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THE RISK OF FIRE SALES IN THE TRI-PARTY REPO MARKET

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This paper studies the risk of "fire sales" in the tri-party repo market, a large and important market where securities dealers find short-term funding for a substantial portion of their own and their clients' assets. We distinguish between fire sales of assets by a dealer who, facing a run that could lead to default, sells securities to generate liquidity, and fire sales of assets by repo investors after a dealer's default has occurred. While fire sales do cause damage no matter how they arise, the tools available to lessen the harm from the two types of fire sales are different. We find that limited tools are available to mitigate the risk of predefault fire sales and that no established tools currently exist to mitigate the risk of postdefault sales. (*JEL* G01, G18)

I. INTRODUCTION

The risk of "fire sales," rapid sales of assets in large amounts that temporarily depress their market prices, is a major source of financial instability. Policymakers' concern for fire sales was one of the driving forces behind the creation of the Term Securities Lending Facility (TSLF) and the Primary Dealer Credit Facility (PDCF) in 2008. Fire sales can amplify problems faced by a financial firm because the reduced sale price of the assets can result in realized losses that lead to a decrease in capital and the possible need for additional asset sales. Excessive sales by a single firm can also propagate stress to other institutions if they face margin calls and are forced to sell assets. The presence of such externalities suggests that market outcomes may not be efficient.[1] As a consequence, mitigating the risk of fire sales is an important objective in the effort to promote financial stability.

In this paper, we discuss the risk of fire sales in the tri-party repo market, a large and important market where securities dealers find short-term funding for a substantial portion of their own and their clients' assets. Because of the size of this market and the fact that some of its participants are vulnerable to runs, fire sales are particularly likely in this market. They can result if a securities dealer defaults and its secured creditors decide to liquidate the collateral—or even in the absence of a formal default if funding becomes difficult to obtain, spurring a rapid reduction in positions.

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1. See Stein (2012) and Antinolfi et al. (2012) for a discussion of the welfare costs of fire sales.

ABBREVIATIONS

ABS: Asset-Backed Securities
CCLF: Capped Contingent Liquidity Facility
CCP: Central Counterparty
DFMUs: Designated Financial Market Utilities
FDIC: Federal Deposit Insurance Corporation
FMU: Financial Market Utilities
LTCM: Long-Term Capital Management L. P.
MBS: Mortgage-Backed Securities
MMFs: Market Mutual Funds
PDCF: Primary Dealer Credit Facility
TSLF: Term Securities Lending Facility
VaR: Value-at-Risk

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Fire sales are one of the three systemic risk concerns highlighted in a May 2010 whitepaper by the Federal Reserve Bank of New York on tri-party repo infrastructure reform (Federal Reserve Bank of New York 2010) and remain a concern of regulators. The 2013 report of the Financial Stability Oversight Council points to the vulnerability of the wholesale funding markets to runs that can lead to destabilizing fire sales. At a conference organized by the New York Fed on October 4, 2013, New York Fed President William C. Dudley and Federal Reserve Board Governor Jeremy C. Stein discussed the risk of fire sales and some policy measures that could reduce their risk.[2]

In the tri-party repo market, it is important to distinguish between fire sales of assets by a dealer who responds to an investor run by selling securities to generate liquidity, and fire sales of assets by repo investors after a dealer's default has occurred. While fire sales do damage no matter how they arise, the tools available to lessen the risk of the two types of fire sales are different. The risk of predefault fire sales by dealers exists because dealers perform maturity and liquidity transformation, and cannot expect to liquidate longer-maturity assets quickly enough to respond to a loss of short-term funding. In contrast, the risk of postdefault fire sales by counterparties to a defaulted dealer exists because repo contracts enjoy an exemption from the automatic stay of bankruptcy, which allows creditors to take possession and dispose of collateral in the event of a default by a debtor.[3] While this exemption makes repo a very liquid product, there is currently no process or mechanism in place to ensure that the creditors of a defaulting dealer collectively liquidate the repo assets in an orderly manner. Disorderly disposal of large amounts of repo assets can lead to rapid sales, sharp price declines that result in margin calls and mark-to-market losses, and a deleveraging spiral. These effects would have an impact on any holder of the asset type in question, not just tri-party repo market participants.

The likelihood of predefault fire sales would be reduced if dealers performed less maturity and liquidity transformation—for example, by lengthening the maturity of their repos, especially against lower quality collateral.[4] In addition, some tools are available to partially mitigate the impact of predefault fire sales, such as either regular or emergency lending by the central bank, or capital and liquidity regulation that can make dealers less vulnerable to failure. However, these tools are limited in a number of ways and may serve to reduce, but not to eliminate, the possibility of fire sales following a dealer's default.

There are currently no established tools to mitigate the risk of postdefault fire sales. Title II of the Dodd-Frank Act provides authority to the Federal Deposit Insurance Corporation (FDIC) to conduct an orderly resolution process for a broker-dealer, which is determined at the point of failure to be systemically important. However, the details of how this authority would be exercised, how the determination would be made, and how quickly the resolution process could be started have not been specified. Market participants could be uncertain about who might be subject to a Title II liquidation process and how quickly it could be executed. This uncertainty could in fact have the effect of accelerating a run, if investors have doubts about a troubled broker-dealer being identified for a Title II resolution. To mitigate the risk of postdefault fire sales in the tri-party repo market, a mechanism or process is needed to ensure that creditor liquidations of assets will be done in a coordinated and orderly manner. Importantly, the details of this mechanism would need to be clearly specified and transparent to market participants in advance of a problem.

A famous incident, the resolution of Long-Term Capital Management L.P. (LTCM), illustrates the difficulty of setting up such resolution tools and the stress that can arise when these tools cannot be relied upon. In 1998, when LTCM appeared to be on the verge of default, the President of the Federal Reserve Bank of New York at the time, William McDonough, convened a meeting of top Wall Street firms, many of whom were creditors to LTCM. These firms understood

2. The 2013 FSOC annual report can be found at http://www.treasury.gov/initiatives/fsoc/Pages/annual-report.aspx. The agenda of the conference and the remarks by President Dudley and Governor Stein can be found at http://www.newyorkfed.org/research/conference/2013/fire_sales/fire_sales_driver_a.html.

3. The bankruptcy proceedings for most broker-dealers would be conducted under the Securities Investor Protection Act of 1970 (SIPA). Under SIPA, the Securities Investor Protection Corporation (SIPC) typically requests a temporary stay of the exercise of any right of setoff without the consent of SIPC and the SIPA trustee. The stay does not prohibit the nondefaulting party from closing out and terminating outstanding repos and using cash to cause the liquidation of a repo, but it does prohibit any person from disposing of securities acquired under a repo without such consent.

4. Lengthening the maturity of repos could lead to greater maturity transformation by lenders and reduce their access to liquid investments, which may make them more vulnerable.

that a failure of LTCM could lead to massive fire sales of the assets that served as collateral for LTCM's repos.[5] Eventually, a group of 14 of the firms agreed to purchase 90% of LTCM, with each providing capital in various amounts, totaling $3.625 billion. LTCM was then slowly wound down, with the new owners making a small profit on the transaction.[6]

In this instance, a market-organized solution was set up to prevent the fire sales that would otherwise have occurred, but only ex post. The stress experienced by financial markets at the time, despite the ultimate success of the rescue of LTCM, underscores the need for a well-established arrangement to be set up in advance. Moreover, failed private sector efforts to save Lehman Brothers underscore the risks associated with relying on ad hoc arrangements.

To date, most of the research on postdefault fire sales has focused on the role of, and potential changes to, bankruptcy law (see, e.g., Acharya, Anshuman, and Viswanathan 2013; Antinolfi et al. 2012; Duffie and Skeel 2012; Roe 2011).[7] However, the prospect of changes to bankruptcy law seems remote, given the current degree of gridlock in Washington, and the press of many other legislative priorities. Moreover, some aspects of the special treatment of repos may be highly desirable for fostering market liquidity. For example, close-out netting is essential for the ability of financial market participants to hedge. In addition, changes to bankruptcy law would not help address the risk of predefault fire sales and could even increase this risk, if lenders gain stronger incentives to stop lending to a counterparty before a default occurs. Our work has taken a very different tack, proceeding from the view that to reduce the likelihood of fire sales and their consequences, one needs to think of this risk both predefault and postdefault. Our framework suggests that mechanisms to mitigate the risk of fire sales can be created within the context of existing bankruptcy rules.

The remainder of the paper is structured as follows. Section II describes the problem of fire sales in the tri-party repo market. Section III distinguishes between predefault and postdefault fire sales. Section IV presents some quantitative work on the time that may be necessary to liquidate tri-party collateral without price impact and the possible losses associated with such liquidation. Section V discusses available tools to address fire sales. Section VI describes the links between predefault and postdefault fire sales. Section VII concludes.

II. THE PROBLEM OF FIRE SALES IN REPO MARKETS

A repo is the sale of a security, or a portfolio of securities, combined with an agreement to repurchase the security or portfolio on a specified future date at a prearranged price.[8] Aside from important legal distinctions concerning bankruptcy treatment (discussed in more detail below), a repo is similar to a collateralized loan.[9]

Shleifer and Vishny (1992) define a fire sale as the forced sale of an asset at a dislocated price. Price dislocation typically occurs if a large amount of assets is sold in a short period of time. Fire sales are a broad concern that extends well beyond the repo market.[10] Nevertheless, stress in the repo market during the financial crisis of 2007–2009 provides striking examples of the kind of dynamics discussed in this paper. The damaging effects of these fire sales led to the creation of the TSLF and the PDCF in March 2008.

On February 28, 2008, Peloton Partners, a London-based investment manager, revealed that it had been getting margin calls and that creditors had begun demanding larger haircuts on mortgage-related collateral. Peloton announced that it was shutting down one fund (Peloton ABS Fund) and would shortly begin liquidating that fund's assets and closing a second fund (Peloton Multi-Strategy Fund) to further redemptions. The next day the *Wall Street Journal* reported that Peloton had only limited success in selling assets on its own and that six of the funds' 14 creditor banks had begun seizing collateral pledged by the funds.[11]

On Monday, March 3, Thornberg Mortgage announced that it had failed to satisfy a $270

5. See transcript of the September 29, 1998, meeting of the FOMC, notably pages 100 and 102–03.

6. See Fleming and Liu (2013).

7. Martin, Skeie, and von Thadden (2014a) study predefault fire sales that can lead to the bankruptcy of a dealer.

8. Under the English-law master agreements for repos, the requirement is to repurchase the same or equivalent securities, where "equivalent" means fungible.

9. This paper focuses on U.S. insolvency proceedings. The treatment of repo in bankruptcy can differ in other jurisdictions.

10. See, for example, Manconi, Massa, and Yasuda (2012) and Merrill et al. (2012) for empirical evidence on fire sales.

11. "Mortgage Rout for a Hotshot Hedge Fund," *Wall Street Journal*, February 29, 2008, and "Banks Seize Assets of Peloton Hedge-Fund Firm," *Wall Street Journal*, March 1, 2008.

million margin call on mortgage-secured loans and that it might have to sell assets to stay in business.[12] In this case also, the *Wall Street Journal* reported that creditors had seized "billions of dollars of collateral from [Thornberg Mortgage] and dumped [the collateral] onto an already turbulent bond market. …"[13]

Both Peloton and Thornberg liquidated subprime-mortgage-related securities at levels significantly lower than their previously recorded market valuations. The unexpectedly low prices prompted a reduction in collateral marks across many nonagency mortgage-backed securities (MBS) that sparked additional liquidations as borrowers struggled to meet margin calls.

The deleveraging spiral claimed another victim on Thursday, March 6, when a leveraged investment fund (Carlyle Capital) sponsored by Carlyle Group, a private-equity firm, failed to meet creditor margin calls.[14] The fund was capitalized with $940 million of investor equity and $21.8 billion of borrowed money (making for a 24-to-1 leverage ratio) and invested in "somewhat obscure and thinly traded" securities.[15] During the following week, creditors began to liquidate the fund's collateral, selling as much as $5.7 billion of securities by Monday, March 10.[16]

The sales may have contributed to the difficulties faced by Bear Stearns and they were cited by both the *New York Times* and the *Wall Street Journal* as a factor in its collapse. The *New York Times* reported that when the CEO of Bear Stearns appeared on television in an attempt to calm fears that the firm was in trouble, "Skittish lenders were already calling in loans made to Carlyle Capital .... Soon the attention spread to Bear Stearns as market players began to question the firm's ability to finance itself, sending the stock into a tailspin."[17] The *Wall Street Journal* reported,

> "The disclosure by Carlyle Capital [that it could not meet margin calls from its bankers] proved to be the spark that set a wildfire through mortgage markets and other parts of the financial system. Carlyle Capital held $21 billion in MBS, and investors feared the firm or its bankers would dump them. That roiled mortgage markets and set off fears of wider financial contagion. This chapter of the credit crisis culminated in the emergency sale of Bear Stearns Cos. to J.P. Morgan Chase & Co. for just $236 million."[18]

It is striking to consider that the initial disruptions were caused by relatively small institutions but that the stress subsequently spread to much larger firms. This risk of contagion led to the creation of the TSLF and the PDCF, both of which played an essential role in mitigating subsequent stress in repo markets.[19]

A. The Risk of Fire Sales in the Tri-Party Repo Market

The tri-party repo market is a particularly large and important segment of the U.S. repo market.[20] At the end of 2014, the tri-party repo market was used to finance close to $1.6 trillion of securities.[21] In this market, the collateral providers are the dealer subsidiaries of large and complex financial institutions. Many of these dealers depend on the tri-party repo market as a way to fund their portfolios of securities and those of their clients. Dealers use this market to obtain short-term financing at a low cost and in a manner that preserves more or less continuous access to their securities to facilitate deliveries and receipt of securities. Cash providers in this market are primarily money market mutual funds (MMFs), securities lenders,[22] and other institutional cash

12. "Will Thornberg Join Failed Lenders?" *Wall Street Journal*, March 4, 2008.

13. "REIT Lender Thornberg Sees Collateral Seized," *Wall Street Journal*, March 8, 2008.

14. *Wall Street Journal*, March 7, 2008.

15. "Carlyle Fund in Free Fall as Its Banks Get Nervous," *Wall Street Journal*, March 14, 2008.

16. "No Delay: Wall Street Got Tough with Carlyle Capital—Despite Fund's Plea, Dealers Moved Fast to Protect Positions," *Wall Street Journal*, March 12, 2008, and "The Bear Stearns Fallout: With Street Watching, 'Repo' Trading Is Light—Market That Turned on Bear Stearns Remains Cautious," *Wall Street Journal*, March 18, 2008 (reporting that $16 billion in mortgage-related assets owned by Carlyle Capital had been seized by repo creditors).

17. "Run on Big Wall Street Bank Spurs U.S.-Backed Rescue," *New York Times*, March 15, 2008.

18. "Fed Fix Works for Now – Mortgage-Bond Market Breathes Sigh of Relief, But the Calm Is Fragile," *Wall Street Journal*, March 20, 2008.

19. See Fleming, Hrung, and Keane (2009) for more details about the TSLF and Adrian, Burke, and McAndrews (2009) for more details about the PDCF.

20. See Copeland, Martin, and Walker (2010) and Copeland et al. (2012) for more detail on the tri-party repo market.

21. Volume data for the market are available at http://www.newyorkfed.org/banking/tpr_infr_reform_data.html.

22. In the United States, securities loans are typically done against cash collateral. Securities lenders invest the cash collateral in a variety of products, including repos.

providers such as mutual funds, insurance companies, corporate treasurers, and state and local government treasurers.[23] These investors primarily seek a safe and liquid investment that provides some interest income. In that sense, overnight repos can be thought of as a secured alternative to bank deposits. Together, MMFs and securities lenders account for over half of all tri-party repo lending.

The tri-party repo market owes its name to the fact that a third party facilitates repo settlement. In the United States, this third-party role is fulfilled by two government securities clearing banks: Bank of New York Mellon and J.P. Morgan Chase.[24] The clearing banks settle tri-party repo transactions through transfers across cash and securities accounts on their books. Specifically, they settle the opening leg of a tri-party repo transaction by transferring securities from the dealer's securities account to the cash investor's securities account, and by transferring funds from the investor's funds account to the dealer's funds account. Movements in the opposite direction occur on the closing leg of the repo. In addition to offering settlement and custodial services, clearing banks provide collateral management services, such as daily revaluation of assets, daily remargining of collateral, and allocation of the borrower's collateral to its lenders in accordance with the lenders' eligibility and risk management constraints.[25] As explained by Garbade (2006), clearing banks also ensure that the collateral will be available to cash providers if a dealer defaults.

The risk of fire sales is a particularly acute concern in the tri-party repo market because of the size of dealers' portfolios and the strong incentives for some lenders to sell collateral quickly in a default event. Large dealers' repo books currently range between $100 billion and $150 billion and, in some cases, reached peak levels in excess of $400 billion prior to the financial crisis. While tri-party repo books have come down significantly, the size and composition of individual dealer books still presents fire sale risk. For positions this large, even the liquidation of collateral usually viewed as liquid, such as agency MBS, could prove challenging over a compressed time frame. In addition, approximately 22% of the assets financed in this market, over $350 billion as of December 2014, are private obligations that are not backed by the U.S. government or its agencies and that tend to exhibit significant price volatility and illiquidity when market conditions are strained.

Fire sales in the tri-party repo market present a risk to financial stability because they affect all holders of the assets, even those beyond the tri-party repo market. Rapid sales will exert downward pressure on the prices of these assets. Other institutions holding these assets will see their capital eroded and may have to delever.[26] Similarly, institutions that have pledged these assets as collateral could face margin calls and may be forced to sell assets. Because of the size of the market and the many similar securities used as collateral by its participants, such a cycle of sales and price declines could serve as a channel of risk transmission within and beyond the tri-party repo market, creating significant losses for all holders of the assets undergoing fire sales. The resulting financial market stress could have a negative impact on the real economy.

Some of the largest lenders in the tri-party repo market, such as MMFs and securities lending agents, are themselves potentially subject to runs by their own clients. For example, the Reserve Primary Fund experienced a run the day after Lehman Brothers Holdings declared bankruptcy in September 2008, driven by investor concerns about the Reserve Primary Fund's holdings of Lehman debt. As the Reserve Primary Fund "broke the buck" and suspended withdrawals, many other prime money funds experienced runs.[27] Separately, a number of securities lending agents using commingled accounts lacked sufficient liquidity to meet client demands in 2008 as parties sought to unwind securities lending transactions. This resulted in a need to limit cash outflows through use of redemption gates or through repayment in kind, using securities purchased with cash collateral.

All of this suggests another avenue of contagion and fire sales in the event of a dealer default in the tri-party repo market. Other dealers could face difficulties in obtaining repo funding if many cash investors started exiting the market because

23. We use the terms "cash providers," "cash investors," and "repo investors" interchangeably.

24. The number of banks in the business of clearing government and agency securities has decreased over time, from nine in 1980 to two today, notably because of mergers. The concentration is likely due to the presence of economies of scale in this business.

25. These services are all provided for a fee.

26. This type of dynamic was first studied in Kiyotaki and Moore (1997). See also Adrian and Shin (2010) and Greenwood, Landier, and Thesmar (2012).

27. Treasury-only money funds were the recipients of some of the flows out of prime money funds.

of runs by their shareholders and creditors. With funding in such short supply, nondefaulting dealers might have to sell securities to avoid defaults. More generally, dealers are vulnerable to any shock that would cause a large class of investors (such as MMFs) to quickly reduce its investment.

In addition, many tri-party repo lenders face operational or regulatory constraints that create strong incentives to liquidate assets immediately after taking possession of them following a dealer's default. Many investors lack the operational capacity or financial resources to ensure orderly disposal of collateral seized as a result of a dealer default. From a regulatory perspective, some tri-party repo investors accept as collateral securities that they are not permitted to own outright or that would, in the aggregate, quickly put them in violation of portfolio composition rules (e.g., by significantly extending average maturities). A counterparty bankruptcy could in theory also instigate a run on the repo investor, if that institution's own investors become concerned about the change in risk profile that results from having to take possession of the collateral backing the repo. Regardless of the trigger, such runs would create a large and sudden need for liquidity that may require rapid sales of the collateral when no other source of backup liquidity is available.

III. FIRE SALES PREDEFAULT AND POSTDEALER DEFAULT

Fire sales can occur whenever a large volume of securities is sold in a short amount of time. In the tri-party repo market, this could occur under two distinct sets of circumstances: (1) if a dealer under stress needs to sell assets it can no longer finance; and (2) if a defaulting dealer's repo counterparties sell their collateral quickly. As noted above, the two types of fire sales could happen simultaneously—for example, if a large-dealer default triggers a broader pullback by cash investors in the repo market, which may force other dealers to sell their assets. While the economic impact of fire sales is the same regardless of whether dealers or lenders are selling, the types of tools that are effective in mitigating fire sale risk will differ, depending on whether the seller is a dealer or a creditor.

A. Predefault Fire Sale

Predefault fire sales occur when a dealer loses access to market sources of secured funding. This might occur for either systemic or idiosyncratic reasons. In a systemic scenario, a shock, such as a pullback of lenders from funding a specific type of illiquid and hard-to-value asset, could reduce all dealers' access to secured funding and create pressure to sell assets in order to generate liquidity and/or reduce balance sheet size. Gorton and Metrick (2012) document a large increase in haircuts in the bilateral repo market. An increase in haircuts reduces the funding that can be obtained for a specific amount of assets and could trigger the sale of some assets. Krishnamurthy, Nagel, and Orlov (2014) provide evidence that MMFs stopped funding nonagency asset-backed securities (ABS) and MBS in the fall of 2008, as the financial crisis reached its peak and many MMFs experienced runs by their shareholders. Interestingly, these authors do not find significant increases in haircuts in the tri-party repo market.

Idiosyncratic loss of access to secured funding would typically occur when lenders run from a dealer because of concerns about its solvency. Copeland, Martin, and Walker (2014) provide evidence of a sharp reduction in the amount of tri-party repo funding at Lehman in the days before the holding company declared bankruptcy. Their paper also provides evidence consistent with Gorton and Metrick (2012) and Krishnamurthy, Nagel, and Orlov (2014), suggesting that, in the bilateral repo market, investors appear more willing to increase margins when a repo becomes more risky because either the borrower or the collateral becomes more risky. In contrast, tri-party repo market investors did not adjust either margins or quantities in a gradual way. They apparently either provided a consistent amount of funding, or abruptly reduced their funding. Unless investor behavior is different in future stress episodes, the tri-party repo market may be at greater risk of fire sales than the bilateral repo market, because the tri-party lender base currently consists of many investors that (for the reasons noted above) have a more binary response to borrower stress than is typical in other secured funding markets—lend, or do not lend.[28]

Dealers face the risk of predefault fire sales because they perform maturity and liquidity transformation. Maturity transformation occurs because the repos have a much shorter tenor than the maturity of the securities that serve as collateral. Liquidity transformation occurs because the

28. Clearly, the risk of fire sales in the bilateral repo market would increase if the set of tri-party repo investors that currently create fire sale risk in that market were to start using the bilateral market more extensively.

time it would take to sell the securities backing the repos without affecting prices exceeds the duration of the repo funding. For example, a portfolio of securities that might take 10 days to liquidate without price impact may serve as collateral for a 5-day repo.

Dealers performing maturity and liquidity transformation in the tri-party repo market could be solvent but illiquid. The value of the securities they hold might exceed the face value of the repo if the securities are held to maturity or sold in a well-functioning market. If, however, the supply of these securities temporarily exceeds the demand by a large amount, then their price might drop to a point where the securities are worth less than the face value of the repo they collateralize. Martin, Skeie, and von Thadden (2014b) model dealers that finance themselves through repos and study how a loss of funding due to a run can force a dealer to sell assets and potentially trigger fire sales.

B. Postdefault Fire Sale

Postdefault fire sales occur after a dealer has defaulted when its repo counterparties sell the collateral quickly. As mentioned, repo counterparties benefit from a special protection in case of bankruptcy because repos are exempt from the automatic stay.[29,30] Because of the exemption, repo counterparties can close out the repo and liquidate the repo securities soon after the bankruptcy of their dealer counterparty. This feature of repo makes it a relatively attractive and liquid investment vehicle from the lender's perspective and has undoubtedly contributed to the growth of repo market liquidity and volume over time. Indeed, the exemption from the automatic stay makes the repo counterparties' claims extremely safe in a "microprudential" sense, as the claims are backed by collateral that can be sold quickly even in the event of a bankruptcy of the dealer. However, this safety comes at a "macroprudential" cost of increasing fire sale risk.

Repo creditors of a defaulting dealer have the right to sell the repo securities, but they are not required to do so. Upon a default event, industry-standard master repo agreements require the cash investor to do one of two things: either (1) immediately sell the securities and net the proceeds against the amount owed to it by the defaulted dealer, or (2) if not selling immediately, determine the market value of the securities and net that value against the amount owed to it by the defaulted borrower.[31] In this latter case, the lender has some discretion over when to sell the assets. If creditors to a defaulted dealer can take the time to sell the collateral at a measured pace, fire sales need not materialize. Nevertheless, several factors make postdefault fire sales likely in the tri-party repo market: (1) the size of the portfolio being financed; (2) the incentives some creditors would likely have to sell their collateral very quickly, owing to a combination of their funding profile and their regulatory requirements; (3) the desire to avoid disputes about the "market value" of the securities calculated in the close-out process; and (4) the collective-action problem faced by repo lenders (explained below).

As noted above, large dealers' repo books currently range between $100 billion and $150 billion. For most asset classes, the volume of collateral that would potentially be liquidated greatly exceeds the total daily volume traded on a typical day. In Section IV, we conduct a value-at-risk (VaR) analysis that illustrates the potential shortfall from liquidating the portfolio of a hypothetical large dealer.

The largest dealers transact with a number of different tri-party repo lenders. Copeland, Martin, and Walker (2014) show that, until a few days before Lehman's declaration of bankruptcy, its U.S. broker-dealer subsidiary had more than 60 different cash investors.[32] Upon the default of a large dealer, many investors would have incentives to sell their assets quickly and might not take into account the combined effect of those sales on the market price of the assets. In that sense, the investors face a collective-action problem. They would all be better off if they could

29. As noted in Footnote 4, a registered broker-dealer is resolved under SIPA, and SIPA imposes a stay on liquidation of securities collateral. It is expected, however, that SIPC will lift this stay in a short time period. Such a short stay would delay, but likely not mitigate, the fire sales.

30. In bankruptcy law, the purpose of the automatic stay is to prevent the destruction of value that can occur when creditors try to indiscriminately seize the assets of a bankrupt firm. See Garbade (2006) for an account of the events that led to the exemption from the stay in the United States. Antinolfi et al. (2012) study a model in which exemption from the stay can lead to fire sales.

31. If the value of the securities exceeds the face value of the repo, the lenders must return the different to the defaulted dealers. Conversely, if the value of the securities does not cover the face value of the repo, the lender receives an unsecured claim on the dealer for the difference.

32. Note that this broker-dealer subsidiary did not declare bankruptcy on September 15, 2008, when the holding company did. Most clients' accounts of the broker-dealer were later sold to Barclays.

coordinate their actions to minimize the effect of their sales on the price of the collateral they are trying to liquidate. Absent this coordination, their actions will result in excessive declines in the price of their collateral, which can be costly for all of them. In addition, some investors may be unable to dispose of assets at a moderate pace, even if they wanted to. For example, MMFs and securities lenders may be forced to sell assets to meet the redemption requests of their own investors. Finally, repo creditors have limited incentives to try to obtain a high price for liquidated collateral because they do not share in the upside once a sale price is sufficient to make them whole on their claim against the dealer. As long as the price decline of the collateral is not bigger than the haircut, the repo creditor does not gain anything from a higher liquidation price. These effects combine to increase the risk of fire sales.

It is worth noting that while predefault fire sales are the result of a sharp withdrawal of funding, which can be associated with a run, the same is not true for postdefault fire sales. Postdefault fires sales are likely to be triggered by the default of a large dealer, regardless of the cause of that default. In many cases, we might expect a dealer default to result from a loss of funding similar to a run. However, it is also possible that an abrupt event, such as significant unexpected investment losses, could move a dealer quickly to default, resulting in postdefault fire sale despite the absence of predefault fire sales, especially if this even triggered concerns about potential difficulties at other dealers.

IV. FIRE SALE RISK FOR DIFFERENT ASSET TYPES

In this section, we consider how the risk associated with liquidating a very large portfolio of assets, similar to those that are funded in the tri-party repo market. Ideally, we would like a method to estimate the price impact of a given volume of securities in a short amount of time. Unfortunately, there is no standard way to estimate this price impact statistically and thus evaluate the risk of fire sales.[33] So we are forced to use an indirect approach instead.

33. Greenwood, Landier, and Thesmar (2012) consider the effect of sales on asset prices. They assume a sales volume of $10 billion leads to a price change of 10 basis points for all assets. Duarte and Eisenbach (2013) apply the framework developed by Greenwood, Landier, and Thesmar (2012) to the U.S. tri-party repo market. See also Amihud (2002) for an attempt to estimate the price impacts of sales for stocks.

TABLE 1
Hypothetical Portfolio

Asset Class	Dollar Value in Billions	Share of Portfolio (%)
U.S. Treasuries and STRIPS	62.1	41.4
Agency debt	6.5	4.4
Agency MBS and CMO	47.7	31.8
Corporate bonds	7.1	4.7
Equities	14.7	9.8
ABS	4.2	2.8
All other	7.7	5.1
Total	150	100

TABLE 2
Liquidation Amounts

Collateral Type	Amount That Can Be Liquidated in One Day Without an Adverse Impact on Market Prices (Normal Market Conditions)
U.S. Treasuries and STRIPS	$7.5 billion
Agency debt	$2 billion
Agency MBS and CMO	$4 billion
Corporate bonds	$250 million
Equities	$500 million
ABS	$125 million

First, we consider how long it would take to liquidate different segments of a hypothetical portfolio of $150 billion, displayed in Table 1, which is approximately the size of the portfolios of the largest dealers in the tri-party repo market. The breakdown of assets is chosen to replicate the publically available data on the collateral composition of the overall tri-party repo market for December 2014. For each asset class, the amount of collateral that can be liquidated on a given day, in normal market conditions and without price impact, is provided in Table 2. The numbers are based on estimates provided by market participants and the New York Fed's Markets staff.[34] For each asset class, the liquidation horizon, shown in Table 3, is determined by combining the amount of collateral from Table 1 with the amount that can be liquidated each day without having a material and adverse impact on the market pricing from Table 2. For example, the liquidation horizon for Treasuries is $62.1/7.5 = 8.28$ days, rounded down to 8.

34. These estimates were also validated by looking at measures of daily turnover for each asset class as well as the distribution of daily asset sales by size.

TABLE 3
Liquidation Horizon

Collateral Type	Days Needed to Liquidate Segment of Hypothetical Portfolio in Table 1
U.S. Treasuries and STRIPS	8
Agency debt	3
Agency MBS and CMO	12
Corporate bonds	29
Equities	29
ABS	34

This simple exercise shows that the number of days needed to liquidate some segments of the hypothetical portfolio is quite large, suggesting a high risk of fire sales. For example, the number of days necessary to liquidate the portfolio of agency MBS and collateralized mortgage obligations (CMO) is 12 days. The portfolio of ABS would take 34 days to liquidate.

These estimates are conservative along several dimensions. The assumption regarding the number of days to liquidate is for normal market conditions taking into account historical daily turnover in each asset class and is meant to avoid signaling effects. Under stressed market conditions, liquidating most asset classes would take longer. One possible exception is Treasury securities, which tend to benefit from flight-to-quality episodes. However, Treasuries are not all equally liquid—on-the-run issues are typically more liquid than off-the-runs, 2-year notes are typically more liquid than STRIPS, for example. Furthermore, even Treasury securities can be subject to variations in market liquidity in some stress scenarios, as observed with short-dated securities during the 2013 run-up to the debt ceiling.[35] In addition, events in Europe during the summer of 2011, for example, suggest that even sovereign debt can become illiquid in some circumstances.

Some subsegments of these broad asset classes may be harder to liquidate than others. For example, STRIPS and TIPS would be much harder to liquidate than other Treasury securities. Our assumptions regarding days to liquidate apply to the most liquid assets in each asset class. So high-yield corporate bonds or some less liquid equities would take longer to liquidate than our assumptions suggest.

Next, we consider a VaR approach for some of the asset classes of the hypothetical tri-party portfolio. This approach uses two inputs: the amount of the asset that can be liquidated on a given day without price impact, as calculated above, and the price volatility of an asset. These are then used to evaluate the potential loss of principal associated with the sale of the assets.

As already noted, the time necessary to liquidate the collateral will depend on the liquidity of the asset at that point in time and the amount being liquidated, two dimensions likely relevant to the risk of fire sales. So while this approach does not allow us to directly measure the potential impact of fire sales, it may be indicative of the risk created by each asset class. It may also inform us about the relative risk of different asset classes.

For each asset class, we use a statistical method described in the Appendix to measure the difference between the value of the collateral at the time the liquidation starts and the total proceeds from liquidation. Average daily volatility of an asset is defined as the standard deviation of the daily return on an index representative of this asset over a given period of time. We use a 30-day average daily volatility from September 15 to October 15, 2008.[36] This is a measure of average volatility during a stressed period, rather than a measure of extreme volatility. We assume that the same amount of collateral is liquidated each day during the liquidation period.

Assuming that asset price changes (returns) follow a normal distribution, with mean zero and volatility corresponding to our value of average daily volatility, we can calculate a distribution of prices over a given liquidation horizon.[37] This allows us to determine the total value generated by the sale of the portfolio and compare it to the value of the portfolio at the beginning of the liquidation period. The shortfall we report in Table 4 is such that losses of this size or greater occur with 1% probability. Table 4 also displays the 25th, median, and 75th percentile haircut for each asset class.[38]

35. http://www.reuters.com/article/2013/10/08/us-usa-fiscal-moneymarket-idUSBRE9970LU20131008

36. While the time period corresponds to 30 calendar days, the number of trading days is 22 for corporates, agencies, and Agency MBS, which do not trade on October 13, and 23 for equities and Treasuries, which include an observation for Columbus Day. The indices we use for each asset class considered are provided in the Appendix. We did not include ABS for this exercise because we could not find an appropriate price index.

37. As a longer liquidation horizon implies a larger volatility, the "root-t rule" is used to adjust the daily volatility measure for each day of the horizon. See the Appendix for more detail.

38. Monthly haircut data for the tri-party repo market are available at http://www.newyorkfed.org/banking/tpr_infr_reform.html

TABLE 4
Liquidation Impact

Collateral	Potential Collateral Shortfall (in Millions)	Liquidated Value (in Millions)	% Shortfall	10th Percentile	Median	90th Percentile
U.S. Treasury (STRIPS)	$1,028	$56,574	1.66	2% (0%)	2% (2%)	2% (3%)
Agency debt	$88	$4,414	1.36	2%	2%	3%
Agency MBS (CMO)	$1,036	$43,076	2.17	2% (2%)	2% (3%)	3% (8%)
Corp bond	$892	$6,445	12.54	3%	8%	15.5%
Equity	$6,005	$8,478	40.90	5%	8%	12%

Our shortfall analysis suggests that losses incurred in the process of liquidating nongovernment and agency collateral could be substantial. Even for some government and agency collateral, such as agency MBS and CMO, losses could be non-negligible. Again, this analysis is conservative for a number of reasons. For tractability, we assume a normal distribution of the returns of the assets we consider. But it is widely recognized that the normal distribution understates the probability of extreme events in this context and, accordingly, the measure of shortfall. As already noted, our liquidation horizons are conservative, which also reduces the potential shortfall.

Some tri-party repo investors may be able to minimize the cost of liquidating their assets. When a large portfolio is liquidated, sensible practice is to hedge first, using the most liquid securities available (such as futures, swaps, and index credit default swaps) and then to liquidate the actual portfolio positions over time removing the hedges. This procedure generally costs less than immediate liquidation of the original portfolio. That said, investors that are subject to their own liquidity pressures, such as MMFs or securities lenders, may not be able to do so. Overall, we find it striking that the potential shortfall associated with nongovernment and agency collateral is quite large compared with the haircut applied in the tri-party repo market.

V. TOOLS TO MITIGATE FIRE SALE RISK

This section discusses tools to mitigate fire sale risk. In addition to considering separately predefault and postdefault fire sales, it is convenient to distinguish between two sets of collateral: (1) government securities, which are backed by the full faith and credit of the federal government, and agency securities that enjoy government support, and (2) risk assets, which are issued by private entities and do not have government backing. Government and agency securities include Treasury securities, debentures issued by Fannie Mae, Freddie Mac, and Ginnie Mae, and agency MBS. Risk assets include all other securities financed in the tri-party repo market, such as corporate bonds, equities, ABS, and whole loans.

Government and agency securities tend to benefit from a flight to quality in the event of broader market stress.[39] Nevertheless, given the quantity of these securities that are financed by many of the largest individual dealers, fire sale conditions could materialize, even for government and agency securities, if the collateral is liquidated in a disorderly manner. In addition to differences in their relative liquidity characteristics and credit profiles, the two sets of collateral receive different regulatory treatment, as described below.

The distinction between predefault and postdefault fire sales, and between government and agency securities and risk assets, provides a helpful framework for analyzing a range of policy options for mitigating the risk of fire sales.

A. Predefault Fire Sale Risk

As noted in Section III, predefault fire sales occur because dealers perform maturity and liquidity transformation. In this case, we are concerned with solvent dealers that lose access to market sources of funding and attempt to liquidate large quantities of securities. The risk associated with maturity transformation can be reduced by lengthening the maturity of repos and making sure that only a small volume matures on any given day. A tool to address the risk related to liquidity transformation is a liquidity backstop. Indeed, the discount window is designed to play

39. We assume that government and agency securities continue to exhibit better credit and liquidity characteristics than risk assets over time, and we do not explicitly contemplate the possibility of a sovereign risk crisis (in which the value of the sovereign guarantee collapses to zero) or a run on housing-related assets.

precisely this role for banks. We consider both types of tools in turn.

"Laddered" Term Funding of Assets. Maturity transformation is central to the liquidity risk faced by dealers in the tri-party repo market. Hence, one option to reduce the risk of predefault fire sales would be to make sure that dealers' tri-party repo books are sufficiently termed out to reduce their vulnerability to a run. Some lengthening of dealer repo books has already occurred as shown in Copeland, Davis, and Selig (2014). For dealers affiliated with bank-holding companies the lengthening is likely due in part to the effect of the new Basel III regulations, notably the liquidity coverage ratio and the net stable funding ratio, which increase the cost of short-term borrowing. As noted above, some of the large lenders in the tri-party repo market may themselves be subject to liquidity pressures. Hence, lengthening the term of dealer borrowing could have the effect of increasing the amount of maturity transformation done by these lenders, which could make them more vulnerable.[40]

Repo books with a term maturity are typically "laddered." Laddering refers to the staggering of dates at which repos in a portfolio mature, so that only a small amount of repos mature each day. For example, a portfolio consisting of $6 billion in risky collateral could be termed out for 60 days. In addition, the portfolio could be broken down into 60 repos of $100 million each and laddered so that only one such repo matures on any given day. Extending and staggering the maturities for repos against risk assets would ensure that a dealer cannot immediately lose all financing for its assets, which reduces the pressure to sell. Moreover, if a dealer is not able to obtain new funding, laddering allows a dealer to sell its assets at a measured pace, reducing the risk of a downward price spiral.

Further stability could be achieved if the repos are structured as "evergreens," providing lead time for recovery or resolution of the dealer. An evergreen repo is a contract that automatically renews on previously set terms. For example, a 60-day evergreen repo struck today becomes a new 60-day repo each successive day until one of the counterparties decides not to renew. The repo then terminates 60 days after the date of nonrenewal. The benefit of evergreens is that they give dealers time to find an alternative source of funding, or to sell assets, when the contract is not renewed. Evergreens, combined with laddering, are particularly useful for funding risk assets, which may require some time to sell without affecting market prices.

Regular Lending Authority. Regular borrowing from the discount window, pursuant to Section 10B of the Federal Reserve Act, could be used by banks to provide funding to their dealer affiliates. In such a case, the bank affiliate could borrow from the discount window against its own collateral, or collateral received from the dealer affiliate through a reverse repo, and then use this funding to lend to the dealer.

Dealers may be able to get this type of funding from bank affiliates for their government and agency securities, but would likely face difficulty obtaining such funding for their risk assets. Indeed, Sections 23A and B of the Federal Reserve Act, as implemented through Regulation W, put strict constraints on interaffiliate transactions, from which interaffiliate repos backed by U.S. government and agency collateral are exempt. In practice, these constraints mean that the largest broker-dealers have very little capacity to fund risk assets through their bank affiliates' access to the discount window. An additional potential constraint is that some of the largest dealers are affiliated with small banks that have small balance sheets. The amount of collateral that such a small bank can finance is constrained by its capital leverage limit.

Emergency Lending Authority. In circumstances determined by the Board of Governors to be "unusual and exigent," and subject to the constraints imposed by the Dodd-Frank Act described below, the Federal Reserve could in theory provide a temporary backstop source of funding to solvent dealers against a pledge of securities collateral and, in that way, facilitate an orderly deleveraging process. This was done, for example, with the introduction of the PDCF in 2008 to backstop the tri-party repo market.[41] A facility such as the PDCF was needed because securities dealers, including primary dealers, do not have direct access to the discount window.

It should be noted, however, that this type of emergency lending might be more difficult to set

40. Anecdotal evidence suggests that some dealers that have been successful at extending the term of their tri-party repo book did so by establishing relationships with new types of counterparties for their borrowing, possibly in addition to lengthening the term of the repos with the counterparties they already had.

41. See Adrian, Burke, and McAndrews (2009).

up today than it was in 2008. Indeed, under the provisions of the Dodd-Frank Act, such lending now can only take the form of a program with broad-based eligibility and could not be done in response to problems at a specific firm. Further, the lending cannot be structured to remove assets from the balance sheet of a single and specific company or established to allow such a company to avoid bankruptcy. Finally, explicit approval from the Secretary of the Treasury is required prior to the extension of any credit.

Market participants have some degree of uncertainty as to when these tools would be used, which may lessen their effectiveness in instilling confidence and in reducing the desire of investors to run. Indeed, investors who are concerned that such lending may not be forthcoming, or may be available only with a delay, would rationally want to reduce their exposure to a troubled dealer before other investors do. Hence, the incentives to be first in line remain as long as the uncertainty persists.

Another potential weakness limiting the effectiveness of this type of backstop is that it may suffer from "stigma," as was observed in the case of the discount window during the fall of 2007.[42] Valukas (2010) discusses possible stigma in the context of the PDCF.

B. Postdefault Fire Sale Risk

In the event that a dealer defaults on its tri-party repo obligations, its counterparties will exercise their rights and obligations under the master repo agreement. Investors would have the ability to sell their collateral soon after a dealer defaults. This action could lead to fire sales because some classes of investors in the tri-party repo market have strong incentives to sell these assets into the market as quickly as possible. In addition, investors face a collective-action problem, as individual investors do not take into account the impact of their sales on the market price of assets. The fire sales could, in turn, lead to market instability.

To mitigate the risk of postdefault fire sales in the present environment, it is necessary for market participants to set up in advance a robust process, or mechanism, with the capability to manage appropriately timed sales of the assets, while also providing for the liquidity needs of the investors. Such processes exist today in a number of financial market utilities (FMU) and, therefore, one potential option would be to move this activity to a FMU that has an established liquidation process with effective risk management. However, given that most tri-party repo activity is not currently cleared and settled through a FMU in the United States, it is also worthwhile to consider other options.

Any process for collateral liquidation, whether part of an FMU or not, would likely need to adopt features that are frequently found in existing FMUs, and have proved effective. In particular, this process would need to include three essential components: (1) rules to determine who would liquidate the repo securities, (2) a source of liquidity to finance the securities until they can be sold, and (3) rules for allocating any losses generated by sale of the securities. A process that does not explicitly rely on a FMU would need to specify how each of these components would be established. It might be possible, for example, to rely directly on the existing market participants to provide these three essential components, or on other institutions, on a contractual basis.

We discuss each component briefly and then provide examples of arrangements that include them.

Rules to Determine Who Would Liquidate the Repo Securities. The risk of fire sales would be mitigated if the assets serving as repo collateral were sold by an institution (or a set of institutions) that has incentives and the ability to maximize the value of these assets. This institution could take many forms, as shown in the examples provided below. Prespecified rules would need to determine how the assets serving as repo collateral are transferred to the liquidation agent and what objective the liquidation agent should pursue on behalf of the repo creditors of the defaulting dealer.

Liquidity to Finance the Securities Until They Can Be Sold. The institution liquidating the assets of the defaulting dealer would need to finance these assets until they are sold. Indeed, the objective of the liquidation process is to give cash back to the creditors of the defaulted dealer as quickly as possible. The financing that these investors were providing must be replaced until the sales are executed. This would require a source of liquidity, which could be obtained through a commitment from market participants, committed lines of credit from other institutions,

42. Armantier et al. (Forthcoming) provide evidence of stigma associated with borrowing at the discount window. See Ennis and Weinberg (2013) for a model.

an emergency facility set up by the official sector, or regular loans made by the central bank.

Rules for Allocating Potential Losses Associated with the Sale of the Securities. A process for facilitating orderly liquidation of assets across many investors would be expected to reduce aggregate losses on the disposition of the assets relative to what would be observed through many individual sales. Nevertheless, any solution would need to feature rules and procedures for allocating potential losses resulting from the liquidation across market participants.

We turn now to some specific examples to illustrate different possibilities for each of the three key elements.

Consortium of Market Participants. First, we consider a process which places the responsibility of liquidation of a defaulted dealer's repo collateral on a consortium of dealers that agree in advance to purchase pro rata shares of a defaulted dealer's repo portfolio and to fund these assets while conducting an orderly liquidation. This example highlights essential features of such arrangements, but other arrangements with similar features could also work.

A group of dealers could agree in advance to purchase the securities from tri-party repo investors following the default of a large dealer. The set of dealers whose default would trigger this procedure might be defined as all member of the consortium of dealers that commit to purchase the securities of a large defaulted dealer. A rule set could be established ex ante that defines how the repo securities are to be divided among participating dealers in the event of a default. For example, these rules could specify that members must bid on the portfolio (i.e., on how much they have to be paid from margin or member resources to take over the liquidation). When efficient to do so, the portfolio to be liquidated can be broken up into a few pieces before being put out to bid. The winning bidder(s) would liquidate the collateral, keeping any proceeds realized in excess of the bid. The more dealers that participate in the arrangement, the fewer securities each individual dealer would be obligated to purchase.

This solution would likely work better for government and agency securities, because they trade in markets that are generally deep and liquid, and the risks associated with holding these assets are well understood by dealers, which could make them more willing to participate in such an arrangement. Dealers may be less willing to commit to acquire securities that are opaque or for which there is considerable private information. For the remainder of this subsection, we focus on the case of government and agency securities.

Operationally, the clearing bank of the defaulted dealer would transfer the securities to the dealers that submitted winning bids. These transfers would provide cash back to the investors and the winning dealers would then be free to dispose of the collateral as they see fit. In this example, the dealers in the consortium would not coordinate their liquidation of the defaulted dealer's repo securities, but coordination may not be necessary as the dealers in the consortium have the knowledge and ability to manage large portfolios of government and agency securities.

Available data help illustrate that the quantity of collateral the winning bidders would have to take on could remain manageable, even if a very large dealer fails. Suppose the ten largest dealers have agreed to purchase the securities from tri-party repo investors following the default of one of them. In September 2013, the ten largest dealers financed about $900 billion in government and agency assets, and the largest portfolio was approximately $135 billion, or 15% of the total. Suppose the largest dealer defaults and that its portfolio is divided into nine pieces roughly proportional to the size of the portfolios of the nine remaining dealers participating in this arrangement. To keep the example simple, assume further that each of the nine dealers wins the piece of the portfolio corresponding to its relative size. In this example, the largest and smallest surviving dealer would finance approximately an additional $19 billion and $2 billion, respectively.[43] Adding more dealers to the arrangement would have the potential to reduce the amount of assets each surviving dealer would have to finance.[44]

For the consortium of dealers, the liquidity could be obtained from a variety of potential

43. Fluctuations of that magnitude are not uncommon in the normal course of business. Between January 1, 2011, and December 6, 2012, the top ten dealers experienced 67 cases where their tri-party repo book changed by 15% or more from one day to the next. The corresponding number for the top 25 dealers is 247.

44. It is worth noting that if multiple dealers were to default at the same point in time, this regime could become quite challenging for individual dealers to manage and may require supplementing with a liquidity backstop provided by the central bank. As described above, such a backstop would help dealers finance the government and agency securities they are unable to fund in the market.

sources, as noted above, such as a buffer built into the dealer's existing liquidity risk management framework, committed lines of credit from other institutions, an emergency facility set up by the official sector, or regular loans made by the central bank.

Ex ante commitments do exist today. For example, the Capped Contingent Liquidity Facility (CCLF) is a mechanism in place at the Depository Trust and Clearing Corporation's MBS central counterparty (CCP). It commits solvent members to fund the portfolio of a failed firm using repos between themselves and the Fixed Income Clearing Corporation.

Liquidity could also be provided, indirectly, by the investors of the defaulted dealer. In principle, the repo lenders of a bankrupt dealer should be willing to finance, at least temporarily, the failed dealer's assets if they are transferred to healthy dealers. Indeed, the risk investors would face in such a case would be smaller than the risk involved in lending to the dealer that just failed. Nevertheless, in the event a solvent member of the consortium would find it difficult to obtain sufficient private sector financing for its share of the assets, the predefault tools discussed in the previous section may be available to allow for a gradual disposition of these assets.

In this example, the consortium dealers would own the assets and dispose of them as they see fit, bearing the risk of losses, but also the possibility of gains. A large position in government and agency securities could take time to liquidate in an orderly manner, and the potential for mark-to-market or even realized gains or losses exists. Several factors make the risk of loss relatively small. Government and agency securities are generally less subject to price volatility than risk assets, in part because the former are traded in deep and liquid markets. Treasuries in particular tend to be in high demand in the event of broader market stress and often experience price appreciation amid a broad flight to quality. In addition, margins on government and agency collateral in the tri-party market today would be adequate, in most cases, to absorb the likely scope of mark-to-market losses, provided there is ample liquidity provision that mitigates pressure to liquidate the securities immediately.

Centralized Liquidation Mechanism. Recognizing that different asset classes have significantly different characteristics, it may be desirable to make use of a single, centralized liquidation agent with tailored expertise as opposed to relying on a consortium of dealers. The orderly liquidation of risk assets following the default of a major dealer might be more difficult to do than for government and agency securities, given the relative illiquidity, opaqueness, and price volatility of risk assets in a stressed market environment. The willingness of healthy dealers to step in to support the liquidation of government and agency securities in a stressed market environment might not extend to these assets, which would (1) take longer to liquidate in the market, (2) be subject to greater price volatility during the holding period preceding liquidation, and (3) be more difficult to fund in the absence of a PDCF-like backstop. As a consequence, the consortium idea that we described may be neither feasible nor advisable for the liquidation of risk assets.

Market participants could agree in advance to contract the responsibility of liquidating the repo securities to a single institution that has expertise in managing and selling assets. This institution would need to have the incentives and the tools to sell assets at a measured pace. For example, the institution designated as the centralized liquidation agent could be a bank, such as the clearing bank of the defaulted dealer, or a special-purpose bank designed specifically for that purpose. In such a case, the liquidation agent may have access to regular discount window lending as a source of liquidity for any repo securities purchased from the investors of the defaulted dealer.[45]

If the liquidation agent were not a bank but, for example, an asset manager, it would need to rely on committed lines of credit from financial institutions such as banks or dealers. The need to access a robust source of liquidity could increase the average cost of financing risk assets in the tri-party repo market, which might lead dealers to finance a smaller quantity of them. Currently, several dealers are financing between $20 billion and $30 billion of risk assets in the tri-party market. The cost of committed credit for portfolios of this size is substantial. Even the largest designated financial market utilities (DFMUs) in the United States do not maintain committed lines of credit this large.[46] If committed lines were pursued, it would be important to consider whether

45. Access to the discount window would not be available if such a bank were managing the liquidation on behalf of the investors but did not own the securities.

46. There are currently eight DFMUs in the United States (http://federalreserve.gov/paymentsystems/designated_fmu_about.htm). The Chicago Mercantile Exchange has the largest amount of committed lines of credit of all the DFMUs. In November 2013, it increased its committed lines of credit to $7 billion, with an option to expand it to $10 billion.

these lines are provided by institutions likely to come under stress at the same time as the large dealers active in the tri-party repo market.

This type of arrangement would likely require an ex ante waterfall outlining the allocation of any losses resulting from the liquidation. These rules could include minimum margins, creation of a participant fund (with contributions from dealers, investors, or both), loss mutualization, or the passing of losses to the original tri-party repo investor post liquidation. In principle, any rules adopted in support of an orderly liquidation process could be embedded in the existing tri-party repo participant contracts and be made a requirement for participation in the market.

Resolution Authority. Acharya and Oncu (2013) suggest the creation of a repo resolution authority, which would purchase the assets from investors at conservative haircuts. The type of institution they suggest could not be set up by market participants alone and would likely need to be created by Congress.

The purchases of the resolution authority would be financed by a repo resolution fund, to which repo lenders would contribute. Hence, liquidity in this case would be provided in part by the investors, in the form of conservative haircuts, and in part by the repo resolution fund.

Acharya and Oncu (2013) envisage that the resolution authority would be needed for the liquidation of risk assets and suggest that Treasury and Agency securities might not need to be included in the repo resolution scheme because they are sufficiently liquid.[47] Sales of risk assets into a stressed market environment would be expected to generate higher market and credit risk losses per dollar than is true for government and agency securities. Notably, our analysis suggests that current haircuts may not be adequate to cover the potential scope of losses in a stress event. Given this factor, and the higher potential for losses per dollar on risk assets, clear rules to govern the allocation and management of losses realized on sales are even more important for risk assets than for government and agency securities.

Acharya and Oncu (2013) offer several ways to protect their repo resolution authority from credit losses. First, the repo resolution authority would purchase the repo securities of the defaulted dealer with a conservative margin. Second, the repo resolution authority would be able to "claw back" the difference between the amount at which the securities were purchased from investors and the liquidation value, should the latter be smaller than the former. Credit risk could be further mitigated by allowing only relatively safe securities to be included in the repo resolution scheme,[48] by requiring that repo investors meet prespecified solvency criteria, and by imposing concentration limits on the asset types a given investor could finance.

For this type of arrangement, as with others, it would be essential that credit risk be borne by market participants and not by taxpayers. As noted above, liquidity may in some cases be provided by the official sector, depending on how the liquidation mechanism is structured. An important design aspect of a liquidation mechanism, should it rely on liquidity provided by the official sector, is that it does not create moral hazard.

Title II of the Dodd-Frank Act. While the orderly liquidation authority from Title II of the Dodd-Frank Act is not specifically designed to address the risk of fire sales in the repo market, it could in theory help reduce this risk considerably. This authority allows the FDIC to transfer all the assets and liabilities of a failing institution, including its broker-dealer, to a bridge institution that would continue to perform on the firm's obligations while orderly liquidation proceeds. Should the FDIC transfer all of a failing institution's repo contracts to a bridge institution, postdefault fire sales could be avoided, so long as the FDIC also provides the necessary funding to make margin calls and instill confidence in the firm's ongoing operations. That said, if market participants are uncertain as to whether and when Title II would be invoked, they may rationally decide to reduce their exposure to a troubled dealer quickly, thereby precipitating predefault fire sales and/or accelerating a dealer default that would prompt fire sales by the dealer's creditors.

VI. CONCLUSION

In considering the range of options to address the issue of fire sales of collateral funded in the tri-party repo market, it is useful to differentiate

47. While the risk of fire sales of Treasuries seems remote, we believe that this risk is material for agency securities, especially agency MBS, based on the analysis in Section VI.

48. The authors envisage that securities that are too risky would be subject to the automatic stay of bankruptcy.

between predefault and postdefault situations as the tools needed to address these risks are different.

By reducing the amount of maturity transformation they perform, broker-dealers can mitigate the risk of predefault fire sales that could be caused by a loss of tri-party repo funding. In addition, the Federal Reserve has some existing tools, such as the authority to conduct both regular and emergency lending (subject to significant limits and constraints), which could also be used to mitigate this risk by facilitating an orderly deleveraging process.

By contrast, there are currently no established tools in place that mitigate ex ante the risk of postdefault fire sales. In today's tri-party repo market, dealers can default for a variety of reasons, and the default of a large dealer could lead to fire sales no matter how the default arises. Hence, an effective regime for risk mitigation must feature a mechanism to ensure ex ante that the incentives faced by tri-party lenders will not result in fire sales in the aftermath of a dealer default. A solution to this collective-action problem will likely require ex ante cooperation and contractual arrangements among tri-party repo market participants.

While ad hoc solutions, as in the case of LTCM, have avoided disasters in the past, the stress associated with such events suggests the need for ex ante well-established solutions. Moreover, the sheer number of creditors in the tri-party repo market would make any attempt to organize a similar solution to manage the failure of a large dealer extremely difficult in practice.

Several approaches could contribute to reducing the risk of fire sales in the tri-party repo market. The resiliency of dealers could be enhanced by reducing their reliance on short-term funding, or through additional capital and liquidity regulation. The volume of assets, particularly lower quality and less liquid assets, financed in the tri-party market could be reduced as a way to reduce the scope for fire sales. The resiliency of tri-party investors could be strengthened, through steps to reduce their own vulnerabilities to run risk.

While improvement along these dimensions would help to reduce the risk of fire sales, we believe that the risk of postdefault fire sales in the tri-party repo market cannot be eliminated altogether absent an ex ante mechanism that provides for the orderly liquidation of tri-party collateral, including by funding such instruments for a period of time and clarifying the incidence of any losses. In addition to the benefits mentioned above, such a mechanism could make predefault runs less likely, as cash lenders would not be as worried about the risk of having to liquidate collateral during a postdefault fire sale.

Active engagement from financial market participants will likely be essential to designing an effective solution. Our work suggests some avenues for future work in this area. In particular:

- What is the best way to design a solution to ensure orderly sales across multiple market participants? Does the answer differ for a clearing bank versus a CCP model?
- As noted in this paper, fire sales in the tri-party repo market can spread financial stress to other markets and the institutions in those markets. Given this risk of contagion, can an effective solution be reached by tri-party repo market participants alone, or should the views of participants in other markets and in the broader financial system be represented as well?[49]
- How should the burden of resources needed for loss absorption, such as haircuts, default funds, and other loss-absorbing buffers, be allocated across market participants?
- Can market participants be relied upon to provide the liquidity necessary to facilitate the orderly liquidation of assets, even in a scenario in which funding markets are undergoing severe liquidity stress? If not, are there ways in which central bank liquidity could be provided in a manner that ensures systemic risk costs are borne by market participants and that does not create moral hazard for market participants?

More work is needed by regulators, market participants, central banks with financial stability responsibilities, and researchers to address this important weakness of our financial system. In the absence of a mechanism or process for ensuring that private market participants have proper incentives to engage in orderly liquidations of assets as needed, the official sector will likely have to resort to emergency measures in order to limit the disruptions to the financial system that fire sales would create. But relying on emergency measures increases the risk that the systemic costs of fire sales will be borne disproportionately by the taxpayer.

49. This is analogous to the distinction between "club" goods and "public" goods.

APPENDIX

This section describes the shortfall calculation for each collateral group:

Assume the liquidity horizons are as given in Table 3.

Assume that the initial amount of a given collateral type is liquidated equally for each day in the liquidity horizon. For example: Agency debt has a 3-day liquidity horizon. Therefore 1/3 of the market value of collateral held on day 1 is liquidated each day.

1. Daily Volatility (Daily Standard Deviation): Use the 120-day average daily volatility measure. The indices we use for this calculation are given in Table A1.

TABLE A1
Price Indices

Collateral Type	Index	Bloomberg Code
Treasuries	Bloomberg/EFFAS Bond Indices U.S. Govt 1–3 Year Trsy	USG1TR Index
Agency debt	Barclays U.S. Aggregate Agency Bond Index	AGZ
Agency MBS	Barclays U.S. MBS Index	VMBS
Corporates	Dow Jones Corporate Bond HG Return	DJCBT Index
Equities	S&P 500 Index	SPX Index

As a longer horizon implies a larger volatility, the convention for adjusting a daily volatility measure beyond one day is to use a root-t rule (McAndrews and Wasilew 2005).

$$\text{Daily Standard Deviation} = \text{Average Daily Volatility} \times \sqrt{t}.$$

Example: Agencies have a 5-day liquidity horizon and an average daily volatility of 0.44%. The volatility on Day 5 is $0.44\% \times \sqrt{5} = 0.985\%$.

2. 99% Confidence Standard Deviation: To consider a 1% event, multiply the Daily Standard Deviation by 2.33 (the z-value for 99% confidence).

$$99\,\%\text{ Confidence Standard Deviation} = \text{Daily Standard Deviation} \times 2.33.$$

3. Daily Liquidation: The percent of total exposure liquidated each day of the liquidation horizon.

$$\text{Daily Liquidation } \% = (1/T) \times 100,$$

where T is the number of days in liquidation horizon.

4. % Remaining Securities: The percentage exposure not liquidated each day.

$$\%\text{ Remaining Securities} = 100\,\% - \text{Daily Liquidation } \% \times T.$$

5. Value Liquidated:

$$\text{Value Liquidated} = \text{Exposure} \times (1 - 99\,\%\text{ confidence standard deviation}) \times \text{daily liquidation } \%,$$

where exposure is the market value (with accrued interest) of collateral.

6. Value Remaining:

$$\text{Value Remaining} = \text{Exposure} \times \%\text{ Remaining Securities}.$$

7. Daily Potential Collateral Shortfall:

$$\text{Daily Potential Collateral Shortfall} = \text{Exposure} \times \text{Daily Liquidation } \% - \text{Value Liquidated}.$$

8. Total Potential Collateral Shortfall:

$$\text{Total Potential Collateral Shortfall} = \sum_{n=1}^{T} \text{Daily Potential Collateral Shortfall},$$

where T is the number of days in liquidation horizon.

9. % Potential Shortfall:

$$\%\text{ Shortfall} = \frac{\text{Total Potential Collateral Shortfall}}{\text{Exposure}} \times 100.$$

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