The role of time-critical liquidity in financial markets

David Marshall and Robert Steigerwald

Introduction and summary

Modern financial markets are critically dependent on large-scale flows of intraday (within one day) liquidity in payment, clearing, and settlement systems. As noted by the Payments Risk Committee, "On a routine day, over $14 trillion worth of payments to and from individuals, institutions, corporations, governments and other enterprises are settled in U.S. dollars worldwide. To complete these transactions, more than $9 trillion flows throughout the financial system."[1]

Table 1 provides a more detailed breakdown of these payment flows. As can be seen, the largest funding flows by dollar value are associated with large-value funds transfer systems and government security clearing, but there are also large flows associated with central securities depositories and retail payments systems. Flows associated with foreign exchange (FX) settlements and central counterparty clearinghouses (CCPs) are somewhat smaller in magnitude, but these flows are critical to financial stability—a fact recognized by the Financial Stability Oversight Council in July 2012, when it designated the main FX settlement engine (CLS Bank), the two major securities CCPs (Fixed Income Clearing Corporation [FICC] and National Securities Clearing Corporation [NSCC]), and the three largest derivatives CCPs (CME Group, Options Clearing Corporation [OCC], and ICE Clear Credit) as systemically important financial market utilities.

This article discusses an important feature of this intraday liquidity usage in payment, clearing, and settlement systems. Specifically, we examine how the processes for settling financial contracts, and related settlement-risk-management operations, increasingly make use of *time-critical liquidity* to address the problem of counterparty credit risk. Under conditions of time-critical liquidity, a settlement payment, delivery of securities, or transfer of collateral must be made *at a particular location, in a particular currency (or securities issue),* and *in a precise time frame* measured not in days, but in hours or even minutes.[2] Examples of time-critical liquidity requirements (which we discuss below) include the settlement process at the Depository Trust Company (DTC), the funding time frame for CLS Bank, and the tight restrictions on the timing of required variation settlements in derivatives clearinghouses.

We use the term "time critical" to denote more than merely the existence of a temporal framework

David Marshall is a senior vice president, associate director of research, and director of the financial markets group in the Economic Research Department at the Federal Reserve Bank of Chicago. Robert Steigerwald is a senior policy advisor in the financial markets group of the Economic Research Department at the Federal Reserve Bank of Chicago. *The authors would like to thank Caroline Echols, Tom Ferlazzo, Richard Heckinger, Bill Johnson, John McPartland, Ann Miner, and Jeff Stehm for helpful comments. All errors remain the responsibility of the authors.*

Economic Perspectives is published by the Economic Research Department of the Federal Reserve Bank of Chicago. The views expressed are the authors' and do not necessarily reflect the views of the Federal Reserve Bank of Chicago or the Federal Reserve System.

ISSN 0164-0682

TABLE 1

Gross daily activity value versus amount needed for settlement

Sector	Estimated gross value of payment transactions	Funding transactions[a]	Funding flows[b]
	(- - - - - - - - - - - -	$billions	- - - - - - - - - - - -)
Large value transfer systems	3,953.0	2,426.1	2,378.2[c]
Foreign exchange settlements	2,067.9	11.6	23.5
Central counterparties (CCPs)[d]	5.8	7.4	12.5
Central securities depositories (CSDs)[d]	1,101.7	55.8[e]	129.5
Government securities clearing[f]	7,646.0	6,408.4	6,408.4
Retail systems	159.8	159.8	159.8
Total for participating firms	14,934.2	9,069.1	9,111.8

[a]Funding may occur through a Fedwire transaction or on the books of a commercial bank.
[b]Includes funding and defunding flows.
[c]Excludes known double counts of funding transactions for other financial market utility sectors.
[d]Information on gross value of payments settled was not collected for some CCPs and some CSDs.
[e]One CSD provided net values of flows.
[f]Includes settlements on the books of the clearing banks, including tri-party repo and internal Fixed Income Clearing Corporation settlements.
Source: Federal Reserve Bank of New York, Payments Risk Committee (2012, p. 17).

for payment obligations. All contracts calling for future performance, and all payment obligations arising from such contracts, specify *some* temporal framework within which performance of the payment obligation is due. For the purposes of this article, however, a time-critical payment has a number of specific characteristics. First, the payment must be made by a specific point in time, rather than merely by a certain date. Second, failure to make a time-critical payment within the predetermined time-certain deadline typically carries immediate consequences for the defaulting party. For example, a CCP member who fails to make a required variation margin payment by the time-certain deadline is subject to being declared in default to the CCP, with immediate suspension of membership privileges and consequent liquidation of the member's positions. This treatment of default is markedly different from non-time-critical obligations, such as routine accounts payable, where failure to discharge a payment obligation when due merely puts the defaulting party in breach of contract.[3]

Third, time-critical payments have a systemic aspect not present for most other payment obligations. In particular, what makes a settlement time critical is that all the participants in a payment, clearing, or settlement system agree to meet their obligations according to protocols (including cutoff times) that are calculated to mitigate settlement risk and result in final intraday settlement. For this reason, the deadlines governing time-critical payments typically are "hard," with little room for flexibility and with no possibility of renegotiating the settlement obligation. In one way or another—ways that differ depending upon the nature of the system involved—the participants are interdependent. Time-critical liquidity obligations reflect this interdependence among system participants who must meet strict risk-management protocols in order to benefit from the reduction of settlement risk and the certainty associated with final, intraday payment or settlement. This systemic interdependence is unlike anything that exists in simple bilateral contracts calling for future performance.

Dependence on time-critical liquidity has developed in response to the adoption over the past 30 years of innovative risk-management practices designed to manage *settlement risk*—the risk that one or more parties to a financial transaction may fail to satisfy the terms of the transaction in a timely fashion. Noteworthy innovations to address settlement risk include:

- The proliferation of real-time gross settlement (RTGS) (such as Fedwire,® which is operated by the Federal Reserve Banks), or equivalent payment mechanisms, to achieve intraday finality of settlement;
- The implementation of delivery-versus-payment (DvP) systems for securities and analogous payment-versus-payment (PvP) systems for foreign exchange to mitigate settlement risks in those markets; and
- The increasing use of collateral to mitigate counterparty credit risk in its various forms, both in payment systems and financial market clearing arrangements, such as CCP mechanisms.

These institutional and risk-management innovations have become standard practice throughout the world. By establishing a framework within which financial market participants can more closely manage settlement and related risks arising from trading in financial markets, these practices have made an important contribution to financial stability.

However, the dependence of these institutional and risk-management practices on time-critical liquidity also increases the risk and cost of illiquidity in financial markets. Financial market participants must be able to make payments, deliver securities, or arrange for the transfer of collateral with a high degree of precision if they are to meet the settlement requirements of the systems in which they participate. Moreover, a failure of timely liquidity provision in one system can hold up settlement completion in other systems. Hence, the growing dependence on time-critical liquidity has important implications for the stability of the financial system.

Financial market participants are well aware of the increasing importance of time-critical liquidity. For example, the Payments Risk Committee highlights the growing importance of time-critical, large-value payments and concludes that

> payment liquidity (also known as intraday liquidity) is critical ... because it is at the core of a bank's capacity to make payments. The recent transformation of the global financial environment has created a heightened reliance upon such liquidity, which in a financial, operational or political crisis, is the first to be affected in the financial markets.[4]

In this article, we analyze the benefits and drawbacks of this increased reliance on time-critical liquidity to manage settlement risk. As we explain in the next section, settlement risk comprises both *credit risk* and *liquidity risk*. Time-critical liquidity is designed to mitigate credit risk, but in doing so it might inadvertently exacerbate liquidity risk. Thus, the notable success of modern payments, clearing, and settlement arrangements at reducing the credit component of settlement risk can have the unintended consequence of increasing the vulnerability of such arrangements to systemic liquidity disruptions.

The potential trade-offs between credit risk and liquidity risk in the settlement process have important consequences for public policy. They raise the question of whether certain arrangements to mitigate credit risk work, in part, by transforming one type of risk (credit risk) into another (liquidity risk). They focus renewed attention on developing processes that reduce liquidity risk without exacerbating credit risk. Examples of such processes could include further exploitation of netting opportunities (e.g., through portfolio margining) or liquidity-saving mechanisms in payment systems (such as so-called hybrid RTGS systems). They motivate an inquiry into potential adverse consequences should liquidity shortages in a future financial crisis interact adversely with time-critical liquidity constraints. And they lead to an inquiry into the appropriate role of central bank liquidity provision in times of unusual liquidity stress.

In the remainder of this article, we explore these questions in detail. In the next section, we characterize more fully the problem of settlement risk. Then we provide an overview of the procedures that are typically used to manage the credit component of settlement risk and the implications of those practices for the management of liquidity. We apply these insights to the management of settlement risk in payments systems, securities and foreign exchange markets, and central clearing arrangements, respectively. Finally, we discuss some related public policy issues.

The problem of settlement risk

Settlement is the process whereby all elements of a trade are completed as expected. Cash-settled financial contracts, such as certain derivatives transactions, typically are settled by means of funds transfers, usually through the interbank payment system. Transactions involving delivery of a financial asset typically are settled through a two-part process involving both a funds transfer and a transfer of the asset itself, a process that may involve other systems and institutions, such as securities depositories, CCPs, and other clearing and settlement arrangements.

A fundamental risk of such financial contracts is that settlement—either by means of a funds transfer or the transfer of a financial asset—may not occur. In most theoretical models, such as the standard Arrow–Debreu framework used by many economists, there is no need to distinguish between trade execution and trade settlement, since these models typically assume full commitment. In reality, however, it has long been recognized that *agreeing* to a trade (the execution phase) does not ensure that settlement will occur.[5] Hence, there is a need to adopt risk-management practices to mitigate this settlement risk.

Settlement risk comprises both credit risk and liquidity risk.[6] According to the Bank for International Settlements' Committee on Payment and Settlement Systems (CPSS), credit risk is "the risk that a counterparty will not settle an obligation for full value, either when due or at any time thereafter" (CPSS, 2003b, p. 17); and liquidity risk is "the risk that a counterparty (or participant in a settlement system) will not settle an obligation for full value when due. Liquidity risk does not imply that a counterparty or participant is insolvent since it may be able to settle the required debit obligations at some unspecified time thereafter" (CPSS, 2003b, p. 29).

An alternative characterization of credit risk versus liquidity risk describes counterparty credit risk as the risk that a party involved in a transaction might not have assets of sufficient value to meet their obligations (or may be unwilling to make this value available). In contrast, liquidity risk is the risk that the party cannot access assets of the particular *form* required to settle the transaction at the time settlement is due. In most cases, the form needed is cash of a particular denomination. However, there are cases in which a particular security must be delivered to settle the transaction. In such a case, the notion of liquidity risk can be extended to include the risk that the needed security cannot be obtained.

Managing credit risk associated with financial settlements

In this article, we argue that dependence on time-critical liquidity follows logically from the basic needs of risk management. It is a fundamental principle of modern risk management that risks should be *identified, quantified,* and *controlled or mitigated*.[7] Such methods are critical if counterparties are to take on only those risks they choose to take on and appropriately manage those risks. Of course, such quantification and mitigation can never be perfect, since risk management is not an exact science. But the conditions of identifiability, quantifiability, and controllability of risk should be met within reasonable tolerances.

While this principle is intuitive, it is often violated in simple counterparty exposures. Consider, for example, a simple loan to a counterparty whose solvency is not well known to the creditor and where collateral or other measures to mitigate credit risk are not implemented. The creditor is exposed not only to the direct risk of the counterparty, but also to the indirect risk of defaults by second-order counterparties (the counterparty's counterparties), third-order counterparties, and so forth. The distribution of these higher-order risks, taken together, may be irredeemably opaque. There may be no meaningful way in which such risks can be identified, much less quantified.

If-and-only-if conditionality

The solution to this problem of risk management for financial transactions is to develop robust risk-management protocols that do not rely on precise identification of these higher-order risks. In practice, this is done by structuring transactions with some form of *if-and-only-if conditionality*.[8] Specifically, once a transaction is initiated, there is a sequence of steps leading to its completion via final settlement. If-and-only-if conditionality arises because certain of these steps will be executed *if and only if* certain conditions are met. These conditions are designed to ensure that any additional counterparty credit risks associated with that step can be identified, quantified, and mitigated *to the extent consistent with the system design*. In particular, these conditions would typically move exposures from more opaque risks (difficult to quantify) toward more transparent risks that are easier to quantify and at least partially mitigate.

The specific conditions incorporated into this if-and-only-if conditionality can be one of two types (Garner, 1995, p. 197):

- *Condition precedent*—a required payment or asset transfer is required *before or at the same time* that some related performance by a counterparty is expected. An example is the requirement in many RTGS payments systems that funding be available at the time a payment is to be transferred.
- *Condition subsequent*—a required payment or asset transfer is required to maintain an existing position. An example is the daily variation margin that must be paid to maintain an open derivatives position that is centrally cleared through a CCP.

Later in the article, we give specific examples of if-and-only-if conditions that are used in payments systems, DvP and PvP settlement systems, and CCPs.

Finality

A payment or security transfer is said to be *final* if the sender cannot unilaterally retrieve or revoke the transfer without additional legal processes. The concept of finality is critical for settlement risk management: If a payment associated with a given transaction is settled without finality, the payment can be unilaterally reversed, and the possibility of such a reversal is itself another form of settlement risk. Therefore, the types of if-and-only-if conditionality implemented to mitigate settlement risk generally require transfers to be made with finality.

Finality is a composite concept involving both legal rules—a payment or asset transfer cannot unilaterally be reversed by the sender (subject to special rules where fraud, mistake, or duress is involved); and economic consequences—a "final" payment or asset transfer may be relied upon by the recipient to support other transactions (for example, funds received may be paid out in settlement of the recipient's other payment obligations).

As we will discuss later, payment systems that guarantee finality (preferably intraday finality) are fundamental to more-complex forms of risk management (for example, securities settlement).

Implications for time-critical liquidity

There is an intimate connection between if-and-only-if conditionality for mitigating settlement risk, finality, and the use of time-critical liquidity. This connection arises because the risk-management conditions typically require delivery of liquid assets. There are examples of conditionalities that require the counterparty merely to promise performance by some future date. An example would be a Fedwire payment by a bank eligible for daylight overdraft credit. However, possession of a low-risk, highly liquid asset provides a higher degree of risk mitigation than any such promise, even by a highly creditworthy agent. As a result, we should not be surprised that the gold standard for risk management is to require counterparties to actually deliver funds and/or securities before the given transaction settles with finality.

Furthermore, risk-management practices in payments, clearing, and settlement systems that incorporate if-and-only-if conditionality generally require that this delivery of liquid assets be made on a time-critical basis. The reason is that finality has a temporal component: It is determined as of a particular time. It would be inherently contradictory to "guarantee finality" without specifying the date and time by which the finality becomes effective. Timing is critical because deferral of finality to the future expands the temporal window within which credit risk remains a problem.

The term "liquidity" is often reserved for cash and near-cash instruments. For our purposes, however, it is useful to expand our notion of liquidity to include, in addition, access to specific securities that may be needed to complete a transaction. Such securities may be needed to collateralize a position, or may be required to complete the delivery leg in a DvP settlement.

Risk management under if-and-only-if conditionality thus implies the need to closely manage time-critical liquidity, both in terms of available funding and access to particular securities. This scrutiny is particularly important where funding is dependent upon credit arrangements (as in most intermediated payment arrangements) or when access to particular securities is dependent upon market dynamics (for example, the willingness of a seller to sell the needed security at the time it is needed). In a crisis, credit provision can contract and markets can hoard the sorts of securities needed to satisfy if-and-only-if conditions. For example, during the fall 2008 financial crisis, there were reports of shortages of Treasury securities that were the most commonly used forms of collateral. This insight has broad ramifications, because if-and-only-if conditionality only addresses credit risk. Liquidity risk (and the corresponding need to manage liquidity) remains an inherent feature of settlement in payments, clearing, and settlement systems.

Interconnectedness

The dependence of financial markets on time-critical liquidity goes beyond the individual risk-mitigation processes described here. In practice, these processes are combined to allow for highly sophisticated risk-management strategies. For example, one can start with an RTGS payment system as the foundation for immediate, intraday finality of payment. An RTGS system can be combined with central securities depository (CSD) functionality to make possible DvP securities settlement. That is, the ability to make final intraday transfers of both funds and securities is a necessary condition to the establishment of effective DvP arrangements. Similarly, a domestic RTGS system combined with a foreign RTGS system makes possible PvP in foreign exchange settlements.

The upshot of these interdependencies is that the failure to meet time-critical liquidity constraints within one system can propagate rapidly to other systems. Thus, the dependence of multiple interconnected systems on time-critical liquidity can increase the fragility of the system as a whole.

Settlement risk in payments systems

Our discussion thus far of settlement risk management and the role of time-critical liquidity has been rather abstract. Next, we provide an extended example of how the logic works in the context of payments systems.

Failure of Bankhaus Herstatt

The risk considerations associated with financial settlements were dramatically illustrated by the market disruption that followed the failure of a German bank, Bankhaus Herstatt, in June 1974. Specifically, the Herstatt incident illustrates how structures that allow participants broad latitude with respect to the timing of liquidity provision can actually exacerbate credit risk.

The facts are as follows. Bankhaus I. D. Herstatt KGaA, a small commercial bank based in Cologne, was closed by the German banking supervisory authorities at about 3:30 p.m. central European time on Wednesday, June 26, 1974,[9] after the interbank system for making deutsche mark payments had closed and Herstatt had received irrevocable payments in deutsche marks and other currencies for settlement of foreign exchange trades. Herstatt's correspondent bank in New York, Chase Manhattan, responded to the news by withholding $620 million in dollar payments that were to be made on behalf of Herstatt. At the time, most interbank payments were made through the Clearing House Interbank

Payment System (CHIPS), which was operated as a deferred net settlement payment system. As such, interbank payments made through CHIPS were only provisional, not final, at the time instructions were processed.[10] Banks exploited this lack of finality in CHIPS by reversing their U.S. dollar payments through CHIPS. The result of these actions was gridlock in the U.S. dollar payment system, triggering systemic "dislocations in the international interbank sector of the Eurocurrency market" (Herring and Litan, 1995, p. 96).

The Herstatt incident demonstrated that any system attempting to control the credit component of settlement risk requires *intraday finality of settlement* (IFS). IFS guarantees that no party can unilaterally unwind a given transaction. Without IFS or some similar finality guarantee, the risk is always present that such an unwinding could lead to an unexpected failure of settlement. In the aftermath of the Herstatt incident, central banks recognized that IFS could not be achieved with the deferred net settlement payment systems that existed at that time. Given the available technology, the only practical method for achieving IFS was to implement an RTGS system. In a gross settlement system, transfers are settled individually without netting debits against credits. In a real-time settlement system, final settlement occurs continuously rather than periodically at prespecified times, provided that a sending bank has sufficient covering balances or credit.[11] As a result, final settlement in an RTGS system is both immediate and continuous.

If-and-only-if conditionality in RTGS payment systems

Simply adopting an RTGS system does not completely fix the problem of providing IFS. While an RTGS system does ensure finality, many such systems do so by having the RTGS system take on credit risk. This credit risk must then be controlled by implementing risk-management practices incorporating if-and-only-if conditionality.

Let us consider how this is done. A payment is settled with finality in a simple RTGS system if and only if sufficient funds are in the payer's account or sufficient overdraft credit is available. Without such conditions, the payment system might guarantee finality to a payment that the payer cannot cover, exposing the system to a degree of payer credit risk that may be extremely difficult to quantify. (That is, it may be difficult to assign a probability to the event that the payer cannot discharge its obligations.) Under the RTGS conditions, this risk can be at least partially controlled by specifying overdraft credit limits. This if-and-only-if conditionality for an RTGS system could be expressed as follows:

Conditionality 1: Payment will be made (funds will be transferred) with finality if and only if the sender has adequate funds on account or immediately available credit in the amount needed to complete the payment transfer.

Conditionality 1 implies a dependence on time-critical liquidity, because any payments beyond those financed by immediately available credit will only be completed if the requisite liquidity is on deposit on or before the time of the transaction. Note that conditionality 1 would not generally result in complete elimination of risk, or even in perfect quantification of risk. Nevertheless, the conditionality that we see so frequently in payment and settlement systems goes a long way to reducing the uncertainty associated with these risks. For example, the risk associated with uncollateralized daylight overdraft credit in the Fedwire RTGS system is mitigated by the supervisory process, since typically such credit is only provided to regulated institutions known to be creditworthy within the tolerances of the overdraft credit limits.

There are other ways of implementing RTGS. Some payment systems that allow for intraday extensions of credit require all such credit to be fully collateralized. The if-and-only-if conditionality for real-time gross settlement payments incorporating collateralized credit would modify conditionality 1 as follows:

Conditionality 2: Payment will be made (funds will be transferred) with finality if and only if conditionality 1 is satisfied and *the amount of collateral necessary to fully collateralize the required credit has been posted at the time the payment is to be made.*

This arrangement contributes to a time-critical liquidity environment because the payment will not be made if the collateral requirement has not been satisfied. As mentioned earlier, we regard securities used as collateral as a form of liquidity, so a requirement that collateral be positioned in a particular location before a payment is executed represents a time-critical liquidity constraint. This is an example of a *condition precedent*, as discussed previously.

The introduction of collateral presents additional systemic considerations. Collateral is generally thought of as a means of mitigating credit risk. But the need to move collateral dynamically, according to precise rules, makes collateral a liquidity phenomenon as well. In particular, the types of securities that are generally eligible for use as collateral are traded in markets like other securities, and because trading in those securities may be liquid or illiquid depending upon the circumstances, the collateralization of financial transactions introduces another dimension of liquidity management into the system. (Box 1 provides a further discussion of how

BOX 1

Time-critical liquidity in Fedwire and other RTGS payments systems

The Fedwire Funds Service, which is owned and operated by the Federal Reserve System, is a classic RTGS system, generally used to make large-value, time-critical, U.S. dollar payments in central bank money.[1] Fedwire payment instructions are processed immediately upon receipt if and only if the account holder issuing the instructions has "sufficient funds, either in the form of account balances held at the Federal Reserve or overdraft capacity" (CPSS, 2003a, p. 443). Unless that condition is satisfied, the payment instruction will be rejected. In accordance with applicable law, a Fedwire payment "is final and irrevocable when the amount of the payment ... is credited to the receiving participant's account or when notice is sent to the receiving participant, whichever is earlier" (Board of Governors of the Federal Reserve System, 2009, p. 7). The Federal Reserve also provides intraday credit, in the form of "daylight overdrafts," to most Fedwire participants. The extension of central bank credit facilitates the smooth and efficient operation of the funds transfer service, but also "converts the liquidity risk otherwise borne by participating institutions to credit risk borne by the Reserve Banks" (Board of Governors of the Federal Reserve System, 2009, pp. 15–16). Any daylight overdrafts must be repaid by the end of the Fedwire operating day, in accordance with the Federal Reserve's payment system risk policy.

The RTGS design has been adopted in many other jurisdictions. A recent World Bank survey documented that 112 systems also employ the individual, payment-by-payment processing logic of the Fedwire system (World Bank, Payment Systems Development Group, 2008). According to the CPSS (2005), this prevalence of RTGS payment structures is due in part to an increasing demand for time-critical payments linked to foreign exchange settlement systems, securities settlement systems, and other financial market utilities. As the CPSS (2005, p. 2) states, "More linkages imply short time frames to make time-critical payments from one system to another, hence the need to achieve finality within that time frame."

[1]For more details, see www.federalreserve.gov/paymentsystems/fedfunds_about.htm; also, Board of Governors of the Federal Reserve System (2009).

time-critical liquidity is used in Fedwire and other RTGS payments systems.)

Settlement risk in securities and foreign exchange markets

The introduction of RTGS systems and improved net settlement arrangements made it possible to make large-value payments with greater assurance of intraday finality, but it did not by itself eliminate Herstatt risk—the principal risk that arises from unsynchronized transfers of financial assets.[12] As Hills and Rule (1999, p. 101) observe: "Where financial transactions involve an exchange of financial assets, any party to the transaction can be exposed to principal risk if the two legs do not settle at the same time." To eliminate that risk, some means must exist to synchronize the settlements—a process that has become known as DvP (which stands for delivery versus payment) for securities settlements and PvP (which stands for payment versus payment) for foreign currency settlements.

In the United States, securities settlement typically occurs one or more days after trade execution. For example, equities settle on the third day after the trade date. On the date when settlement is scheduled to occur, the seller or its agent must deliver a security to the buyer, and the buyer must deliver payment to the seller. If these two operations are not closely coordinated, one or both parties will incur settlement risk. For example, if the seller delivers the security before receiving funds from the buyer, the seller could lose the full principal value of the transaction if the buyer were to default after delivery of the security was completed.

To mitigate that risk, central securities depositories (CSDs) typically settle securities using delivery versus payment or DvP. While the details of this process can be somewhat intricate, the key point is that delivery of securities to the purchaser and payment of funds to the seller occur if and only if the CSD is satisfied that each party has met its obligations. Once the CSD is satisfied that payment has been received and that the securities are available for transfer, title to the securities passes to the buyer on the books of the CSD[13] and cash is released to the seller.

The if-and-only-if conditionality characterizing a DvP system can be expressed as follows:

Conditionality 3: A securities transfer will take place if and only if the buyer has immediately available funds to pay for the delivery of securities and the seller has immediately available securities to be delivered to the buyer, and both the funds transfer and delivery of securities can take place with finality.

BOX 2

Time-critical liquidity in DvP securities settlement

The most liquidity-intensive implementation of DvP is a so-called Model 1 system, in which both securities and funds settle on a gross basis, trade by trade, with funds transfer and securities transfer occurring simultaneously (CPSS, 1992). As noted in Payments Risk Committee (2003, pp. 21–22), “Participation in such systems requires participants to maintain substantial money balances during the business day.” Examples of Model 1 DvP systems include the Federal Reserve’s system for settling transfers of U.S. government and agency securities (the Fedwire Securities Transfer System) and the TARGET2-Securities service currently under development by the European Central Bank (ECB).

An alternative, less liquidity-intensive implementation of DvP is the so-called Model 2 system, in which securities settle on a gross basis throughout the day, but funds are settled on a net basis at the end of the processing cycle. An example of a Model 2 system is the Depository Trust Company (DTC), which is the primary securities settlement system for U.S. corporate equities and fixed-income securities.

The netting feature of Model 2 systems makes them somewhat less reliant on time-critical intraday liquidity provision than Model 1 systems. Even so, Model 2 systems typically rely on if-and-only-if conditionality to appropriately control settlement risk. This is clear in the following description of the DTC’s settlement system from the International Monetary Fund’s financial sector assessment report for the United States:

> During the day, participants [in DTC] receive incoming securities *to the extent their payment settlement account has sufficient net payment credits or sufficient net payment debit capacity and subject to DTC’s net debit cap and collateral controls.* (International Monetary Fund, Financial Sector Assessment Program, 2010, pp. 12–13, italics added)

Conditionality 3 implies a dependence on time-critical liquidity because the buyer must have the full amount of liquid funds available within the time frame mandated by the DvP settlement schedule. Similarly, the seller must make the securities available within the relevant time frame. If such funds are not made available by the relevant deadline, the buyer is in default and the transaction will not go through. (Box 2 provides more details about the use of time-critical liquidity in DvP securities settlement systems.)

Foreign currency settlements use a payment versus payment, or PvP, process. Like DvP, the PvP process requires both legs of a transaction to be settled either simultaneously or with equivalent assurances that one leg will be settled if and only if the other leg is settled with finality. The conditionality for such a PvP arrangement can be expressed as follows:

Conditionality 4: Payment in one currency will take place if-and-only-if immediate payment in the other currency (or possibly currencies) can take place with finality.

The key institution implementing PvP in foreign exchange markets is CLS Bank, a special-purpose institution designed to handle the settlement of foreign currency transactions. CLS Bank began operations in September 2002 and currently provides services for 17 actively traded currencies (CPSS, 2003a). (Box 3 discusses how time-critical liquidity is used in CLS Bank’s PvP settlement system.) In addition, the large-value payment system in Hong Kong (known as the Clearing House Automated Transfer System, or CHATS) has been linked to other payment systems to facilitate settlements on a PvP basis between the Hong Kong dollar and the U.S. dollar, euro, renminbi, and ringgit (CPSS, 2003a, and Hong Kong Monetary Authority, 2013).

Since both legs of a DvP or PvP transaction must be made with finality, it follows that the associated payments must also be made with finality. More generally, these types of FX or securities settlement systems depend critically on a payments infrastructure that can reliably transmit funds subject to tight deadlines, which, in practice, means an RTGS system. For example, this is why neither DTC nor CLS accepts payments through CHIPS, which is not an RTGS system.[14]

Finally, it should be noted that settlement systems incorporating DvP or PvP may allow for a form of settlement failure when the if-and-only-if conditionality is not met. To give an example, if the seller of a security fails to deliver the security into a DvP settlement system, the buyer simply retains funds equal to the purchase price of the security. This principal is not at risk, since it will be paid if and only if the security is available for delivery. The only risk is that the security price may have changed before the transaction is eventually completed or a substitute transaction is undertaken to replace the failed transaction.

Settlement risk in CCPs

Central clearing via CCPs is a standard feature of exchange-traded securities and derivatives markets and is increasingly used to settle and guarantee contracts that are traded over the counter (OTC). For both

BOX 3

Time-critical liquidity in CLS Bank's PvP FX settlement system

The PvP system for foreign currency settlement operated by CLS Bank depends on precise coordination of foreign currency settlements to eliminate settlement risk. Specifically, each CLS member has an account with CLS Bank that is divided into subaccounts, one for each currency being traded. Settlement instructions must be submitted by 12 midnight central European time (CET).[1] Settlement starts at 7:00 a.m. CET of the settlement date (continuing throughout the settlement period until 9:00 a.m. CET) by debiting the subaccounts of currencies being sold and *simultaneously* crediting accounts of currencies being bought.

Settlement occurs when CLS Bank simultaneously debits and credits the accounts of two settlement members in accordance with eligible instructions that were submitted, and is final, irrevocable, and binding upon 1) the submitting members of such instructions; 2) the settlement members through whose accounts such instructions are settled; and 3) CLS Bank. However, the settlement for a matched pair of instructions may only occur if the settlement of such instruction would not cause the settlement member's account to fail any of three risk management tests—positive adjusted account balance, short position limit (per currency), and aggregate short position limit. To ensure that there are sufficient balances in the settlement member accounts to meet these risk tests, members must provide funding in the needed currencies. This funding must be provided according to a tight time schedule. In this way, CLS Bank relies on time-critical liquidity provision. As described in CPSS (2003a, p. 462):

> Members must submit payments to CLS Bank to provide funds in the correct currencies to cover projected net debit positions. They can do so by making a single payment for the full amount at 8 am CET or a series of payments in hourly installments. CLS Bank makes payouts throughout the settlement day to members in currencies in which they have a net credit position, subject to the constraint that the sum of all currency balances (positive and negative) in a member's account, converted into US dollars, is not negative. … In normal circumstances, settlement members will have zero balances in their CLS Bank accounts at the end of each day, and CLS Bank will have zero balances in its central bank accounts at the end of each day.[2]

As with DvP, policymakers and industry participants clearly recognize the liquidity implications of CLS Bank's system for PvP settlement of foreign currency transactions. As the Payments Risk Committee (2003, p. 26) has noted: "The key liquidity issue the market faces is the requirement to make large timed payments, in non-domestic currencies, during a small time window and in some cases outside normal domestic banking hours."

[1]Instructions can also be submitted for same-day settlement between midnight and 6:30 a.m. before the revised pay-in schedule is issued.

[2]Actually, payouts are made only during the settlement and funding period from 7:00 a.m. to 12:00 p.m. CET.

securities and derivatives contracts, the CCP mitigates credit risk by becoming the legal buyer to every seller and the legal seller to every buyer, a process known as *novation*. Thus, the need to manage counterparty credit risk associated with bilateral trades is replaced by the CCP's need to manage the creditworthiness of its clearing members. Of course, all participants in the market now depend on the CCP's own creditworthiness.

CCPs typically mitigate the credit risk they incur under novation by requiring all of their counterparties to post initial margin (or performance bond). That is, CCP members and their customers can open new positions only under the condition that the necessary margin is posted to the CCP within a prespecified time. Such arrangements illustrate a type of if-and-only-if conditionality that incorporates a condition subsequent (as defined earlier). That is, the condition becomes binding only *after* the trade to which it applies has been initiated. The CCP retains the power to terminate the open position if the trader fails to post the required margin or bond at the future time specified.

As a (simplified) example, we can look at the case of a trader taking a long position on a futures contract traded on an organized exchange. An if-and-only-if conditionality relevant to this trade may be expressed as follows:

Conditionality 5: The clearinghouse will novate the trade (that is, agree to act as the substituted legal counterparty to the trade) if and only if the clearing member posts initial margin within the time frame specified by the CCP's rules.[15]

The initial margin requirement induces a need for time-critical liquidity, because failure to post margin by the time it is due would constitute a default to the clearinghouse. Notice how conditionality 5 converts the CCP's exposure to an opaque set of risks (risk that the trader might default, or one of the trader's higher-order counterparties might default) into a more transparent set of risks associated with the clearing member's solvency and ability to post acceptable initial margin. Monitoring the clearing members rather than monitoring the entire body of traders is advantageous, because clearinghouses intensively vet potential members and impose financial, credit, and other standards for membership. In addition, clearing members' financial resources (including capital and liquidity), activities, and creditworthiness are audited by the CCP on an ongoing basis, with the clearinghouse often empowered to impose restrictions on member activities if warranted.

In practice, clearinghouses typically impose multiple mechanisms to control financial risks. The cumulative effect of this multiplicity can create a chain of if-and-only-if conditionalities. Often, this chain is the key factor in generating time-critical liquidity constraints. To illustrate, let us return to the futures contract example. Posting initial margin in and of itself would eliminate risk to the CCP only if the margin requirement were sufficiently high to cover (with high probability) the cumulative exposure of the CCP to clearing member default risk over the entire life of the contract—from the trade date to the delivery date. To economize on performance-bond collateral, the CCP typically marks participants' positions to market on a daily basis,[16] and requires participants to settle the day's accumulated gains and losses via exchange of variation margin.[17] Thus, the CCP compounds conditionality 5 with another if-and-only-if conditionality, as follows:

Conditionality 6: The clearinghouse will novate the trade if and only if conditionality 5 holds and *the clearing member agrees to post daily variation margin, incorporating marking to market, as demanded by the CCP within the precise time frame specified*.

This compounded if-and-only-if conditionality dramatically reduces the needed initial margin. By introducing payment of daily variation margin as a condition subsequent, the initial margin need only be sufficient to cover a possible clearing member default over a single day forward. Clearly, conditionality 6 induces a requirement for additional time-critical liquidity, since a position at the clearinghouse will be kept open only if daily variation margin is paid promptly, according to the deadlines specified by the clearinghouse.

This requirement of timely variation margin is an integral component of the CCP's risk-management structure. That means that the receipt of variation margin when due is compulsory (not simply desirable or beneficial). The reason is that initial margin requirements are set in relation to expected receipt of variation margin within a precise time frame, day in and day out, as variation margin falls due. Therefore, the CCP's default rules mandate consequences for a failure to comply with variation margin requirements when due (that is, forfeiture of initial margin and recourse to other CCP financial safeguards).

Moreover, variation margin payments must be made with finality. In particular, if a clearing member were to default, the CCP must have certainty that any margin payments previously made by the defaulting entity can be used to satisfy any liquidity shortfalls resulting from the default. For this reason, variation margin payments must be made using a system that supports intraday or even real-time finality. Typically, this would require use of an RTGS payments system.[18] (Box 4 gives a further discussion of time-critical liquidity requirements in two important derivative CCPs, the Chicago Mercantile Exchange and the Options Clearing Corporation.)

Public policy implications

We have argued that the imperative to mitigate credit risk associated with financial market settlements leads logically to increased use of time-critical liquidity. The benefits of credit risk mitigation are sufficiently great that we are likely to see continued movement in this direction. Recent developments pointing toward increased use of time-critical liquidity include the following:

- The commitment of the Group of Twenty (G20) leaders in October 2009 that all standardized OTC derivatives be centrally cleared clearly goes in this direction, as does the mandate in title VII of the Dodd–Frank Act for increased use of centralized clearing and the expanded development of CCPs in emerging markets (G20, 2009; Financial Stability Board, 2010).
- Title VII of the Dodd–Frank Act mandates increased use of collateral for swaps not centrally cleared. As we have discussed, collateral requirements typically carry with them time-critical deadlines for delivery of collateral. In addition, proposed regulations to implement this provision of Dodd–Frank would forbid or attenuate the practice of rehypothecation, whereby the recipient of collateral can sell or otherwise use the collateral as if it were the recipient's property. Such restrictions could, in effect, decrease the supply of acceptable collateral precisely when requirements for collateral are increasing.
- Finally, recent proposed revisions to the international standards for financial market infrastructures include a proposal to increase financial resources dedicated to mitigating counterparty credit risk. In particular, the international standards in effect prior to April 2012 recommend financial resources sufficient "to withstand, at a minimum, a default by

BOX 4

Time-critical liquidity in derivatives CCPs

Two major derivatives CCPs in the United States are the CME Clearing House (CME Clearing) and the Options Clearing Corporation (OCC). CME Clearing is an unincorporated division of the Chicago Mercantile Exchange Inc. that provides central counterparty clearing and settlement services for exchange-traded futures contracts, as well as certain options and OTC derivatives contracts. The OCC is a clearinghouse for exchange-traded equity options as well as certain futures contracts. It currently provides central counterparty clearing and settlement services to nine options exchanges and five futures markets.[1]

CME Clearing marks open contracts to market twice daily and settles payment obligations once in the morning and once in the afternoon of each business day. The OCC normally marks open contracts to market once daily and settles payment obligations incurred in the morning of each business day. (They have the authority to conduct additional intraday marking-to-market if warranted.) For both of these CCPs, settlement occurs through designated settlement banks that act as settlement intermediaries between the CCP and its clearing members. Each CCP and its clearing members grant settlement banks the authority to credit or debit their respective accounts for daily market activity based on clearing instructions sent by the CCP.

Both CCPs rely on time-critical payments that must be completed according to tight deadlines. Specifically, CME Clearing sends settlement information for CME clearing members to the settlement banks before 7:30 a.m. CT and again at approximately 12:30 p.m. CT. Clearing members must complete the settlement amounts (or have their settlement bank irrevocably commit to making the required payment on the clearing member's behalf) before the 7:30 a.m. deadline for the morning settlement cycle and within about one hour from receiving settlement information for the afternoon cycle. For the OCC, settlement information for each clearing member is sent to the settlement banks before 9:00 a.m. CT. Payment of the settlement amounts must be made (or irrevocable commitment from the clearing member's settlement bank must be obtained) before the 9:00 a.m. deadline. Failure to meet these deadlines constitutes default under the OCC's rules. The OCC also commits to initiate payments to its clearing members by 10:00 a.m. CT.

[1]Currently, these exchanges and markets include: BATS; Boston Options Exchange; C2 Options Exchange Inc.; Chicago Board Options Exchange Inc.; International Securities Exchange LLC; NASDAQ OMX PHLX; NASDAQ Options Market; NYSE Amex Options; NYSE Arca Options; CBOE Futures Exchange LLC; ELX Futures LP; NASDAQ OMX Futures Exchange; NYSE Liffe US; and OneChicago Exchange.

the participant to which it has the largest exposure in extreme but plausible market conditions."[19] These standards were replaced by the Bank for International Settlements' Committee on Payment and Settlement Systems and the Technical Committee of the International Organization of Securities Commissions (CPSS–IOSCO), which recommend strengthening these standards to enable institutions "involved in activities with a more-complex risk profile" or "systemically important in multiple jurisdictions" to withstand the default of the *two* participants generating the largest credit exposure (CPSS–IOSCO, 2012, p. 37).

All of these efforts to mitigate credit risk have clear value. However, the trend toward increased dependence on time-critical liquidity raises an important question, in our view: To what extent does this settlement risk mitigation merely *transform* credit risk into liquidity risk? In other words, once the more straightforward steps to reduce credit risk have been taken (for example, through netting), might further actions to mitigate credit risk have the unintended consequence of increasing liquidity risk?

The main concern with this increased dependence on time-critical liquidity, from a public policy standpoint, is that it may exacerbate the effect of periodic liquidity crises. More specifically, as payment, clearing, and settlement (PCS) systems create increased demand for time-critical liquidity, participant institutions need to take steps to ensure the flow of funding needed to meet these time-critical liquidity constraints. These efforts may drive increasingly tight and interdependent payment flows as system participants attempt to meet time-critical liquidity demands across PCS systems. This process can make the PCS infrastructure more sensitive to systemic perturbations during a crisis episode.

An alternative way to think about this increased sensitivity to systemic perturbations is in terms of demand and supply dynamics. The *demand* for time-critical liquidity is unlikely to decrease during such a crisis.[20] Indeed, the need for time-critical liquidity may tend to increase during a crisis, as collateral haircuts expand and margin requirements adjust upward in light of increased market volatility and declining asset valuations. But the *sources* of time-critical liquidity may well attenuate in a crisis environment, as pervasive uncertainty induces institutions and individuals to hoard liquid assets.

Let us consider in detail three examples that illustrate how time-critical liquidity requirements can interact adversely with the diminished willingness of intermediaries to provide liquidity during a crisis.

1987 market break

On Monday, October 19, 1987 (Black Monday), stock markets around the world crashed, shedding a huge value in a very short time.[21] As a result of the market price declines and increased volatility on Black Monday, intraday and end-of-day margin requirements at derivatives clearinghouses rose to record levels. For example, clearing members of the CME faced margin calls (reflecting both mark-to-market variations and increased initial margin requirements) around ten times the previous average margins (Carlson, 2006). At the same time, banks became less willing to advance credit to clearing members. Bernanke (1990) and Carlson (2006) argue that aggregate liquidity provision could have been insufficient without Federal Reserve action. As Bernanke (1990, p. 148) states, "The Fed 'persuaded' the banks, particularly the big New York banks, to lend freely, promising whatever support was necessary."

Just as serious was the problem of *gridlock* in the flow of mark-to-market variation settlements and initial margin requirements. This disruption was manifested in various ways. Payments on behalf of clearing members that had received margin calls from a clearinghouse were significantly delayed.[22] In addition, clearing members that were expecting margin payments from a clearinghouse found it necessary to meet the payment expectations of significant customers before receiving payment from the clearinghouse. Notably, two major clearing members, Kidder Peabody and Goldman Sachs, advanced funds for customer margin calls only to find themselves short by over $1.5 billion when payments due to them were delayed.[23]

The situation was exacerbated by an operational failure that shut down the Fedwire system for two and a half hours on the morning of October 20, 1987. This service interruption occurred just when large funds transfers needed to be made to complete margin settlements on Chicago's futures and options clearinghouses.

Sentinel

A second example of how markets that depend on time-critical liquidity can be disrupted during a financial crisis is the case of Sentinel Management Group Inc. Sentinel was a registered futures commission merchant (FCM) that specialized in investing funds of futures market participants (including some clearing members of the CME) in the money markets. In effect, it functioned analogously to a money market mutual fund for other FCMs. Sentinel had experienced heavy customer demand for redemptions during the onset of market volatility in mid-August 2007, causing a "run" on the firm and impairing its ability to meet its customer obligations. As a result, Sentinel announced on Monday, August 13, 2007, that it would not allow further redemptions from at least one of the portfolios it managed. Four days later, Sentinel filed for bankruptcy (see Lamson and Allen, 2011). The effect of these actions was to impede disbursement of customer funds to a number of CCP clearing members that were relying on these funds to meet their obligations to the clearinghouse. In a court appearance involving Sentinel on August 20, counsel for the U.S. Commodity Futures Trading Commission (CFTC) argued that "eleven FCMs will fail if the money is not distributed ... and there will be reverberations throughout the economy" (Lamson and Allen, 2011, pp. 7–8). Presumably, the CFTC's concern was that these FCMs may have had payments owing to the clearinghouses and had no source of readily available funds other than their Sentinel investments. As it turned out, the bankruptcy court did permit sufficient disbursements to avoid any FCM defaults.

Tri-party repo market

A third example of how sources of time-critical liquidity can attenuate during a crisis is the potential instability of the tri-party repurchase (or repo) market under certain conditions (Gorton, 2009). The tri-party repo market is a short-term credit market that is used as an important source of time-critical liquidity in payments, clearing, and settlement mechanisms. In this market, users of short-term credit borrow from providers of short-term credit (typically money market mutual funds) by selling securities to the lender with a simultaneous agreement to repurchase the securities on a specified future date at a prespecified price. The "third party" is a clearing bank that facilitates funds transfer and acts as collateral custodian.

Under the operating procedures that prevailed during the financial crisis of 2007–09, the clearing banks at the heart of the tri-party repo market would each day provide large amounts of intraday credit, in effect providing bridge financing between the time when funds are returned to the lenders (typically between 8:00 and 8:30 a.m. eastern standard time, or EST) and when new loans are executed (typically between 3:00 and 6:00 p.m. EST) (see Copeland et al., 2011). This practice could lead to greater instability during a crisis. As explained in Federal Reserve Bank of New York (2010, p. 13):

> The daily hand-off of credit extensions between overnight cash lenders and clearing banks creates an incentive for each to reduce its exposure quickly by pulling away from a potentially troubled dealer before the other one does. Indeed, as dealers came under severe stress, clearing banks reconsidered their longstanding practice of routinely extending intraday credit, as they recognized the potential risk it posed to them.

During the recent financial crisis, there was a risk that, recognizing this inherent vulnerability of the tri-party repo market, lenders would withdraw liquidity, with damaging consequences both for the market as a whole and for weakened market participants that were critically dependent upon funding ordinarily available through short-term funding markets.

Discussion

All of these examples illustrate how dependence on time-critical liquidity can exacerbate financial market turmoil during a financial crisis. This is a problem that clearly needs to be addressed, but the solution is not obvious.

One way of addressing this problem would be to reduce the use of time-critical liquidity. But, as we have stressed in this article, time-critical liquidity is a key component of mechanisms to reduce settlement risk in financial transactions. In practice, efforts to reduce use of time-critical liquidity would weaken financial markets' commitment to ensuring same-day settlement, a goal that has been enshrined in 39 years of post-Herstatt practice.

Furthermore, the goal of guaranteeing same-day (or even intraday) settlement is explicitly incorporated in the current international standards, the *Principles for Financial Market Infrastructure* (PFMI), adopted in April 2012 under the auspices of the CPSS–IOSCO.[24] Specifically, a major focus of the PFMI is the problem of liquidity risk, and in particular the need to carefully manage intraday liquidity to achieve prompt settlement of financial transactions. For example, principle 7 of the PFMI states explicitly that

> an FMI should maintain sufficient liquid resources in all relevant currencies to effect *same-day* and, where appropriate, *intraday* ... settlement of payment obligations with a high degree of confidence under a wide range of potential stress scenarios ... in extreme but plausible market conditions. (CPSS–IOSCO, 2012, p. 57, italics added)

Recent developments in FMI design and academic thinking about the liquidity demands associated with settlements in FMIs might be interpreted as reflecting a reduced commitment to same-day assured settlement under certain conditions, such as the default of one or more FMI participants (see, for example, Hull, 2012). These developments are worth following as the PFMI are implemented in the coming months and years.

A consequence of PFMI principle 7 is that the liquidity risks undertaken to mitigate credit risk should be well contained by mandating robust minimum liquidity resources for payments, clearing, and settlement institutions. These resources would typically take the form of cash on hand, dedicated same-day liquidity facilities provided by a consortium of banks, and arrangements in advance to facilitate repurchase agreements. Such regulatory mandates are clearly warranted. An implication of the arguments in this article is that robust liquidity risk management is of crucial importance to modern PCS systems, and this importance is likely to increase over time.

Ensuring that liquidity resources are adequate to withstand a crisis requires constant vigilance. Financial crises are times when market participants tend to hoard liquidity. For example, in the midst of a crisis, a party that had committed to provide time-critical liquidity may be incapable or unwilling to fulfill on that contractual obligation. In addition, same-day liquidity facilities typically must be renewed every 364 days. If the renewal date occurs during a financial crisis, it may be difficult to renew the facility to obtain the desired capacity. Furthermore, for some financial market utilities (such as large, global swaps CCPs), the only institutions with sufficient financial capacity to participate in these liquidity facilities may be the utilities' own members. This state of affairs would raise the uncomfortable problem of *wrong-way risk*, wherein part of the resources used to protect a utility against the default of one of its members is the capital of that very member.

In addition, repo markets could become less reliable sources of liquidity during a crisis if money market mutual funds and other providers of liquidity to the repo markets move their resources into Treasury securities and other ultra-safe vehicles. Even cash can be a less reliable source of liquidity in a crisis if the cash is in the form of commercial bank deposits, since commercial banks themselves are more likely to fail in a crisis situation. Finally, there may be a level of liquidity risk beyond which a financial market utility cannot self-insure and remain viable as an economic entity. That is, the costs of such self-insurance may exceed the economic value of the utility itself.

If private liquidity provision may be inadequate in certain extreme conditions, it may be useful to create a framework in which central bank liquidity can act as a backstop. The principles in CPSS–IOSCO (2012) explicitly permit financial market utilities to count central bank credit toward their liquidity resources, provided the utility has routine access to such credit. Certain jurisdictions provide such routine access to central bank liquidity.[25] However, CPSS–IOSCO (2012) also recognizes the obvious moral hazard problem of having a payments, clearing, or settlement utility count *emergency* (that is, nonroutine) central bank liquidity as part of its liquidity resources for the purposes of meeting the standards mandated by the PFMI.

In conclusion, we note that the trade-offs we have discussed between credit risk management and liquidity requirements appear to be fundamental to modern financial markets. It is likely that future policy developments will continue to grapple with optimal institutional design in light of these concerns.

NOTES

[1]See Federal Reserve Bank of New York, Payments Risk Committee (2012, p. 9). The Payments Risk Committee is a private sector group of senior managers from U.S. banks that is sponsored by the Federal Reserve Bank of New York. The committee's primary goal is to foster enhancements to the safety and resiliency of financial market infrastructure, including steps to strengthen the clearing and settlement of financial transactions, and to inform the Federal Reserve Bank of New York about developments, conditions, and practices in payments, clearing, and settlement systems (see www.newyorkfed.org/prc/).

[2]See Heckinger, Marshall, and Steigerwald (2009). For purposes of a payment through a funds transfer system, "location" refers to an account specified by the recipient into which a payment or securities transfer must be made. Thus, a payment made in the right currency at or before the time settlement is due would not meet the requirements of time-critical liquidity if it is not placed at the disposal of the intended recipient in the account specified by the recipient.

[3]The remedy for such a breach of contract typically involves the payment of damages intended to compensate the nondefaulting party for loss. Consequential damages are generally disallowed.

[4]See Federal Reserve Bank of New York, Payments Risk Committee, Cross-border Collateral Pool Task Force (2003, p. 7). There is an important and growing literature discussing the many aspects of liquidity more generally. See, for example, Brunnermeier and Pedersen (2009); Nikolaou (2009); and Garleanu and Pedersen (2007).

[5]See, for example, Nosal and Steigerwald (2010).

[6]For a comprehensive discussion of credit and associated risk associated with financial transactions, see Duffie and Singleton (2003). For the purposes of this article, we focus on credit and liquidity risks associated with settlement and rely principally upon risk definitions drawn from the payment, clearing, and settlement context.

[7]This principle is stated both explicitly and implicitly in the risk-management literature, including in a standard recently promulgated by the International Organization for Standardization (2009).

[8]Our use of the term "if-and-only-if conditionality" is consistent with the way some of the risk-management practices described in this article have been described by policymakers. See CPSS (1992, 1995) and Group of Thirty (2003).

[9]See Koleva (2011).

[10]For example, according to Bech and Hobijn (2007, p. 4), "until 1981, final settlement occurred on the morning of the next business day through the transfer of balances across the books of the Federal Reserve." See also Federal Reserve Bank of New York, Payments Risk Committee, Intraday Liquidity Management Task Force (2000).

[11]See, for example, CPSS (1997, 2005); Mills and Nesmith (2008); and Bech and Hobijn (2007).

[12]CPSS (1992) defines principal risk as "the risk of loss of the full value of securities or funds that [a nondefaulting party] has transferred to the defaulting counterparty" (p. 13). See also CPSS (1995).

[13]Our description of this process is, of course, highly simplified. In practice, further interfaces exist between CSDs and registrars, transfer agents, custodial institutions, and the like.

[14]Special considerations apply where CLS Bank is not a direct member of the payment system for making final payments in a currency settled through CLS Bank on a PvP basis. For example, CLS Bank is not a member of the Canadian Payment Association and, therefore, is not a direct participant in the Large Value Transfer System (LVTS) for Canadian dollar payments. Furthermore, LVTS has aspects of both an RTGS system and a so-called continuous net settlement system. As a consequence, the Bank of Canada, which is a direct participant in LVTS, provides CLS Bank with an account and processes payments through LVTS on CLS Bank's behalf. (See Bank of Canada, www.bankofcanada.ca/wp-content/uploads/2012/02/fsr-1202-miller.pdf.) All Canadian dollar payments made or received by CLS Bank are final when posted to its account by the Bank of Canada.

[15]This stylized example simplifies the actual conditions. In reality, additional conditions would typically be imposed, such as that the trade is within the applicable position limits, that the clearing member has sufficient capital, and so on.

[16]In this stylized example, variation margin is posted daily. In fact, many CCPs require variation margin to be posted two or even three times each day.

[17]We follow common practice in using the term "variation margin" to denote the exchange of funds for mark-to-market settlements. However, these daily settlements serve a role rather different from that served by initial margin (performance bond). In particular, the latter constitutes collateral whose function is to mitigate risk, while the former constitutes payment of market gains and losses.

[18]In the *Principles for Financial Market Infrastructures*, released in April 2012, the Bank for International Settlements' Committee on Payment and Settlement Systems and the Technical Committee of the International Organization of Securities Commissions (CPSS–IOSCO) do not rule out net settlement systems, but note that any system relying on batch settlement "may expose participants to credit and liquidity risks for the period during which settlement is deferred" (CPSS–IOSCO, 2012, p. 66).

[19]See CPSS–IOSCO (2004, p. 23). Similar wording is found in CPSS (2001) and CPSS–IOSCO (2001).

[20]As a practical matter, operators of payment, clearing, and settlement systems have little discretion to forbear on time deadlines for liquidity provision, because forbearance fundamentally undermines the if-and-only-if conditionalities that underlie their risk-management methodologies.

[21]For more details of this event, see http://en.wikipedia.org/wiki/Black_Monday_(1987).

[22]See U.S. General Accounting Office (1990, p. 41), which summarizes the evidence of persistent delays in the completion of settlement payments:

> According to the SEC February 1988 Report, between October 19 and October 30, 1987, clearing members made late payments to stock clearing organizations approximately 60 times. ... On October 19, 20, and 21, CME received late payments from several of its members. According to CME, clearing banks were late in confirming member payment for 26 of CME's 90 clearing members. Thirteen of those payment confirmations were between a half hour and an hour late on October 20. These late payment confirmations violated clearing organization rules and increased clearing organization risk. CFTC officials said that although some payment confirmations from clearing banks to the CME House Division were late, by the time of the opening of the S&P 600 contract for trading, all payment confirmations were received by CME.

[23]Bernanke (1990); see also, Brimmer (1989). There has been some confusion in the literature regarding the liquidity problems Goldman Sachs and Kidder Peabody faced in connection with this incident. See Tamarkin (1993).

[24]See CPSS–IOSCO (2012). As used in the PFMI, the term "financial market infrastructure" (FMI) refers to any of a number of institutions that support financial transactions, including payments systems, CSDs, securities settlement systems, and CCPs.

[25]The availability to FMIs of routine access to central bank credit is dependent upon many factors, including whether the FMI is chartered as a banking institution (a requirement in some jurisdictions), the type of FMI (for example, whether it functions as a CSD, a CCP, or some other kind of market infrastructure), the type of credit (for example, intraday, overnight, or emergency), and the statutory authority of the relevant central banks to exercise discretion in extending such credit. Broad generalizations in this area are difficult to make and are subject to change as legislation and central bank credit policies are amended from time to time. Although a complete typology of credit policies for FMIs is outside the scope of this article, our research based on publicly available sources indicates that Belgium, France, Germany, Japan, and Switzerland are jurisdictions in which some form of routine access to central bank credit may be afforded certain FMIs. U.S. law and Federal Reserve policy do not currently permit nondepository institutions (including certain FMIs) routine access to central bank credit.

REFERENCES

Bank for International Settlements, Committee on Payment and Settlement Systems, 2005, *New Developments in Large-Value Payment Systems*, Basel, Switzerland, May, available at www.bis.org/publ/cpss67.pdf.

__________, 2003a, *Payment and Settlement Systems in Selected Countries*, Basel, Switzerland, April, available at www.bis.org/publ/cpss53.pdf.

__________, 2003b, *A Glossary of Terms Used in Payment and Settlement Systems*, Basel, Switzerland, March, available at www.bis.org/publ/cpss00b.htm.

__________, 2001, *Core Principles for Systemically Important Payment Systems*, Basel, Switzerland, January, available at www.bis.org/publ/cpss43.pdf.

__________, 1997, *Real-Time Gross Settlement Systems*, Basel, Switzerland, March, available at www.bis.org/publ/cpss22.pdf.

__________, 1995, *Cross-Border Securities Settlements*, Basel, Switzerland, March, available at www.bis.org/publ/cpss12.pdf.

__________, 1992, *Delivery versus Payment in Securities Settlement Systems*, Basel, Switzerland, September, available at www.bis.org/publ/cpss06.pdf.

Bank for International Settlements, Committee on Payment and Settlement Systems, and Technical Committee of the International Organization of Securities Commissions, 2012, *Principles for Financial Market Infrastructures*, Basel, Switzerland, April, available at www.bis.org/publ/cpss101a.pdf.

__________, 2004, *Recommendations for Central Counterparties*, Basel, Switzerland, November, available at www.bis.org/publ/cpss64.pdf.

__________, 2001, *Recommendations for Securities Settlement Systems*, Basel, Switzerland, November, available at www.bis.org/publ/cpss46.pdf.

Bech, Morten L., and Bart Hobijn, 2007, "Technology diffusion within central banking: The case of real-time gross settlement," *International Journal of Central Banking*, Vol. 3, No. 3, September, pp. 147–181.

Bernanke, Ben S., 1990, "Clearing and settlement during the crash," *Review of Financial Studies*, Vol. 3, No. 1, January, pp. 133–151.

Board of Governors of the Federal Reserve System, 2009, "Fedwire Funds Transfer System: Assessment of compliance with the core principles for systemically important payment systems," report, Washington, DC, revised March 2009, available at www.federalreserve.gov/paymentsystems/files/fedfunds_coreprinciples.pdf.

Brimmer, Andrew. F., 1989, "Distinguished lecture on economics in government: Central banking and systemic risks in capital markets," *Journal of Economic Perspectives*, Vol. 3, No. 2, Spring, pp. 3–16, available at www.jstor.org/stable/1942665.

Brunnermeier, Markus K., and Lasse Heje Pedersen, 2009, "Market liquidity and funding liquidity," *The Review of Financial Studies*, Vol. 22, No. 6, pp. 2201–2238.

Carlson, Mark, 2006, "A brief history of the 1987 stock market crash with a discussion of the Federal Reserve response," Finance and Economics Discussion Series, Board of Governors of the Federal Reserve System, working paper, No. 2007-13, November, available at www.federalreserve.gov/pubs/feds/2007/200713/200713pap.pdf.

Copeland, Adam, Darrell Duffie, Antoine Martin, and Susan McLaughlin, 2011, "Policy issues in the design of tri-party repo markets," Federal Reserve Bank of New York and Stanford University, working paper (preliminary), July, available at www.darrellduffie.com/uploads/working/CopelandDuffieMartinMcLaughlin_Working_July%2023_2011.pdf.

Duffie, Darrell, and Kenneth J. Singleton, 2003, *Credit Risk: Pricing, Measurement, and Management*, Princeton, NJ: Princeton University Press.

Federal Reserve Bank of New York, 2010, "Tri-party repo infrastructure reforms," white paper, May 17, available at www.newyorkfed.org/banking/nyfrb_triparty_whitepaper.pdf.

Federal Reserve Bank of New York, Payments Risk Committee, 2012, "Intraday liquidity flows," report, March 30.

Federal Reserve Bank of New York, Payments Risk Committee, Cross-border Collateral Pool Task Force, 2003, *Managing Payment Liquidity in Global Markets: Risk Issues and Solutions*, report, March, available at www.newyorkfed.org/prc/files/manage.pdf.

Federal Reserve Bank of New York, Payments Risk Committee, Intraday Liquidity Management Task Force, 2000, *Intraday Liquidity Management in the Evolving Payment System: A Study of the Impact of the Euro, CLS Bank, and CHIPS Finality*, report, April, available at www.newyorkfed.org/prc/files/ILM.pdf.

Financial Stability Board, 2010, *Implementing OTC Derivatives Market Reforms*, Basel, Switzerland, October 25, available at www.financialstabilityboard.org/publications/r_101025.pdf.

Garleanu, Nicolae, and Lasse Heje Pedersen, 2007, "Liquidity and risk management," *The American Economic Review*, Vol. 97, No. 2, May, pp. 193–197.

Garner, Bryan A., 1995, *A Dictionary of Modern Legal Usage*, 2nd ed., New York: Oxford University Press.

Gorton, Gary, and Andrew Metrick, 2009, The run on repo and the panic of 2007-2008, Yale University and National Bureau of Economic Research, working paper, March 9, available at http://economics.mit.edu/files/3918.

Group of Thirty, 2003, *Global Clearing and Settlement: A Plan of Action*, report, Washington, DC.

Group of Twenty, 2009, "G20 leaders' statement," Pittsburgh Summit, Pittsburgh, PA, September 24–25.

Heckinger, Richard, David Marshall, and Robert Steigerwald, 2009, "Financial market utilities and the challenge of just-in-time liquidity," *Chicago Fed Letter*, Federal Reserve Bank of Chicago, No. 268a, November.

Herring, Richard J., and Robert E. Litan, 1995, *Financial Regulation in the Global Economy*, Washington, DC: The Brookings Institution.

Hills, Bob, and David Rule, 1999, "Counterparty credit risk in wholesale payment and settlement systems," *Financial Stability Review*, No. 7, November, pp. 98–114, available at www.bankofengland.co.uk/publications/Documents/fsr/1999/fsr07art2.pdf.

Hong Kong Monetary Authority, 2013, "Payment systems," webpage of HKMA website, available at www.hkma.gov.hk/eng/key-functions/international-financial-centre/infrastructure/payment-systems.shtml.

Hull, John, 2012, "CCPs: Their risks, and how they can be reduced," *Journal of Derivatives*, Vol. 20, No. 1, Fall, pp. 26–29.

International Monetary Fund, Financial Sector Assessment Program, 2010, *The Depository Trust Company's Observance of the CPSS-IOSCO Recommendations for Securities Settlement Systems: Detailed Assessments of Observance*, country report, No. 10/128, Washington, DC, May.

International Organization for Standardization, 2009, "Risk management—Principles and guidelines," report, No. ISO 31000:2009, Geneva, Switzerland, available for purchase at www.iso.org/iso/catalogue_detail.htm?csnumber=43170.

Koleva, Gergana, 2011, "'Icon of system risk' haunts industry decades after demise," *American Banker*, June 23, available at www.americanbanker.com/bankthink/bankhaus-herstatt-icon-of-systemic-risk-1039312-1.html.

Lamson, Donald N., and Hilary Allen, 2011, "SEC and CFTC joint rulemakings under Dodd-Frank—A regulatory odd couple?," *Securities Regulation & Law Report*, March 7.

Mills, David C., Jr., and Travis D. Nesmith, 2008, "Risk and concentration in payment and securities settlement systems," *Journal of Monetary Economics*, Vol. 55, No. 3, April, pp. 542–553.

Nikolaou, Kleopatra, 2009, "Liquidity (risk) concepts: Definitions and interactions," European Central Bank, working paper, No. 1008, February, available at www.ecb.eu/pub/pdf/scpwps/ecbwp1008.pdf.

Nosal, Ed, and Robert Steigerwald, 2010, "What is clearing and why is it important?," *Chicago Fed Letter*, Federal Reserve Bank of Chicago, No. 278, September.

Tamarkin, Bob, 1993, *The Merc: The Emergence of a Global Financial Powerhouse*, New York: Harper Business.

U.S. General Accounting Office, 1990, *Clearance and Settlement Reform: The Stock, Options, and Futures Markets Are Still at Risk*, report, No. GAO/GGD-90-33, Washington, DC, April, available at http://archive.gao.gov/d24t8/141098.pdf.

World Bank, Payment Systems Development Group, 2008, *Payment Systems Worldwide: A Snapshot. Outcomes of the Global Payment Systems Survey 2008*, Washington, DC, available at www.mfw4a.org/documents-details/world-bank-payment-systems-worldwide-a-snapshot-outcomes-of-the-global-payment-systems-survey-2008.html.