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ABSTRACT

The credit crisis was sparked by a shock to fundamentals, housing prices failed to rise, which led to a collapse of trust in credit markets. In particular, the repurchase agreement market in the U.S., estimated to be about $12 trillion, larger than the total assets in the U.S. banking system ($10 trillion), became very illiquid during the crisis due to the fear of counterparty default, leaving lenders with illiquid bonds that they did not want, believing that they could not be sold. As a result, there was an increase in repo haircuts (the initial margin), causing massive deleveraging. I investigate this indirectly, by looking at the breakdown in the arbitrage foundation of the ABX.HE indices during the panic. The ABX.HE indices of subprime mortgage-backed securities are derivatives linked to the underlying subprime bonds. Introduced in 2006, the indices aggregated and revealed information about the value of the subprime mortgage-backed securities and allowed parties to buy protection against declines in subprime value via credit derivatives written on the index or tranches of the index. When the ABX prices plummeted, the arbitrage relationships linking the credit derivatives linked to the index and the underlying bonds broke down because liquidity evaporated in the repo market. This breakdown allows a glimpse of the information problems that led to illiquidity in the repo markets, and the extent of the demand for protection against subprime risk.

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Introduction

The credit crisis was sparked by a shock to fundamentals, housing prices failed to rise, which then led to a collapse of trust in credit markets. To shed light on this, I investigate the relationship between two markets, one for cash securities and one synthetic. The first market is the repurchase market, estimated to be about $12 trillion, larger than the total assets in the U.S. banking system. This market has grown to play a crucial intermediation role for asset-backed and mortgage-backed securities, especially as the intermediation has shifted out of the traditional banking sector. The other market is the synthetic market for subprime residential mortgage risk, which can be traded via the ABX.HE indices, derivatives linked to underlying subprime bonds. The ABX indices played several important roles in the panic. Starting in January 2006, the indices were the only place where a subprime-related instrument traded in a transparent way, aggregating and revealing information about the value of subprime residential mortgage-backed securities (RMBS). Other subprime-related instruments, RMBS bonds, Collateralized Debt Obligation tranches, Structured Investment Vehicles' liabilities, and so on, do not trade in visible markets and there are no secondary markets. See Gary Gorton (2008). Also, the ABX allowed for hedging subprime risk. These two markets are linked by an arbitrage relationship, but this breaks down during the crisis, an indication of the disappearance of the repo market for subprime-related instruments.

During the panic, and continuing today, the repo market shrank dramatically, drying up completely for subprime residential mortgage-backed securities (RMBS), because of counterparty risk. The inability to buy or sell the underlying subprime bonds, combined with the overwhelming demand for hedging via derivatives linked to the ABX can be seen in the "basis," the difference in spreads between the ABX index and the underlying cash bonds. Though there

are frictions, the basis should be small, but it explodes during the panic, an indication of the disappearance of the repo market for these bonds.

I. The ABX Indices and the Panic

The panic, starting in 2007, is described by Gorton (2008). Subprime mortgages featured a unique security design that depended on home price appreciation; the mortgages were essentially short maturity, requiring refinancing. In 2006 and 2007 a total of $1.2 trillion of subprime mortgages were originated, of which 80 percent was securitized. The securitization of subprime mortgages also had a unique design, reflecting the home price sensitivity of the mortgages, and involving a dynamic build-up of credit enhancement as the underlying mortgages refinanced, paying cash into the securitization. Rated tranches of subprime securitizations were sold into collateralized debt obligations, tranches of which were in turn sold to structured investment vehicles, and so on. This chain of linked structured securities depended on house prices, and the final location of these risks – the end investors – are not known.

As long as house prices appreciated, subprime mortgages could be refinanced, and the various structured securities linked to subprime mortgages were attractive investments. House price appreciation was positive over the period when subprime mortgages were issued in significant amounts, roughly starting in 2000, through 2006. In some of those years, the appreciation was very high, e.g., house prices grew almost 19 percent in 2005 and 15 percent in 2006. But, prices turned down in 2006. Looking back now we can see that the annual rate change in August 2007, from the previous August, was minus 14 percent.

The house price data is calculated with a lag. So, when house prices started to drop, it not immediately known, now was it possible to determine the extent of the impact on subprime-related securities, and off-balance sheet vehicles' liabilities. There are no secondary markets for

securitization tranches, collateralized debt obligation liabilities, or the liabilities of other structured vehicles, such as structured investment vehicles. As discussed by Gorton (2008), an important part of the information story in the panic was the introduction of new synthetic indices of subprime risk, traded over-the-counter. The ABX.HE 06-1 ("ABX") (this is the official name for the 2006 first vintage), launched by dealer banks, began trading on January 19, 2006.[1]

The ABX Index is a credit derivative referencing an (initially) equally-weighted index linked to twenty subprime residential mortgage securitization transactions that were issued in the prior six months. A new vintage of the ABX and subindices is issued every six months. The twenty subprime securitization transactions specified must have settled within the last six months, have a minimum deal size of $500 million, have a maximum average FICO score of 660, and must meet other criteria, as well.[2] In addition to the main index, there are five subindices which reference different tranches of the same twenty securitization transactions, where each subindex references tranches with the same rating category, e.g., the ABX 06-1 BBB- index refers to the equally-weighted index of the twenty BBB- tranches from the twenty transactions that were originated in the second half of 2005.

The ABX indices trade based on the price, for a fixed coupon. The initial coupon is determined at the launch of each ABX.HE index based on an average quote from a survey of the market makers, the dealer banks. Subsequently, trades require an upfront exchange of premium/discount relative to "par." In a typical transaction, a protection buyer pays the protection seller a fixed coupon at a monthly rate on an amount determined by the buyer. An investor wanting to hedge subprime risk or otherwise establish a short credit position using the

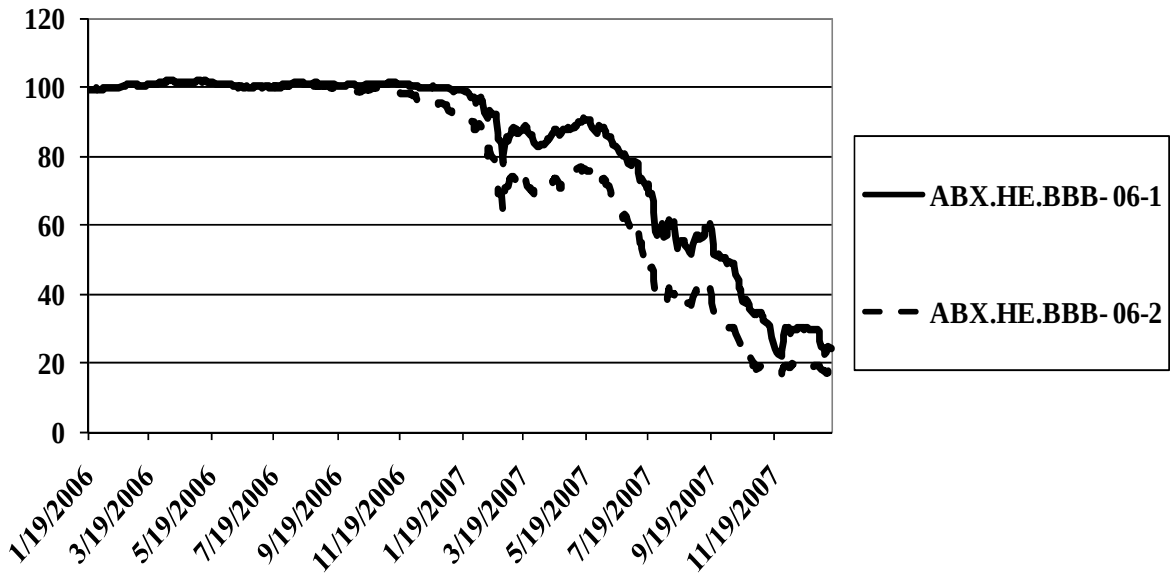
[1] So, unfortunately, there are no observations on early index subprime product, such as the 2005 vintage. Moreover, no vintages were issued after 2007-01.
[2] See "Index Methodology for the ABX.HE Index for the Sub-Prime House Equity Sector," Markit (2008).

index (known as the “protection buyer”), is required to pay a monthly coupon to the other party (the “protection seller”). The payment is calculated based on the outstanding notional amount of the index and a fixed. In exchange for the payment, the protection buyer in an ABX index contract is compensated by the protection seller when any interest or principal shortfalls or write-downs on the underlying mortgages affect the constituent RMBS

When a credit event occurs, the protection seller makes a payment to the protection buyer in an amount equal to the loss. There is no physical settlement. Credit events include the shortfall of interest or principal as well as the write-down of the tranche due to losses on the underlying mortgage loans.

With the advent of the ABX indices, market participants could, for the first time, express views about the value of subprime bonds, by buying or selling protection. For the first time information about subprime values and risks was aggregated and revealed. In 2007 the ABX prices plummeted. This is shown below for the BBB- ABX indices referencing subprime risks from the first half of 2006 and the second half of 2006, as explained below. The common knowledge created, in a volatile way, ended up with the demand for protection pushing ABX prices down. The ABX information together with the lack of information about location of the risks led to a loss of confidence on the part of banks in the ability of their counterparties to honor contractual obligations. The panic was on, starting with a run on structured investment vehicles; see Gorton (2008).

Figure 1: ABX BBB- Subindex Prices



II. The ABX-Cash Basis

ABX prices are an accurate reflection of the risk of the underlying subprime bonds to the extent that an arbitrage relationship between the index and the cash instruments that the index references holds. Define "the basis" for a given cash instrument as the credit default swap (CDS) spread minus the spread on the cash bond for that name or tranche. So the basis is negative when the cash spread is wider than the CDS spread and it is positive basis when the CDS spread is wider than the cash spread. To fix ideas, think of the ABX index as referencing one BBB subprime bond, for simplicity. Imagine an investor who compares the market spread on the BBB subprime tranche (expressed as an annual percentage), S_{cash}, to the spread on the ABX index referencing that same bond, S_{CDS} (also expressed as an annual percentage). The basis is $S_{CDS} - S_{cash}$. So, $S_{CDS} < S_{cash}$ is a negative basis, and vice versa. The cash instrument has to be funded, so the difference $S_{CDS} - S_{cash}$ should equal the cost of funding, say R_{CF}. Intuitively, the

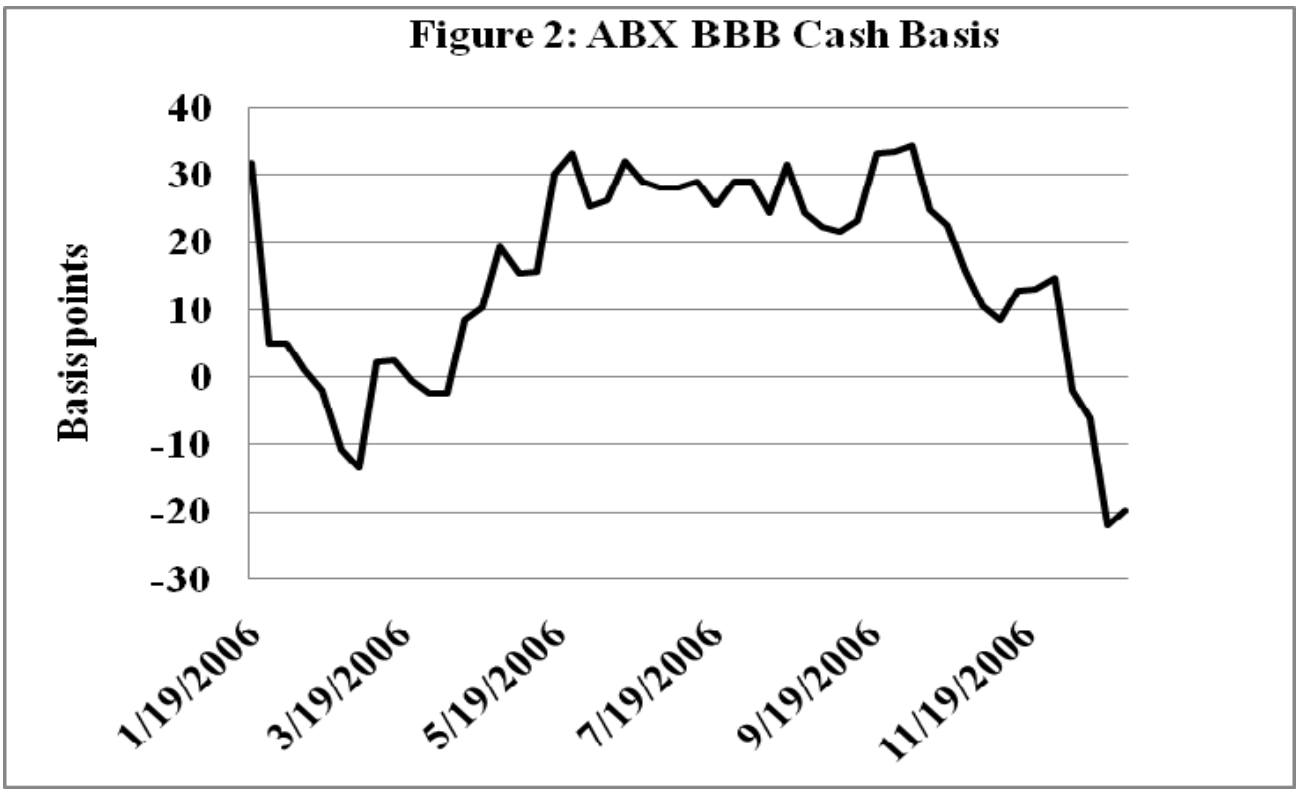
arbitrage should work as follows. If $S_{CDS} - S_{cash}$ is less than R_{CF}, then an arbitrageur should buy the bond and buy protection on the bond via the ABX index, thereby eliminating the credit risk, and earning a return greater than R_{CF}. If $S_{CDS} - S_{cash}$ is greater than R_{CF}, then the arbitrageur should short the risk bond and write protection via the ABX instrument, again earning the difference. For details, see, e.g., Darrell Duffie (1999). This suggests that $S_{CDS} - S_{cash}$ should equal R_{CF}; the cost of funding is discussed further below.

I examine the basis with daily spread data from a dealer bank. The ABX index prices were converted to spreads by the bank.[3] The subprime bonds are floating rate. The bank collects spreads for primary issuance or secondary spreads if these are observed. The subprime spreads series end after February 7, 2008 because of a lack of trading. The subprime bond spreads are not the exact bonds referenced by the ABX index because these did not trade. But, the arbitrage could be conducted using on-the-run subprime bonds that were reasonable substitutes. I focus on the BBB tranche of the ABX index, and also look at the 2006-01 vintage because this is the longest time series.

Figure 2 shows the basis for the BBB tranche of the ABX index during its first year of existence. The basis moves within a fairly narrow range, varying between 34 and -22 basis points, a fairly tight range. The basis should be compared to the cost of funding (or the amount earned), which is the repo rate. For example, suppose LIBOR is 3.1 percent. Suppose, in the repo market, that the haircut for this bond is 10 percent and that the repo rate is LIBOR plus 10

[3] The dealer bank's methodology for computing ABX spreads is, briefly, as follows: (1) the bank uses their proprietary model to project prepays/defaults/losses/durations, etc, using base case home price appreciation assumption (-15% 1yr, -3% 1yrs, 0% 2yrs, +3% rest); (2) The bank uses the risky duration computed above, along with the market price (to get upfront payment) and the constant coupon to obtain the par spread for the index. So, the parameters for the spread computations are: the upfront premiums (market observed); the ABX coupon, which is constant); and the risky duration, which is computed from the proprietary model computed. Roughly, the equation used is: Spread = (Upfront / Risky Duration) + ABX Coupon.

basis points. Then, in a negative basis trade, for a bond priced at $100, the cost of funding is ($100 – ($100*10%))*(LIBOR +10 bp) = $90*3.2%= $2.88.



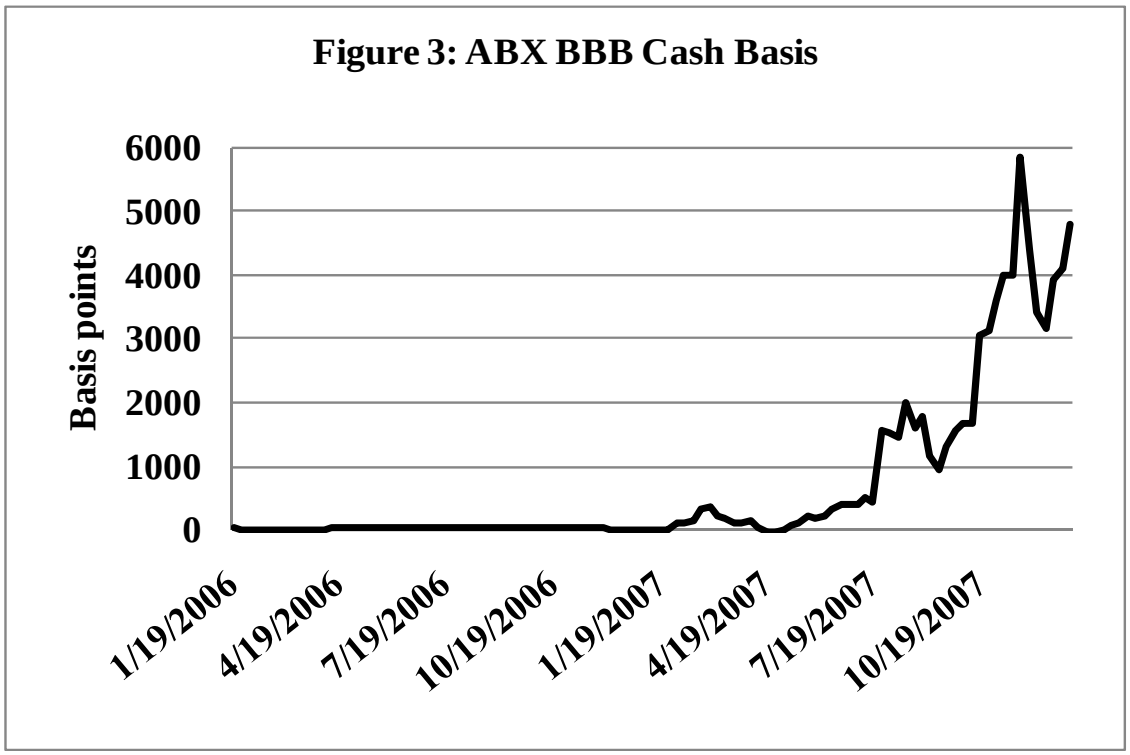
To complete the example, if the bond pays LIBOR plus 100 basis points (bps) and the cost of protection is 60 bps, then the income on the transaction is $100*(3.1%+100-60) = $3.5. So, initially the arbitrage appears profitable. The example shows how the repo market is crucial to keeping the basis narrow.

III. The Repo Market

Repo is likely one of the largest financial markets, although there are no official statistics on the size of the market. Repo is integral to intermediation by dealer banks because when assets are purchased for sale later the assets are financed by repo. Repos are essentially secured loans, so counterparty risk is usually not an issue. According to Timothy Geithner (2008), tripartite

repo was $2.5 trillion in 2007.[4] Tripartite repo is estimated to be about 15 – 20 percent of the repo market[5], making the total market about $12 trillion (including repo and reverse repo), compared to total assets in the U.S. banking system of $10 trillion (see Geithner 2008).

Figure 3 shows the ABX 2006-01 BBB basis from inception through January 1, 2008, the last day for which any prices of subprime RMBS bonds are observed by the dealer bank. The



basis explodes at the end of July 2007, which reflects a number of factors. First, financing in the repo market became very expensive and disappears for some asset classes, like subprime bonds. Second, the plummeting ABX prices revealed the decline in value of subprime bonds, leading to massive demands for hedging, reflected in the low ABX prices and high spreads. Figure 2 provides a glimpse of the liquidity crisis, which was coincident with the fall in house prices and

[4] In tripartite repo a custodian bank or clearing organization acts as an intermediary between the two repo parties. There is no data that I know of that quantifies the amount of bilateral repo.
[5] Private communication from a repo trader.

ABX prices. ABX spreads widened much more than cash spreads. And this explosive behavior of the basis is consistent with perceived changes in the repo market in the summer of 2007, particularly in August 2007.

Table 1 shows the repo market haircuts for different collateral at different points in time. Of particular relevance are the first two columns of the table. The implications of this are very dramatic. Imagine a firm that is levered 30:1, by borrowing in the repo market. If the haircut doubles, or goes from zero to a positive amount, the required deleveraging is massive! Most investment banks were levered 30:1, equivalent to about a 3 percent haircut. If the haircut rises to 6 percent, at least half the assets will have to be sold.

Another sign of trouble is a "repo fail." A "repo fail" occurs when one side of the agreement fails to abide by the contract.[6] Table 2 shows repo fails by primary government security dealers, greatly exceeding previous episodes of stress in the repo market.

Table 2: Repo Fails by Primary U.S. Government Security Dealers
(For the week ended October 1, 2008; $ billions)

Type of Security	Fails to Receive	Fails to Deliver
U.S. Treasury Securities	$2,498	$2,292
Federal Agency and Government-sponsored Enterprise Securities	$100	$87
Mortgage-backed Securities	$39	$37
Corporate Securities	$25	$41

Source: Government Securities Dealer Statistics Unit, Federal Reserve Bank of New York

What happened in the repo market? Dealer banks would not accept collateral because they rightly believed that if they had to seize the collateral, should the counterparty fail, then there would be no market in which to sell it. This was due to the absence of buyers because of the deleveraging. This led to an absence of prices for these securities. If that value cannot be

[6] This event is not considered a contractual default in the repo market. See Michael Fleming and Kenneth Garbade (2005).

Table 1: Repurchase Agreement (Repo) Market Haircuts during the Crisis*

Asset Class**	July '07 Pre-Crisis	Late July-August	Q3 2007	Q4 2007	Q1 2008	Q2 2008	Q2--> Current*
Corporates A-AA rated	0%	0%	0%	0%	0%	0%	0%
Corporates BBB rated	0%	0%	0%	0%	0%	0-5%	0-5%
Corporates < BBB-rated	0%	0%	0%	0%	0%	0-5%	0-5%
ABS AA-AA *	0%	2-5%	3-7%	5-10%	10-15%	15-20%	20-25%
ABS BBB-AA	0%	3-7%	5-10%	10-15%	15-20%	20-25%	20-30%+
ABS < BBB	0-2%	5-10%	10-15%	15-20%	20-25%	No financing	No financing
CLO, Other AA-AAA	0%	2-5%	3-7%	5-10%	10-15%	15-20%	15-25%
CLO, Other BBB-AA	0%	3-7%	5-10%	10-15%	15-20%	20-25%	20-30%
CLO, Other < BBB	0-2%	5-10%	10-15%	15-20%	20-25%	No financing	No financing
CMO, Other AA-AAA	0%	3-7%	4-8%	5-10%+	15-20%	20-25%	20-30%+
CMO, Other BBB-AA	0%	5-10%	5-10%+	15-20%	20-25%	20-25%	No financing
CMO, Other < BBB	0-2%	5-10%	10-20%	20-25%	No financing	No financing	No financing
CDO AA-AAA	0%	3-7%	5-10%	10-20%	15-20%	15-20%	15-20%
CDO BBB-AA	0%	5-10%	10-15%	15-25%	20-30%	25-30%	No financing
CDO < BBB	0-2%	10%+	15-20%	25-30%	No financing	No financing	No financing

Source: Repo trader.

* As of September 15, 2008.

Notes: Haircut ranges are for average terms of 1-3 months for inter-dealer or investment-grade major market participants. All haircuts are approximations and vary by specific counterparty. Distressed inter-dealer names are subject to higher initial haircuts or cannot access financing. Asset classes listed as “No financing” are not repo-able.

**ABS = asset-backed securities; CLO = collateralized loan obligation; CMO = collateralized mortgage obligation; CDO = collateralized debt obligation.

determined, because there is no market – no liquidity – or there is the concern that if the asset is seized by the lender, it will not be saleable at all, then the lender will not engage in repo. Repo traders report that there was uncertainty about whether to believe the ratings on these structured products, and in a very fast moving environment, the response was to pull back from accepting anything structured. If no one would accept structured products for repo, then these bonds could not be traded – and then no one would want to accept them in repo transactions.

IV. Conclusion

The decline in the ABX prices revealed the shock to the valuation of subprime risk, but it did not reveal where these risks resided. That uncertainty caused a loss of confidence in credit. This can be seen in the breakdown in the arbitrage foundation of the ABX.HE indices during the panic. The explosive behavior of the basis shows that the concern about the location of the risks led to fear of counterparty default, especially in the repo markets, where defaults would lead to delivery of bonds that could not be sold. These problems in the repo market are very significant because the repurchase agreement market in the U.S. is estimated to be $12 trillion, larger than the total assets in the U.S. banking system. This market is central to the "shadow banking system," the nexus of structured vehicles that issues bonds into the capital markets (see Gorton 2008). This short-term financing market became very illiquid during the crisis and an increase in repo haircuts (the initial margin) caused massive deleveraging. If no one would accept structured products for repo, then these bonds could not be traded – and then no one would want to accept them in a repo transaction. This externality is reminiscent of Marco Pagano (1989). The extreme stress in the repo market can even be seen in the repo market for U.S. government securities, where the instances of "repo fails" where borrowed securities have not been returned on time have reached a record.

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