of concerns that financial market turmoil

might spill over to the real side of the economy.

From this account we can identify several key features of liquidity crises. The apparent trigger for the crisis was an unexpected event that called long-standing models into question. Lenders responded by cutting back on providing liquidity. The effect of the crisis was to push prices below their fundamental, or fair, value. More precisely, the prices of risky assets fell, while those of assets perceived to be safe rose; that is, there was a flight to quality. There was *commonality of illiquidity* — problems spilled over from one market to another. A *liquidity spiral* was created: These falling prices caused margin requirements to be breached, thus leading to asset sales, which then led to further drops in prices and thus to further losses, and so on. Government intervention played a role in resolving the crisis.

The Current Financial Market Turmoil. Many of these features are also present in the disruption in financial markets that began in the summer of 2007, sparked by the downturn in subprime mortgage markets. Not surprisingly, the sharp increase in default rates on mortgages called into question models of subprime mortgage credit quality (as well as lenders' underwriting standards). There was also a flight to quality — for example, the premium paid by high-quality (AAA-rated) corporate borrowers over U.S. Treasury bonds nearly doubled in the summer of 2007 (Figure 1). In this case, market participants suddenly demanded much more compensation to bear even a small amount of risk. The cutback in the provision of private-sector liquidity was even more dramatic than in the case of LTCM. This may be seen most strikingly in the interbank market; the London InterBank Offered Rate (LIBOR) that banks charge one another in the London interbank market

⁵ See, for example, the September 1998 Federal Reserve Senior Loan Officer Opinion Survey: <http://www.federalreserve.gov/boarddocs/snloansurvey/199810/default.htm>.

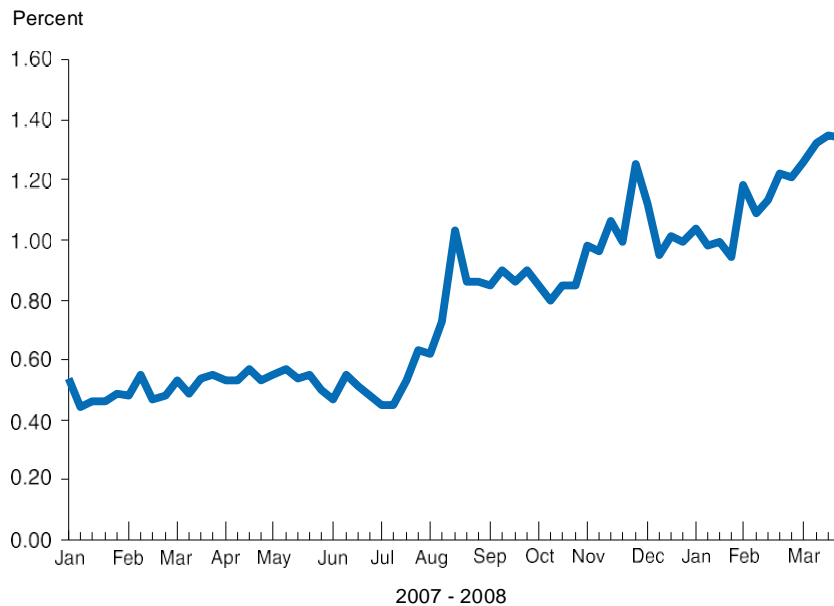
⁶ Like most hedge funds, LTCM had borrowed heavily to finance its portfolio and borrowing allowed it to generate higher returns per dollar of outside investment. However, LTCM's lenders required that the value of these assets, which served as collateral to secure its loans, stay above a certain minimum *margin requirement*. When the prices of its assets fell, these collateral agreements were breached, and lenders issued *margin calls*. This required LTCM to come up with additional cash or securities in order to avoid the forced liquidation of its portfolio.

⁷ A convertible bond is a type of bond that can be converted into shares of stock in the issuing company, usually at some pre-announced ratio. Hedge funds are significant traders of convertible bonds, as part of a popular strategy known as convertible arbitrage.

⁸ In this example, prices are below their fair value because of binding collateral constraints. However, another reason that prices may fall in a crisis is that one side of the market has more information than the other, and thus, asset sales may be interpreted as negative information about fundamentals. For a similar model motivated by the 1987 stock market crash, see the paper by Gerard Genotte and Hayne Leland.

⁹ The fair value of the convertible bond is calculated by using an option valuation model; these models are extensions of the well-known Black-Scholes pricing formula.

¹⁰ Although it will not be discussed here, the economic rationale behind the Fed's coordinating role is also of interest; see the paper by Stephen Morris and Hyun Shin.

FIGURE 1**Five-Year AAA Corporate Bond Rate —
Five-Year Treasury Bond Rate**

shot up relative to the baseline U.S. Treasury bill rate as banks sought to conserve their scarce liquidity. The problems were particularly pronounced in term (that is, not overnight) interbank markets (Figure 2). These events were widely understood in the popular press as reflecting *liquidity hoarding*. Finally, the Federal Reserve and other central banks intervened in several different ways. (See *Federal Reserve Responses to Recent Problems in Interbank Markets*.)

PRIVATE MARKETS MAY PROVIDE TOO LITTLE LIQUIDITY

One central feature of these episodes is the inadequacy of the private market's provision of liquidity. In studying this issue, Bengt Holmstrom and Jean Tirole explore various means by which firms may obtain liquidity and show that the private market may

not always be able to provide adequate liquidity on its own. They then consider possible government responses.

They consider firms that have long-lived projects, for example, manufacturing plants that can produce a good for several years before becoming obsolete. These firms may experience a "liquidity shock," a sudden need for funds to keep the project going. This could be due, for example, to an unanticipated, temporary shortfall in sales, so that internal funds that were previously used to keep projects going are no longer available. But if these funds are not available, the firms' assets must be liquidated immediately, at a loss. How can the firms obtain enough liquidity to continue their projects?

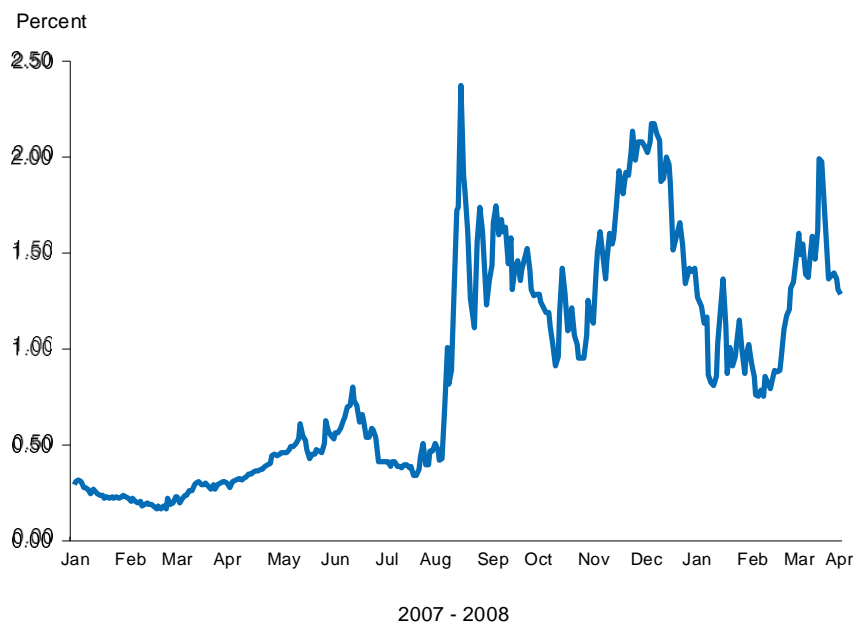
These projects are still profitable, so one might think that a firm that has been hit by a shock could simply borrow against its future project returns. But lenders may be unwilling to offer

sufficient funds to the firm because the greater the firm's required debt payments, the smaller the firm's own share of the returns from the project. This means that the firm has less incentive to exert enough effort to ensure that the project succeeds.

To guard against this risk of illiquidity, a firm might hold cash or other safe assets, such as Treasury securities, that can be sold in case it experiences a shock. Since these assets are safe, the firm can always sell them to raise funds. But Holmstrom and Tirole also show that this is not generally an ideal way to allocate scarce liquidity because lucky firms that do not experience a shock will be left with assets they do not need, while unlucky firms have no way to gain access to those assets.

What is needed instead is some way for firms to obtain insurance against unexpected liquidity needs. This can be facilitated through a financial intermediary that can offer lines of credit to firms, which they draw upon only if they experience a shock. In effect, the financial intermediary takes stakes in all of the firms' future returns and lends only to those firms that have been hit by a shock. When liquidity shocks are *idiosyncratic* — that is, the shock hits only a few firms at once — Holmstrom and Tirole show that this is indeed the best way to provide liquidity to the private sector.

However, in a liquidity crisis, in which the liquidity shock is an *aggregate* one (that is, it hits many firms at once — for example, a recession that hits all firms' sales), the private market is not able to meet each firm's liquidity needs. The reason is that firms' aggregate demand for liquidity will exceed the private sector's ability to meet this need. In this case, there is scope for the government to provide liquidity in times of crisis. The government is able to commit to providing liquidity when

FIGURE 2**Three-Month LIBOR — Three-Month T-Bill Rate**

the private market can't, either by taxing consumers or by printing money.

Holmstrom and Tirole suggest that this intervention may take many forms. For example, it could take the form of government securities that pay off only in the event of a particular aggregate liquidity shock. Sundaresan and Wang document this in connection with the run-up to Y2K. They show that privately supplied liquidity dried up as the millennium approached. In response, the Federal Reserve intervened by issuing options on the fed funds rate.¹¹ Alternatively,

¹¹ These options, which were sold to Treasury bond dealers, each gave the holder the right to borrow \$50 million from the Fed at a pre-specified interest rate, on a specific date between December 23, 1999, and January 12, 2000. The Fed also responded in other ways, for example, by creating a "century date change special liquidity facility" for banks.

Holmstrom and Tirole suggest that monetary policy could serve this role by easing financing conditions in times of crisis.

VERY UNLIKELY CONTINGENCIES CAN AFFECT THE AVAILABILITY OF LIQUIDITY

While Holmstrom and Tirole focus on the lack of sufficient liquidity in the private sector as a rationale for government intervention, another feature of some liquidity crises is that what liquidity is available is not efficiently allocated. That is, liquidity is not allocated to those who need it the most. The reason is that the liquidity crisis may make market participants overly concerned about extremely unlikely risks and lead them to hoard liquidity so as to insure against these risks.

Ricardo Caballero and Arvind

Krishnamurthy study this phenomenon and show how government intervention may be useful in resolving it. They focus on liquidity crises that begin with unexpected events that call widely held beliefs and models into question. We have seen that this may characterize both the 1998 LTCM collapse as well as the recent disruption in financial markets that began with the downturn in subprime mortgage markets. Having scrapped old models, but without well-articulated new models to take their place, investors may tie up so much capital in response to concerns about extreme — but unlikely — events that they are unwilling to provide financing to meet more moderate — but likelier — liquidity needs.

Consider the example of corporations that deposit funds in a bank and, in return, have access to lines of credit that they can draw on should they experience a liquidity shock. In Caballero and Krishnamurthy's model, a sudden liquidity shock hits some firms in the economy and generates a need for borrowing. But those firms not affected by this first shock grow concerned that they may be hit by a second shock, even though this second shock is very unlikely. The unaffected firms react by preemptively drawing down their own lines of credit.¹² That is, they *hoard* liquidity. The result is that there is much less available for those firms that actually need liquidity because they have been hit by the first shock.

Reports in the popular press during the recent financial market disruption frequently refer to liquidity hoarding motivated by uncertainty. For example, in explaining elevated inter-

¹² Firms may act preemptively because they are concerned that when the second shock hits, their credit quality will deteriorate so much that they will violate the covenants in their lines of credit and, thus, will be unable to borrow any further.

est rates in the interbank market, the *Wall Street Journal* quoted one banker as saying that “[banks and investors] are still fearful of each other and everybody is worried about counterparty risk and so people are hoarding their balance sheets.”¹³ This article also suggested that government intervention might reassure market participants and so reduce the impetus to hoard liquidity. We will see that, in Caballero and Krishnamurthy’s model, government intervention can play such a role.

But why would banks hoard capital in response to an unforeseen shock? Caballero and Krishnamurthy

assume that market participants are *uncertainty averse*. That is, when evaluating outcomes about which they are *uncertain*, they use the most pessimistic probability assessments. In particular, each participant overweights the probability that he will be among those hit by the second shock. (See *Uncertainty Aversion*.) This creates a desire to hoard liquidity against this unlikely shock.

Caballero and Krishnamurthy then discuss how government intervention might remedy this market failure. Their prescription is for the government to act as a lender of last resort. More precisely, by committing to provide liquidity in the event that the second shock occurs, the government thereby frees the private market to insure itself against the first, more likely, shock. Indeed, Caballero and Krishnamurthy quote former Fed Chairman Alan Greenspan to this effect: “... [p]olicy practitioners operating under a risk-management paradigm may, at times, be led to undertake actions intended to provide insurance against especially adverse outcomes.”

¹³ See the article by Greg Ip and Joellen Perry.

LIQUIDITY AND ASSET PRICES

We have seen that one way for firms to generate liquidity in times of need is to sell assets. But the level of liquidity can affect the value of these assets. This can then result in a “spiral,” in which falling liquidity reduces asset values, which, in turn, leads to lower liquidity, and so on.¹⁴ We have already discussed one example of this: the convertible bond market during the 1998 collapse of LTCM. These forced sales, Mitchell, Pedersen, and

Falling liquidity reduces asset values, which, in turn, leads to lower liquidity.

Pulvino argue, were the result of binding capital constraints.

Markus Brunnermeier and Lasse Pedersen develop a model that explains these spirals, along with many other features of liquidity crises. They focus on a particular aspect of liquidity: the need for immediacy. In their model a *customer* may arrive with an immediate need to sell an asset today, but no buyer may be available. So there is a need for temporary liquidity to bridge this gap (what they term *market liquidity*). This need for immediacy is provided by *speculators* (for example, securities dealers or hedge funds). The speculators serve a valuable economic role: They buy the asset today and then sell it at some later date when a buyer arrives. The speculators require funds in order to operate, and they obtain these funds from *financiers*, for

¹⁴ The feedback between asset values and financing conditions has also been explored by macroeconomists seeking to explain the depth and persistence of economic downturns. An early and influential example is Irving Fisher’s “debt deflation” theory of the Great Depression.

example, banks. So they themselves also have a need for liquidity. Brunnermeier and Pedersen call this *funding liquidity*.

In normal times, financiers themselves have adequate funding liquidity; therefore, they are able to provide market liquidity to their customers and thus assets are priced “fairly.” That is, the price of an asset accurately reflects its expected future cash flows. However, when funding liquidity is scarce, there will also be insufficient market

liquidity, and asset prices will need to fall below this fair value to induce speculators to buy.

But why would funding liquidity be scarce? One reason is that speculators may have incurred losses on their other activities (as LTCM did). In addition, falling prices can themselves negatively affect speculators’ funding liquidity. The reason is that speculators are limited in how much they can borrow by a collateral constraint.¹⁵ That

¹⁵ Brunnermeier and Pedersen model this as a maximal value-at-risk (VaR) for the speculators. Banks commonly use value-at-risk to measure market risk, both for themselves and for their counterparties. Indeed, the Basel II Accord — an international agreement regarding how much capital banks need to put aside to guard against financial and operational risks — encourages the use of VaR to determine the amount of regulatory capital a bank must hold against its market risk. In the Basel II framework, VaR is calculated using a 10-day horizon, at a 1 percent probability level. So if a bank’s market risk model predicts that there is only a 1 percent chance that the value of its portfolio will decline by more than \$1 million in the next 10 days, its VaR is \$1 million. VaR thus depends critically on the volatility of the value of the assets. In Brunnermeier and Pedersen’s model this goes up in a crisis because price declines make the world appear to be more volatile.

Federal Reserve Responses to Recent Problems in Financial Markets

A

s of March 2008, the Federal Reserve has responded in several ways to the liquidity problems associated with the recent disruptions in financial markets. These interventions provide examples of the

policy instruments available to central banks.

- *Discount Window* – The Fed took two broad classes of actions to ease disruptions in financial markets by making it less costly for depository institutions to borrow directly from the Fed through the discount window. The discount window offers some advantages over private markets during episodes of tight credit. First, the Fed accepts a wider variety of collateral than do bank lenders (particularly during periods of financial market turmoil). In addition, by lending directly to depository institutions, the Fed can supplement the interbank market at times when it is not functioning well.^a However, depository institutions are often reluctant to borrow directly from the Fed because of the perceived stigma it carries.

One step the Fed took was to narrow the spread between the discount rate (which is the rate that depository institutions must pay to borrow directly from the Fed's primary credit facility) and the federal funds rate (the rate at which banks borrow and lend among themselves, for one day at a time, on an unsecured basis). It also extended the terms of discount window loans; before the summer of 2007 they were overnight or very short-term loans. The Fed did this in two stages: On September 18, 2007, the Fed reduced the spread from 100 basis points above the target fed funds rate to 50 basis points and extended the maturity of discount window loans to up to 30 days. On March 16, 2008, it lowered the spread

further, to 25 basis points, and also extended the maximum maturity of discount window loans to 90 days.

- *Term Auction Facility (TAF)* – This was a new policy tool announced on December 12, 2007. The Fed undertook to make 28-day loans directly to depository institutions at rates determined through competitive auctions. From these institutions' perspective, the TAF has several potential advantages over the discount window. One is that borrowing from the TAF may carry less of a stigma for a depository institution than accessing the discount window. In addition, depository institutions were able to place bids below the discount rate, so that they had the possibility of receiving funding at lower rates. While the TAF was new for the Fed, the European Central Bank regularly uses a similar tool.
- *Primary Dealer Credit Facility (PDCF)* – On March 16, 2008, the Fed announced the PDCF, which is a new, temporary discount window facility. The PDCF provides overnight funding to primary dealers^b at the discount rate, in exchange for a specified range of collateral, including investment-grade mortgage-backed securities and asset-backed securities. This facility is intended to improve the primary dealers' ability to provide financing to participants in securitization markets and promote the orderly functioning of financial markets more generally.
- *28-Day Single-Tranche Repurchase Agreements* – On March 7, 2008, the Federal Reserve announced that it would initiate a series of term repurchase agreements^c that are expected to cumulate to \$100 billion. There

^a Recall that there was a particularly large spread between LIBOR and Treasury rates, suggesting that there were indeed problems in the interbank market.

^b Primary government securities dealers (*primary dealers*) - of which there are 20 - are banks or securities broker-dealers who may trade directly with the Fed. They are active participants in the Fed's open market operations as well as in U.S. Treasury auctions. Several of these are investment banks, and many others are subsidiaries of commercial banks. The current list of primary dealers may be found at http://www.newyorkfed.org/markets/pridealers_current.html.

^c A repurchase agreement (or "repo") is a collateralized borrowing agreement structured as a sale of the collateral (in this case by dealers to the Fed), along with an agreement to buy it back at a higher price in the future (in this case, 28 days later). This higher price implicitly determines an interest rate, known as the "repo rate."

^d Although these 28-day single-tranche repos differ from the ones typically conducted by the Fed, in the past the Fed has occasionally conducted either 28-day, or single-tranche, repos.

Federal Reserve Responses ... *continued*

are two main differences between these agreements^d and typical Fed repurchase agreements. First, they are 28-day repos; typically the term is shorter. In addition, they are “single-tranche”: dealers may submit any of the following types of collateral — Treasuries, agency debt, and agency mortgage-backed securities — and pay the same repo rate regardless of its type. By contrast, the repo rate typically differs by the type of collateral, with those pledging Treasuries paying the lowest rate and those pledging mortgage-backed securities the highest. Since under the new program market participants face the same rate regardless of the collateral, they have an incentive to submit only mortgage-backed securities.^e

- *Term Securities Lending Facility (TSLF)*—On March 11, 2008, the Fed announced an expansion of its securities lending program. Under the new program, the Term Securities Lending Facility, the Federal Reserve will lend up to \$200 billion of Treasury securities to primary dealers for a term of 28 days (rather than overnight, as in the existing program) by a pledge of other securities, including federal agency

debt and both agency and AAA-rated nonagency mortgage-backed securities. The TSLF is intended to promote liquidity in the financing markets for Treasury and other collateral and thus to foster the orderly functioning of financial markets more generally.

- *Cooperation with Other Central Banks*—Other central banks also undertook to increase their liquidity provision through similar means. In addition, the Fed entered into “reciprocal currency arrangements,” in which it lent dollars to the European Central Bank and the Swiss National Bank, which, in turn, offered dollar loans to their member banks. This was the first time since September 11, 2001, that the Fed had entered into such arrangements with central banks in Europe.

This period was also characterized by a slowing economy and by concerns that continued financial market turmoil could slow the real economy further. In response, the Fed reduced its target for the fed funds rate. Between September 2007 and March 2008, the Fed cuts its target from 5.25 percent to 2.25 percent

^e That this was in fact the case can be seen from the New York Fed’s announcements of the results of its single-tranche repos on March 7, 11, 18, and 25, 2008.

is, the speculators must post securities to back any loan they take. (See *Margins and Liquidity*.) This collateral constraint becomes tighter during a crisis for two reasons. First, the value of the collateral is lower in the crisis, because asset prices have fallen. In addition, falling prices make the world appear more volatile, which also leads the bank to tighten its collateral constraint. This results in a liquidity spiral, as described above.

In addition to liquidity spirals, Brunnermeier and Pedersen are able to explain other characteristic fea-

tures of liquidity crises. The first is the flight to quality: a rush to buy safe assets, which is reflected in a relative appreciation in their price. This is an outcome of Brunnermeier and Pedersen’s model because when liquidity is scarce, market participants prefer to conserve it by investing in less risky assets. This causes the price of riskier assets to fall more than those of safe ones (and hence causes their yield to rise relative to that of safe assets). Another feature that Brunnermeier and Pedersen are able to explain is the commonality of liquidity across securi-

ties and markets, that is, the tendency for liquidity problems to spread from one market to another (as was the case for the convertible bond market in 1998, discussed earlier). This occurs because speculators provide liquidity in many markets simultaneously, and so a deterioration in their financing position (even if initially caused by a shock to a single market) will affect all of these markets.

Brunnermeier and Pedersen also discuss the possible regulatory responses to a crisis. First, they argue that if the regulator “knows” that this

Uncertainty Aversion

R

icardo Caballero and Arvind Krishnamurthy use uncertainty aversion in their model to explain the hoarding of liquidity. There is evidence that decisions are indeed characterized by aversion to

uncertainty; that is, individuals seek to avoid ambiguous situations in which probabilities are not known. A classic example is the Ellsberg paradox.

In the Ellsberg paradox, there is an urn containing 90 balls: 30 red balls and 60 black and yellow balls in unknown proportion. A ball is drawn, and an individual is then asked whether he prefers to bet that this ball is red (gamble A) or black (gamble B). Most people choose gamble A. That is, they prefer to bet on a red ball, which they know will occur one-third of the time, against the chance of a black ball, whose probability lies somewhere between 0 and two-thirds. Note that gamble B reflects *uncertainty*, in that the precise probability that a ball is black is unknown.

Then the ball is replaced and another is drawn. The (same) individual is now asked whether he prefers to bet that the ball is either red or yellow (gamble C) or black or yellow (D). Most people choose gamble D in this case. That is, they prefer to bet that a black or yellow ball is drawn, which they know will happen two-thirds of the time, against the chance of a red or yellow ball (the latter

probability lies somewhere between one-third and 1).

But there is a certain inconsistency in these two choices because the second gamble is really equivalent to the first, with the addition of the possibility of yellow balls to each option. So if someone prefers gamble A over B, he should actually prefer gamble C over D. For example, if one believes there are more red balls than black balls (and hence prefers gamble A over B), one also believes that there are more red or yellow balls than black or yellow balls, and so should prefer gamble C over D.

Ellsberg explained these seemingly contradictory choices as reflecting individuals' dislike for uncertainty, that is, for unknown probabilities. They prefer A over B because they know that one-third of the balls are red; conversely, they prefer D over B because they know that two-thirds of the balls are either black or yellow.

Since this evidence is inconsistent with the canonical economic model of expected utility maximization,* it has led to the development of alternative models of decision-making under uncertainty. One of these, developed by Itzhak Gilboa and David Schmeidler, models individuals faced with unknown probabilities as pessimistic – that is, as making decisions under the “worst case” probabilities. This is the approach used by Caballero and Krishnamurthy.

* In particular, the “sure-thing principle.”

is, in fact, a temporary liquidity shock, he should try to convince banks to lend to speculators. If the regulator is correct, banks' profits in times of crisis will actually be higher. However, attributing superior information to the regulator is, of course, a very strong assumption. In addition, Brunnermeier and Pedersen suggest that the regulator can help stabilize prices by providing liquidity directly to the speculators (or to the banks that finance them).

CONCLUSION

Financial intermediaries serve to allocate the private market's wealth so as to meet firms' and investors' liquidity needs. But “liquidity crises,” in which the market fails to function properly, are a recurrent feature of financial markets.

During these episodes the demand for liquidity may be so great that it cannot be met by the private sector alone. This creates a role for govern-

ment intervention; the government can provide liquidity in these circumstances through its ability to raise funds by taxing consumers.

In addition, these episodes may also be characterized by a misallocation of private liquidity. Market participants may hoard liquidity because they become concerned about extremely unlikely events. In this case there may be a further role for the government in insuring against these extreme events.

Margins and Liquidity

I

n Markus Brunnermeier and Lasse Pedersen's model, margin requirements play a key role. They may exacerbate liquidity crises and thus facilitate a liquidity spiral.

Likewise Mark Mitchell Pedersen and

Todd Pulvino document the role that capital constraints have played in many real-life liquidity crises (for example, in the convertible bond market in the 1998 LTCM crisis). Given that they may exacerbate crises, why do margin requirements and capital constraints exist? And are they optimally determined by private markets?

On the most basic level, requiring borrowers to post margin, or collateral, facilitates lending by increasing the likelihood that lenders will be repaid.^a Viral Acharya and S. Viswanathan show how this can help to provide liquidity. Consider firms facing liquidity shocks. If they are able to borrow enough, they can meet their liquidity needs without selling any assets. However, firms may be limited in what they can borrow because lenders are concerned that the firm might divert funds to risky projects. In general, borrowers have a tendency to prefer riskier projects than their lenders because lenders bear the brunt of any losses when the firm defaults. By pledging their assets as collateral, firms are able to reassure lenders that they will indeed invest efficiently; so firms are able to borrow more and thus meet larger liquidity needs.

While collateral does facilitate borrowing, if the liquidity shock is large, not all firms will be able to borrow enough to survive, and some will need to be liquidated early. In cases where there are many more sellers than buyers, this will in turn lower asset prices. These lower prices then lead to tighter collateral constraints and thus to a liquidity spiral, as described earlier.

Although Acharya and Viswanathan show that the ability to post collateral is valuable to society, does it follow that the private market sets collateral requirements optimally? In a different model, John Geanakoplos and Felix Kubler present an example suggesting that this is not always the case.^b They show that margins may be too loose in good times and too tight in crises because lenders do not take into account the effect that the margins they set have on market prices. So there may also be a role for government regulation of margin requirements (such a view was also recently expressed by former Treasury Secretary Robert Rubin). Indeed, Geanakoplos and Kubler suggest that margins may be too loose in good times, since lenders do not realize that their lending increases the risk of a future crisis; conversely, margins may be too tight in crises, since increasing lending would raise prices and thereby ease the crisis. The extent to which this intuition can be generalized is unclear, and further research in this area would be valuable.

^a For more on the economic role of collateral, see the article by Yaron Leitner.

^b See also the presentation by John Geanakoplos at the Philadelphia Fed Policy Forum.

This frees up the private markets' liquidity and allows it to be used more effectively.

Another feature of liquidity crises is the interaction between liquidity and asset prices. A lack of liquidity can lower asset prices below their fair,

or fundamental, value. Since liquidity is often obtained by using these assets as collateral for loans, this in turn can lead to lower liquidity provision. The outcome is a "liquidity spiral," in which the resulting illiquidity can lower asset prices even further, and so

on. Further research is needed on this role of collateral in providing liquidity and, in particular, on the question of whether government intervention can improve on the private market's use of collateral. ●

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