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THE INFORMATION VIEW OF FINANCIAL CRISES

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ABSTRACT

Short-term debt that can serve as a medium of exchange is designed to be information insensitive. No one should be tempted to acquire private information to gain an informational advantage in trading that could destabilize the value of the debt. Short-term debt minimizes the incentive to acquire information among all securities of equal value backed by the same underlying asset. These features align with observed practice in money markets (markets for short-term debt). They are also consistent with financial crises occurring periodically. In the information view adopted here, financial crisis can occur when the collateral backing the short-term debt is thought to have lost enough value to raise doubts among the traders that some may acquire private information. The purpose of this paper is to review some of the burgeoning empirical literature that bears on the information view sketched above. We focus on evidence related to three key implications of information insensitive debt: (i) adjustments to external shocks will occur along non-price dimensions (less debt issued, higher haircuts, added collateral, etc);(ii) in a crisis some of the short-term debt turns information sensitive; (iii) money markets feature low transparency as well as purposeful opacity.

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Every banker knows that if he has to *prove* that he is worthy of credit . . . in fact his credit is gone.

Walter Bagehot

1. Introduction

A security is said to be *information sensitive* if the benefit of producing costly private information about a security's payoff outweighs the cost; otherwise the security is information-insensitive. Some securities are specifically designed to be information-insensitive, in particular short-term bank debt. Why are cash flows tranching to achieve this property? What are the implications of this? And, what is the evidence for this? In this paper, we investigate the research on these issues.

The reason for issuing information-insensitive debt was articulated by Gorton and Pennacchi (1990) who argued that such securities are desired by uninformed agents for transactions where they may face privately-informed traders to whom they lose money in transactions. Dang, Gorton, and Holmström (2015) (DGH) introduced the concept of information-sensitivity and used it to show that debt is least information-sensitive and that the optimal collateral for backing that debt is itself debt. In their two-period trading model, debt-on-debt is the optimal contract. Such debt maximizes the amount of trade that an uninformed agent can conduct without fearing that the counter-party collects private information. In fact, all money-like instruments are debt-on-debt. In the U.S. free banknotes were backed by state bonds, U.S. national banknotes were backed by government bonds, demand deposits are backed by the loan portfolio of the bank, repo is backed by a debt collateral, a mortgage-backed security is backed by mortgage debt, and so on. Thus, the rationale for tranching cash flows is to create an information-insensitive debt contract.

In the DGH model a financial crisis is an information event. When there is adverse news about the fundamental value of the collateral that backs short-term debt, the price or fair value of the debt declines. More importantly, the information-sensitivity of the short-term debt increases. So information-insensitive debt could become information-sensitive, because sophisticated investors have an incentive to acquire private information (if they can). To maintain information-insensitivity in money markets, less debt can be issued (in the case of a repo, the haircut can be increased), the maturity can be shortened or collateral can be added. Sometimes these measures are insufficient. A bank run may occur if information-insensitivity cannot be maintained. In that case, no one wants the debt for fear of adverse selection. Such an event is a *financial crisis*. Indeed, financial crises are precisely events in which this regime-switch happens: information-insensitive debt becomes information-sensitive. This switch is a "loss of confidence". The crisis occurs because there is no price discovery market to fall back on. Instead quantities have to adjust. In the recent crisis for example, the asset-backed commercial paper market dried up: quantities went to zero; see Covitz, Liang, and Suarez (2013). And haircuts on some categories of collateral backing repo went to 100%, i.e. no lending. See Gorton and Metrick (2012).

But, why is information-insensitive debt produced if it is vulnerable to a systemic bank run? As alluded to above, agents need a way to efficiently transact and that requires using a security that is always valued and trades against cash one-to-one. This was not always the case. For example, in the U.S. during the pre-Civil War period when private bank notes were used to transact. Bank note discounts (the haircuts from

par) varied over time and over geography. Transacting with such claims was difficult because of uncertainty about the accuracy of the discounts. Attempting to produce information-insensitive private money has occupied humans for centuries (see Gorton (2017)).

The defining characteristics of money markets are polar opposites to those of stock markets. Stock markets are secondary markets, with all trade occurring on organized exchanges involving a lot of information production by analysts. By contrast, money markets are primary markets with most of the trade over-the-counter with little information produced. See Holmström (2015).

We will focus on empirical research that bears on three of the defining characteristics of money markets as a system: information-insensitivity; nonprice adjustment; and the deleterious effects of transparency.

Empirical researchers have drawn implications beyond DGH to motivate empirical work consistent with broad characterizations of securities by their degree of information-sensitivity. For example, some studies show that sophisticated investors (institutions) and unsophisticated investors behaved differently in crises in terms of information production. And there are cases where holders of short-term debt have distinguished between banks during a crisis, not rolling over the debt of some banks but rolling over the debt of other banks. DGH is about primary short-term debt markets, but researchers have analyzed the secondary markets for corporate and municipal bonds in terms of information-sensitivity. Other studies show how debt responds when its information environment changes either due to the introduction of credit default swaps or by regulation. We review the most important of these studies.

In Section 2 we discuss the historical basis for producing information-insensitive debt and its theoretical rationale. In Section 3 we discuss the empirical work about quantity adjustment, information production, and the switch from information-insensitive to information-sensitive debt. The empirical work on corporate and municipal bonds is the focus of Section 4. Section 5 concludes with a brief discussion of policy issues.

2. Private Information Production, Opacity, and Liquidity

In this section we briefly review historical problems with a privately-produced medium of exchange that is not information-insensitive. Then we turn to a short summary of the theory and the implications of the theory for notions of “liquidity”.

A. Private Money in Pre-Civil War America

The problem for uninformed agents is most easily seen in the U.S. pre-Civil War era (i.e., prior to 1863) when banks issued their own private currencies.¹ Hundreds of these currencies circulated at discounts from par in transactions some distance from the issuing bank. These monies were information-sensitive. For example, Figure 1 shows the discounts from par (the haircuts) on Bank of Virginia bank notes when used in transactions in Philadelphia. The y-axis is the discount from par or haircut, as a percentage of face value. A discount or haircut is designed to recover information-insensitivity in the face of some

¹ Private bank notes were issued by banks in many countries. Schuler (1992) finds sixty cases of such free banking in history.

information that has arrived or that might arrive from some distance away. These discounts (or prices) were quite volatile. But, these discounts were efficient in the Fama sense. The discounts reflected the various risk factors of individual U.S. states, e.g., whether branch banking was allowed in the state, whether state insurance schemes existed, the type of bank charter, etc. So, bank note systems were not characterized by chaotic wildcat banking and over-issuance problems that have often been alleged (e.g., see Friedman (1959)). See Gorton (1996, 1999).

Nevertheless, while note markets were “efficient”, bank notes were not *economically* efficient. Questions about the value of a note proffered in a transaction regularly occurred. There were disputes and court cases over the value of particular notes. It was simply hard and costly to actually transact (and write contracts) using bank notes. For example, Sumner (1896):

It is difficult for the modern student to realize that there were hundreds of banks whose notes circulated in any given community. The bank-notes were bits of paper recognizable as a species by shape, color, size and engraved work. Any piece of paper which had these came with the prestige of money; the only thing in the shape of money to which the people were accustomed. The person to whom one of them was offered, if unskilled in trade and banking, had little choice but to take it. A merchant turned to his [bank note] ‘detector’ [a newspaper]. He scrutinized the worn and dirty scrap for two or three minutes, regarding it was more probably ‘good’ if it were worn and dirty than if it was clean, because those features were proof of long and successful circulation. He turned it up to the light and looked through it, because it was the custom of the banks to file the notes on slender pins which made holes through them. If there were many such holes the note had been often in bank and its genuineness was ratified. All the delay and trouble of these operations were so much deduction from the character of the notes as current cash. (p. 455)

The phrase “if unskilled in trade and banking”, refers to uninformed traders who “had little choice but to take it”. This problem had been recognized by Ricardo (1876), for example:

In the use of money, everyone is a trader; those whose habits and pursuits are little suited to explore the mechanism of trade are obliged to make use of money, and are no way qualified to ascertain the solidity of different banks whose paper is in circulation; accordingly we find that men living on limited incomes, women, laborers, and mechanics of all descriptions, are often severe sufferers by the failure of country banks . . . (p. 409)

And the uninformed traders lost money. McCulloch (1879): “The losses that the people sustained . . . could be counted by millions. The losses to which they were subjected in traveling from State to State and in making exchanges were greater still. The State bank system was a system under which bank-note brokers [informed traders] were enriched, and the people [uninformed traders] defrauded” (p. 972).

Private bank notes did not trade one-to-one for cash, making transactions costly. And the exchange ratio varied. The resulting problems motivated the search for a more efficient form of debt, which at that time was the development of demand deposits and in the U.S. government entry into money provision.

B. Theory

In this subsection we summarize the main results of DGH, explaining information-insensitivity and crises. Subsequently, we will articulate some of the implications and extensions of DGH that other researchers have proposed to do empirical research.

Suppose an agent is considering trading for a security offered at price p (perhaps the agent is selling goods or services, for example). The payoff of the security is $s(x)$, where x is a random variable with density $f(x)$ and $E(s(x))$ is its expected value. The agent offered the security can produce private information about the exact realization x at a cost γ . What is the value of producing private information? Is it worth paying the cost?

If $p < E(s(x))$, the security is viewed as being undervalued. If the agent were to produce information and learn x , then he would not buy the security in states where $s(x) < p$ because he would realize a loss of $p - s(x)$. Integrating over all x where $s(x) < p$ gives the expected loss of the buyer in low payoff states. We define $\pi_L(\cdot) = \int \max[p - s(x), 0] f(x) dx$ as the information-sensitivity of a security in the loss region. If $p > E(s(x))$, then the security is viewed by a potential buyer as over-valued. The agent would not buy the security unless he produced information. In this case, the buyer makes a profit if he produces information and finds that $s(x) > p$. We define the information-sensitivity in this case as $\pi_R(\cdot) = \int \max[s(x) - p, 0] f(x) dx$ which measures the expected profit of a security in high payoff states. I.e., the loss if the transaction is foregone. See Figure 2 for an illustration showing π_L and π_R . The two measures are identical if $p = E[s(x)]$. DGH show that the value of information is $\pi = \min[\pi_L, \pi_R]$ for any price p , any distribution $F(x)$ and irrespective of whether the trader is a buyer or seller.

Faced with a price, the counterparty compares the value of information, π , with the cost of producing the information, γ . If $\pi > \gamma$, then it is profitable to produce information. Evidently, there are two ways to make a security information-insensitive: lower the value of information, π , and raise the cost of producing information, γ . We say that a security is *information-insensitive* if no agent finds it profitable to produce private information about the payoffs to the security and all agents know that this is the case. The cost of producing the private information is greater than the expected value of the information. In this sense, the security is viewed as “safe”.

Figure 3 provides some intuition for information-insensitivity. The figure shows the contractual payoff on a debt contract, the usual hockey stick-like profile. The height of the flat portion is the face value or principal amount of the contract. The 45-degree line starting at the kink corresponds to the debt holder obtaining all of the payoffs of the project if the borrower cannot repay the principal amount (bankruptcy). The x-axis shows the value of whatever collateral is backing the contract, e.g., a loan or bond portfolio, a specific bond, payoffs from a project. Note the black curved line. This is the Black-Scholes value of the bond. Note that this value detaches from the flat part before the kink, indicating when the bond may be information-sensitive. Still, if the cost of producing information is high enough, no agent will produce information. In general, if the cost of information production is nontrivial, and if counterparties (rationally) share the view that the collateral value is far enough to the right, then the value of information production

will be such that the debt will be information-insensitive. The empirical evidence for this is discussed in the next section.

DGH show that, among all securities, debt is least information-sensitive. It has the lowest π . There is no need for an agent to turn the bank note “up to the light and [look] through it”. In other words, trade is most efficiently conducted when agents do *not* collect information, and when each agent knows that other agents have the same belief in which case there is no adverse selection and no fear of adverse selection. “Liquidity” provision is precisely the ability to trade without fear of endogenous adverse selection, that is, when no information is produced.

In contrast, Townsend (1979) argues that the purpose of debt is to force firms to release cash to lenders. Lenders only produce information about a borrower’s project payoff if the borrower defaults. Then the lender pays a cost to learn the true “state” of the firm. The lender does not care about the state of the firm if the debt is repaid. In this case, it would be desirable for the cost of producing information to be as low as possible. In contrast, information-insensitive securities are designed so that the cost of producing information is high. In fact, a cost of infinity would be best.

How can the Information-insensitivity of debt be maximized? DGH show that, among all securities, the debt should be backed by debt as collateral: debt-on-debt, maximizes information-insensitivity. The intuition is straightforward. If debt itself is least information-sensitive, then backing it by debt makes it even more so. In fact, this is what we observe. Short-term debt is always backed by debt. Demand deposits are backed by bank loans; repo is backed by a specific bond; asset-backed commercial paper is backed by asset-backed securities, and so on. Debt-on-debt is quintessentially banking. Further, Dang, Gorton, Holmström and Ordoñez (2017) argue that banks keep the nature of their loans secret to make it hard to produce information about the bank.

Debt-on-debt is the best structure for making short-term debt information-insensitive. In other words, for creating an instrument with a price that does not change. But, when there is adverse news about the fundamental value of the debt collateral that backs the tradable debt, the price or fair value of that debt declines. Although price declines, the information-sensitivity of the tradable debt increases. So some sophisticated investors have an incentive to privately learn more about the payoff and the value of debt. This creates a fear of adverse selection. Formally, the price or fair value of debt is $p=V=\int \min[x,D]dF(x)$ where D is the face value of debt and $F(x)$ the distribution of the collateral x . The information-sensitivity is $\pi_l(\cdot)=\int \max\{p-\min[x,D],0\}dF(x)$. When public information about $F(x)$ arrives, this changes the value and price of debt as well as the information-sensitivity of debt. Even though a change in $F(x)$ leads to a decline in p (i.e. the area π_l in Figure 2 becomes smaller) this can increase the information-sensitivity because there is more probability mass in the lower tail.

When there is adverse news about the fundamental value of the debt collateral that backs the tradable debt, suddenly there may be no market for the collateral; it is viewed as a lemons market.² Although no one has invested in the technology for understanding how to value the collateral, e.g., subprime

² The existence of “prices” does not mean there is a market. During the Financial Crisis, “prices” were quoted, but there was no (or little) trade at such prices.

mortgage-backed securities, still agents are not sure that there are not privately informed agents. Hanson and Sunderam (2013) and Pagano and Volpin (2012) discuss why collateral is produced to be information-insensitive in the primary market, but then has implications for the secondary market if bad news arrives.

In standard finance theory interest rates vary with default risks. A haircut as a response to a change in default risks constitutes a kind of puzzle from the standard finance view. Why not just raise the interest rate? Consider a loan with size L that is collateralized by an asset x where x pays off either 0 with probability q and $x > 0$ with probability $1 - q$. In the low state the loan defaults. The lender breaks even if the repayment D is such that $(1 - q) * D = L$ or $D = L / (1 - q)$. So the breakeven interest rate is $r = D / L - 1$. If default risk q increases the interest r increases. This is the standard theory. Why would a lender demand a haircut when default risk increases? The information sensitivity (or expected loss) of the loan is $\pi_L = q * L$. If default risk q increases the information-sensitivity of a loan increases. Suppose sophisticated loan investors have information costs γ . When default risks increases such that the threshold $\pi_L = \gamma$ is exceeded, there is a regime switch and the only way to recreate information-insensitivity of a loan is to reduce the loan size L such that $L = \gamma / q$. The higher the default risk the smaller the loan. But, no one is sure that default risk has increased and agents might, if they can, produce private information about this. Rather than increasing the interest rate investors reduce the quantity of trade to recover information-insensitivity. The risk is that the debt becomes information-sensitive, in which case most agents may not know the true default risk. DGH show that information-sensitivity is not rank-correlated with variance and skewness of a security. A security with low variance can have higher information-sensitivity than a security with higher variance.

C. Theoretical Implications and Qualitative Evidence

DGH is about primary markets for short-term debt, debt that is typically overnight or a few days. Because of the short maturity it is possible to change the terms of the contract quickly. Agents, in the face of bad public news (e.g., house prices are declining) correlated with collateral value, can try to maintain the information-insensitivity of debt. There are five ways to do this: (1) reduce quantity and lower the face value of the debt; (2) add collateral; (3) reduce the riskiness of the collateral; (4) increase the haircut; (5) shorten the maturity. Figure 4, for example, shows the increase in haircuts on an equal-weighted index of haircuts and ten structured products, e.g., mortgage- and asset-backed securities that were used as collateral for repo. Maturities also decreased. Figure 5 shows the dramatic shortening of dealer banks' positions after the Lehman failure. Similarly, Figure 6, from Gorton, Metrick and Xie (2015), plots the LIBOR minus the overnight index swap (OIS) three month spread and the short/long issuance ratio for AA asset-backed commercial paper. The ratio is defined as the ratio of the amount of CP issued with a maturity of less than 20 days (over a 30 day window) divided by the amount of CP issued with a maturity of 20 days or greater (over a 30 day window). The LIBOR minus OIS is a measure of bank counterparty risk. The figure shows that as this measure rises, maturities of CP shortened.

If there is a crisis, quantities adjust to zero: no one wants the short-term bank debt; they want cash. Such a switch is a financial crisis. Such a switch has historically occurred with many different forms of short-term debt: bank notes, demand deposits, sale and repurchase agreements, various forms of commercial paper, certificates of deposit, and money market funds. In each case the switch occurs when the value of

the underlying collateral is questioned. See Gorton (2018). Figure 7 shows the outstanding amounts of asset-backed commercial paper (ABCP) and financial firms' commercial paper. ABCP declined from \$1.2 trillion to about \$420 billion in a short period of time. See also Covitz, Liang, and Suarez (2013).

To prevent a switch from an information-insensitive to an information-sensitive state quantities adjust as with haircuts on the backing collateral rising, in the case of repo. Sometimes there is information-production which leads to "dry-ups" when some banks cannot get funding but others can. On occasion the information acquisition is done by sophisticated investors, leaving the unsophisticated behind. Sometimes maturity is shortened to try to maintain information-insensitivity. A financial crisis occurs when short-term debt becomes information-sensitive and quantities go to zero as in the recent financial crisis. Bilateral repo essentially went to zero. See Gorton and Metrick (2012).

The Federal Reserve's response to the crisis is also instructive and provides further evidence. Rather than implement transparency, the Fed did the opposite. Emergency lending programs were put into place, and these programs were designed to make loans in secret, protecting the anonymity of borrowers in order to avoid identifying weak banks, which might then face runs. Borrowers become stigmatized if their name is revealed. Also, in an attempt to prevent revelation of weak financial institutions, the SEC instituted short-sale bans on the stock of 797 financial firms starting on September 18, 2008.

The idea of *reducing* information in a financial crisis has a long history. In the U.S. prior to the existence of the Federal Reserve Bank, private bank clearinghouses responded by financial crises cutting off information. Member banks were prohibited by the private bank clearinghouse from publishing their financial information in the papers, which in normal times they were required to do. The clearinghouse operated an internal discount window, but the identities of borrowing banks was kept secret. See Gorton and Tallman (2018). The response of private bank clearinghouses and central banks to crises has been to make markets in the collateral for which there is no market and this involves *reducing* transparency in order to go back to a system of information-insensitivity. Reducing transparency is a way to try to recreate opacity so that short-term debt can maintain information-insensitivity. See Gorton and Ordoñez (2019). Following the U.S. bank holiday declared by President Roosevelt in 1933, New York state bank regulators suspended publication of state banks' balance sheets, but national bank regulators did not. Anderson and Copeland (2019) compare the different responses to these two policies and show that state banks had deposit increases not withdrawals.

In non-crisis times, in order to prevent information production about their assets, banks are opaque.³ See Dang, Gorton, Holmström, and Ordoñez (2017). Deposit insurance makes the backing collateral for demand deposits the government's taxing power; it will not be profitable for depositors to produce information. Still today even with deposit insurance banks are opaque. Badertscher, Burke and Easton (2018) examine the stock price reactions to the quarterly release of the bank *Call Reports*, which contain information that banks have self-reported to the regulators. They find significant and large stock price reactions of banks upon release of the information, even if the *Call Reports* are released following the

³ In the U.S. bank note discounts revealed information. But, when private bank notes were replaced by National Bank notes and demand deposits, banks endogenously became opaque. See Gorton (2015). Later, deposit insurance makes demand deposits info-insensitive.

quarterly bank earnings announcements. Mean price volatility and volume are also elevated on release dates.

Bank examiners also produce information, which is kept confidential. DeYoung et al. (2001) find that this information is informative and is eventually revealed in bank subordinated debt prices. Also, see Berger and Davies (1998).

D. Summary

Money market instruments are opaque by design. Debt backed by debt collateral is the optimal design to make the short-term debt information-insensitive. There is no price discovery, no costly information gathering about payoffs, and everyone knows this. Consequently, their price does not change. In fact, raising the interest rate does not compensate for the risk of the instrument becoming information-sensitive. That is a different risk than default risk.

The fact that the price of a money market instrument is not supposed to change means that the margin for adjustment is quantities (and maturity). A financial crisis occurs when information-insensitive debt becomes information-sensitive. Questions are asked about the backing collateral. And, since no one knows how to price the information-sensitive collateral, there are no prices.

A main message of DGH is that money markets are fundamentally different from equity markets. Money market instruments are information-insensitive. There is only a primary market for such instruments. Equity is information-sensitive and trades in a secondary market. And, these differences explain much about the infrastructure surrounding these two categories of assets. Table 1 lists the characteristics for information-insensitive money market securities and information-sensitive equity securities. Looking down one of the columns, one can see that the characteristics of each system are consistent. But, looking across the rows it is apparent that the two systems are polar opposites.

3. Empirical Evidence

In this section we review some of the more important papers that provide evidence about information-sensitivity, nonprice adjustments when bad public news arrives, and the harmful effects of transparency in a variety of contexts.

A. The Switch from Information-Insensitive to Information-Sensitive and Information Production

New public information about the fundamental value of collateral can change the information-sensitivity of securities. The transition from information-insensitive to information-sensitive can result in information being produced and informed investors acting on their private information. Gallagher, Schimdt, Timmermann, and Wermers (2018) and Brancati and Macchiavelli (2019) provide empirical evidence for this view.

One setting where information was produced at the start of a crisis is money market funds at the onset and during of the Eurozone crisis, 2011-2012. Money market fund (MMF) shares are a form of short-term quasi-debt that is it is treated as information-insensitive debt by fund shareholders although technically

it is not debt. During non-crisis times these instruments are essentially priced at par; they are information-insensitive. Gallagher, Schmidt, Timmermann, and Wermers (2018) (GSTW) study investor information production, MMF redemptions, and MMF managers' rebalancing decisions during the Eurozone crisis. They find that there was significant selective information acquisition and, although there were redemptions at all funds, the reductions were largest for funds with the most sophisticated investors, who did produce information. "Under these circumstances, MMF shares become information-sensitive because MMF's risk exposures are suddenly differentiated following the acquisition of information" (p. 1).

At the start of the Eurozone crisis, bad news about the exposures of European banks to a potential default of some European debt came out. Not all agents have the same cost of producing information. Thus, more sophisticated investors (institutions) produced information and made redemptions at the money market funds that had higher exposure to information-sensitive European bond issuers. As a result, money managers adjusted their portfolios to "avoid information-sensitive European risks" (abstract) that is to keep their funds information-insensitive.

Using proprietary data from the Investment Company Institute GSTW create the variable "SOPH" (for sophisticated investors). SOPH is the fraction of a fund which is held by institutional investors. From this measure three categories of sophistication are created: HiSOPH, which is 82 percent institutions, and the remaining funds are split into MidSOPH, and LoSOPH.

GSTW measure information production by the number of page views the different categories of investors conducted with regard to fund filings on the Security and Exchange Commission's EDGAR website. Figure 8 shows the results for the three categories of investors: HiSOPH, MidSOPH, and LoSOPH. Note that the axis for low and mid-sophistication groups is different from that for HiSOPH. The figure shows the dramatic increase in visits to the SEC website around the start of the Eurozone crisis. "Our measure of investor information acquisition from the SEC EDGAR website . . . points to little information prior to June 2011, followed by a substantial increase in information acquisition during the crisis. This increase occurred almost exclusively among funds with a high concentration of sophisticated investors" (p. 3).

Importantly, there is no price discovery with MMFs. The sophisticated investors produce information, but this is not observed by the less sophisticated who remain uninformed. The sophisticated withdraw from the MMFs, but this is unobserved by the other investors. The uninformed did not withdraw.

The sophisticated investors act on their information. Funds with relatively more sophisticated investors experienced relatively higher outflows about 10 percent of aggregate assets from early June to early July 2011. GSTW also show that the selective information acquisition by sophisticated investors led to responses by the fund managers, who attempted to recover information-insensitivity by rebalancing their portfolios. Fund managers sold securities that had become particularly information-sensitive, uncollateralized debt from French/Belgian financial issuers like BNP Paribas or Dexia, for example. Further, fund managers shortened maturities dramatically.

According to DGH, a financial crisis is a shift from information-insensitive to information-sensitive short-term debt. Brancati and Macchiavelli (2019) (BM) examine the Panic of 2007-2008 and ". . . provide direct

evidence that while in good times bank debt is largely informationally insensitive, it becomes significantly sensitive to information in bad times” (p. 2). BM essentially show that in non-crisis times, when the economy is to the right of the kink in Figure 3, there is no information produced. But, to the near the kink or to the left of the kink information is produced.

BM have two main results. First, they find that precise information amplifies the sensitivity of default risk to market expectations: pessimistic expectations have a larger effect on default risk (measured by CDS spreads) the more precise information is. Precise information (measured by the dispersion of analysts’ forecasts) also has a direct and negative impact on default risk. Pre-crisis, these effects are not at work, suggesting that bank debt is informationally-insensitive in good times. Secondly, they find that more information is produced at the onset of the crisis. More analysts are assigned to cover banks and that the analysts produce significantly more precise information (measured by the standard deviation of bank ROA).

BM focus on banks’ credit default swap (CDS) spreads and the relations between median analysts’ forecasts of banks’ returns on assets (ROA) and the dispersion of those forecasts (DISP). A reduction in the standard deviation of analysts’ forecasts is interpreted as an increase in the precision of information. They interact the precision of the information with the ROA forecasts to see if more precise information has a larger impact on CDS spreads. This is deemed the “information multiplier”. In addition, they look at whether more precise information has a larger impact on banks that are expected to do poorly, those banks with a “bad” ROA forecast. Further, they examine this over the period January 2004-December 2012 to understand whether the effects on CDS spreads are amplified during the crisis.

Their benchmark specification is:

$$CDS_{i,t} = \rho CDS_{i,t-1} + \gamma_1 E_t(ROA_{i,t+1Y}) + \gamma_2 E_t(ROA_{i,t+1Y}) PRECISE_{i,t} + \gamma_3 E_t(ROA_{i,t+1Y}) IMPRECISE_{i,t} \\ + \gamma_4 DISP_{i,t} BAD_{i,t} + \gamma_5 DISP_{i,t} GOOD_{i,t} + \beta^T x_{i,t-1} + \eta_i + \lambda_t + \varepsilon_{i,t}$$

where $PRECISE_{i,t}$ is an indicator function specifying when information is “precise”, which means that the standard deviation of analysts’ individual forecasts about bank i at time t is below the median of its cross-sectional distribution. $IMPRECISE_{i,t}$ is the complement of $PRECISE_{i,t}$. $DISP_{i,t}$ is the standard deviation of analysts’ forecasts formed at time t about the one fiscal year ahead ROA (indicated by the subscript 1Y). $BAD_{i,t}$ is a dummy variable indication that expectations in month t about bank i are in the bottom quartile (or decile) of its monthly cross-section distribution. $GOOD_{i,t}$ is the complement of $BAD_{i,t}$. $x_{i,t-1}$ is a vector of controls. Finally, there are bank and time fixed effects.

The specification allows the authors to study whether more precise information amplifies the reaction of CDS spreads to expected future bank profitability during a crisis as compared to normal times. Is it the case that $|\gamma_2| > |\gamma_3|$? They find that in a crisis more precise information amplifies market expectations of default risk, and that more precise information increases default risk for banks that are expected to perform poorly. These effects are not present in non-crisis times.

BM also ask whether more information is produced at the onset of a crisis, to distinguish good banks from bad banks. They estimate a panel of banks where the dependent variables are the dispersion of analyst forecasts or the number of analysts assigned to cover each bank. At the onset of the crisis more analysts are assigned to cover banks and there is a significant decrease in the dispersion of analyst forecasts. That is more resources are devoted to information production and more information is produced.

B. Nonprice Adjustments

That quantity adjustments sometimes result in the quantity going to zero, rather than the price adjusting, is most easily seen in the recent financial crisis. As noted above, in Figure 6, asset-backed commercial paper and bilateral repo declined significantly. See Covitz, Liang, and Suarez (2013) and Gorton and Metrick (2012). But, other margins may also adjust. In this subsection we look at evidence consistent with this.

Pérignon, Thesmar, and Vuillemeys (PTV) (2018) study the wholesale CD market in Europe during 2008-2014. They argue that the switch from information-insensitive to information-sensitive debt should occur when there is the arrival of bad public news: “We show that ratings downgrades can be such public news; [CD] issuance drops significantly for issuers facing downgrades. Along the same lines, we also find that dry-ups typically occur after drops in stock prices” (p. 5). But, their basic finding is that there was not an all-out run. Rather information appears to have been produced and lenders discriminated between good and bad banks. “Importantly, the CD market did not experience any global freeze and dry-ups did not have a strong aggregate component. . . . We then show that banks experiencing [funding] dry-ups are those whose performance is set to decrease in the future, controlling for current performance” (p. 3).⁴

CD issuing banks attempted to maintain the information-insensitivity of their CDs. Issuers facing a dry-up decreased the maturity of new CD’s in the several months before the decline in their CD volume. PTV also show that there was not much of an increase in CD rates, differentiating the risk of different banks “ . . . suggesting that risk is not priced on a bank-by-bank basis” (p. 578). “These results are consistent with the idea that prices are not the main variable used to clear the CD market . . . ” (p. 578). The dry-ups experienced by some banks were due to sophisticated investors becoming informed and cutting lending to weak banks, i.e., adjusting the quantity. “Overall, these results . . . suggest that adjustments in the CD market occur primarily through quantities rather than prices . . . ” (p. 606).

If short-term bank debt is information insensitive, then the exchange rate of the debt with cash is one-to-one and, since the price of the bank debt does not change, the quantities adjust. This should be true in crises but also in normal times. Gorton (1988) examines a Baumol-Tobin money demand equation in which there is a cash-in-advance constraint. The cash-in-advance is a reduced form for Gorton and Pennacchi (1990). Gorton (1988) shows that the currency-deposit ratio is determined by an Euler equation, as in asset pricing, but in this case the stochastic discount factor interacts with the expected return on the debt. In standard asset pricing, the Euler equation is used to price assets, based on the intertemporal terms of

⁴ The authors define a “full dry-up” is a case where the bank’s CD issuance ceases. A “partial dry-up” is a case where issuance drop by 50 percent or more. Brancati and Macchiavelli (2018) show that funding dry-ups in the U.S. are preceded by maturity shortening.

trade (the stochastic discount factor). Asset prices change based on the stochastic discount factor. But when the prices of cash and bank debt are constant; the exchange rate is fixed at one-to-one. Asset prices do not change, so the Euler equation shows how the quantities change depending on the interaction of the stochastic discount factor and the expected return on the bank debt. The quantity adjustment fits naturally into the standard Euler equation framework when the price of privately-produced debt is information-insensitive.

Gorton (1988) examines the U.S. National Banking Era, 1863-1914, a period with five major banking panics. He estimates the money demand model described above and shows that the model not only describes quantity adjustments during normal times but also explains banking panics based on changing information. Empirically, in the Euler equation framework, when agents receive unexpected information about coming recessions, and this shock was above a threshold, there was a panic. There was never a panic without the information shock exceeding the threshold and the threshold was never exceeded without a panic occurring. This is consistent with DGH's model in which the switch from information-insensitive to information-sensitive occurs upon receipt of sufficiently bad news. Normal times and panic are described by the quantity adjustment model.

C. Transparency

Opacity is a desirable feature of money market instruments. The private bank notes that circulated as money during the pre-Civil War were not efficient forms of money because they were information-sensitive. In the modern era money market funds (MMFs) have been an efficient form of money because the implicit contract defining MMFs was that they would not "break-the-buck", but rather would maintain the one-to-one ratio of an MMF share and cash. This feature allowed MMFs to effectively compete with demand deposits. But, following the Lehman failure there was a run on MMFs. The surprising regulatory response to this was to eliminate MMF moneyiness.

In 2014 the U.S. Securities and Exchange Commission introduced money market fund (MMF) reforms. This resulted in outflows from prime MMFs exceeding \$1 trillion because these funds lost their moneyiness. They became information-sensitive. There were no effects on government MMFs. The share of government MMFs increased from 33 percent to 76 percent. The effects of these reforms have been studied by Baghai, Giannetti, and Jäger (2018) and Cipriani and La Spada (2018).

Baghai, Giannetti, and Jäger (BGJ) (2018) analyze the effects of the new post-crisis U.S. money market regulations on the moneyiness (information-insensitivity) of money market funds. In particular, under the new rules institutional money market funds (MMFs) must reveal their net asset value regularly. In other words, the new regulations sought to ensure transparency. These funds can no longer maintain their opacity. MMFs thus are no longer money-like. The authors show that (1) MMFs lose their money-like quality; and (2) since MMFs are no longer money-like, the MMF managers change their behavior, making their funds riskier so as to offer higher rates to maintain demand. This is in contrast to PTV and GSTV where managers take steps to undo the shock to maintain information-insensitivity.

To show that the moneyiness of these funds decreased, the authors show that assets under management were no longer correlated with proxies for money demand, e.g., no longer negatively correlated with the

four-week spread of Treasury bills over the overnight index swap rate. In this BGI follow Sunderam (2015) and estimate the following type of equation:

$$\ln(\text{Total net assets})_t = \alpha + \beta(T - \text{bill} - \text{OIS})_t + \varepsilon_t$$

The T-bill-OIS spread is a measure of money demand; it measures the convenience yield. T-bills are a riskless cash instrument while OIS is a riskless derivative. Sunderam focused on showing that more asset-backed commercial paper was issued pre-crisis when the convenience declined, i.e., with a greater demand for T-bills, its yield would fall relative to OIS. So the correlation is negative. With respect to MMFs, BGI show that following the announcement of the money market reforms the correlation became positive, suggesting that MMF's liabilities were no longer considered money-like. “. . . we find that the aggregate net assets under management of MMFs are no longer negatively associated with the spread of four-week Treasury bills over the four-week overnight indexed swap (OIS) rate, which is typically thought to be low when the demand for money-like securities is high” (p. 3). There was also an adjustment of quantity. Many prime MMFs exited the industry or changed into government MMFs, which are not affected by the change in regulation.

In general, investors in mutual funds are sensitive to performance, with inflow following good performance and vice versa. Post-reforms MMFs are no longer money-like and so they may then be concerned about this sensitivity of flows to performance, like information-sensitive mutual funds. Indeed, BGI find that post-reform the remaining MMFs increased the portion of their portfolio holding riskier assets. And, MMFs became more sensitive to their performance. And: “Importantly, the increase in flow-performance sensitivity is particularly pronounced for MMFs that sell predominantly to institutional investors” (p. 4).

Cipriani and La Spada (CL) (2018) also study the effects of the 2014 SEC money market reforms. CL compare the response of MMF investors' to the 2014 regulatory change with past episodes of industry dislocation, in particular the MMF run following Lehman's collapse in 2008. Also, the 2014 rules affected institutional investors and retail investors differently. Both of these types of funds were required to install liquidity fees and redemption gates, but only institutional funds were required to switch to a floating net asset valuation. These differences allow CL to examine an empirical design (differences-in-differences) that uses these differences.

CL examine the net yield spread between prime and government funds in a differences-in-differences design and estimate the premium for moneyness to be 20 basis points for retail investors and 28 basis points for institutional investors (who were affected more by the regulations). They also estimate that before the reform prime and government funds were close substitutes, but the reform caused the elasticity of substitution between the two types of funds to drop from 0.50 to 0.11. In words, post-reform the two types of funds were viewed as different. “This decrease confirms that, whereas before the regulation prime and government MMFs were perceived as very similar financial products, such similarity disappeared once shares in prime MMFs became information sensitive and therefore ceased to be perceived as money-like assets” (p. 3).

The DGH debt-on-debt structure also says that the collateral backing the short-term debt is also debt, and this debt should be information-insensitive. In the DGH model the backing collateral can be tranced so that the senior tranche is the collateral, which has the junior tranche as a buffer against losses. Because of the junior equity-like piece the short-term debt backed by the senior tranche can be information-sensitive. This is the logic of securitization. (For example, see Stenzel (2013).) Securitization grew because of a need for high quality debt that could be used as collateral. Prior to the financial crisis, the debt frequently used to back repo and asset-backed commercial paper was asset-backed securities (ABS) and mortgage-backed securities (MBS). ABS and MBS are bonds that are backed by portfolios of loans. ABS and MBS securities are designed to achieve both goals of low information-sensitivity and high costs of producing information.

Securitization illustrates that for the construction of information-insensitive debt, tranching is superior to slicing, i.e., a junior-senior structure is best. Securitization results in bonds with different ratings, all investment-grade. The residual tranche (equity) does not trade, so no information is revealed. The AAA/Aaa tranches of ABS/MBS were viewed as safe debt. Xie (2012) finds that, on average, 86.3% of an ABS/MBS deal was rated AAA.⁵ Although viewed as “safe”, during the financial crisis the quantities of ABS and MBS also changed, issuance dropped dramatically. This is shown in Figure 9, where again the quantities adjusted.

In the aftermath of the Panic of 2007 there were many calls for more transparency with regard to mortgage-backed securities. Such transparency could destroy the information-insensitivity of the AAA/Aaa tranches used as collateral. This was examined by Balakrishnan, Ertan, and Lee (2019) (BEL). BEL empirically analyze the European Central Bank’s Loan-level Disclosure program (ECB LLD), implemented in January 2013. The ECB LLD established specific information requirements for asset-backed and mortgage-backed securities that were accepted as collateral by the ECB. The rules require monthly or quarterly disclosures of specified details of the underlying loans that were securitized. BEL focus on mortgage-backed securities. The sample is 56,377 security-months based on 1,930 tranches from 12 European countries. The price data, from Bloomberg, consists of marks provided by dealer banks.

The goal of the ECD LLD initiative was to create “transparency”. However, BEL show that this public loan-by-loan disclosure resulted in *reduced* liquidity for senior tranches by 7.9 percent and *increased* liquidity for the information-sensitive risky tranches by 5.0 percent (super-senior tranches were not affected).⁶ That is, the information-insensitive senior tranches lost liquidity whereas the information-sensitive tranches became more liquid. This is consistent with the junior tranches being information-sensitive and the senior tranches, which were information-insensitive, became sensitive.

BEL also look at these liquidity effects across the dimension of investor sophistication. The ECB LLD disclosures provides data but still a level of sophistication is required to make use of these data. BEL measure the degree of sophistication by the standard deviation across the number of distinct MBS deals that an investor invested in, calculated pre-regulation. “. . . we find that enhanced disclosures do not

⁵ Gorton and Metrick (2013) provide a survey of the literature on securitization. Also, see Gorton and Souleles (2006).

⁶ Liquidity is the number of trading days without a trade divided by the total number of trading days in a month.

impair liquidity for MBSs of which investors are similar to one another in terms of skill and expertise in processing disclosed information (our empirical proxies for investor sophistication). In contrast, there is a 15.3% increase in illiquidity for cases with greater disparity in investor sophistication” (p. 5).

In summary, these regulatory responses to the financial crisis backfired.

D. Summary

These researchers have drawn implications of DGH and gone beyond. DGH says nothing about sophisticated and unsophisticated investors. Nor are there dry-ups in DGH. The empirical work is consistent with their implications.

4. Corporate and Municipal Bonds

DGH is about short-term debt, although the debt collateral backing that may be long-term debt such as AAA/Aaa ABS or MBS (or Treasuries). The short-term debt market is only a primary market because the maturities are short. Short-term debt can be restructured, e.g., a change in the haircut or maturity, easily if it is rolled over. Corporate bonds are longer maturity than money market instruments. Holders have no way to introduce a haircut or to shorten the maturity. The bond can be sold but there is no way to turn a bond into cash prior to maturity. Longer-term bonds trade over-the-counter but, in fact, rarely trade. Figure 10, for example, shows the percentage of the outstanding amount of U.S. corporate bonds that trade each year, less than fifty basis points per year.⁷ Also, see Mizrach (n.d.). Nevertheless all securities have the property of information-sensitivity. But, we do not expect corporate bonds to be fully information-insensitive except perhaps for those that are AAA/Aaa.

There are large quantity adjustments with bond issuance, however. While the bonds outstanding cannot change, issuance can shrink. Bond issuance shrank significantly during the panics of 1884, 1893, 1907 and the Great Depression.⁸ Similarly, during the Panic of 2007-2008 the issuance of securitization shrank significantly as seen above in Figure 9.

Researchers have investigated implications of information-sensitivity for corporate and municipal bonds, and in this section we summarize their work.

A. Corporate Bonds and Information-Sensitivity

Corporate debt does have some characteristics of information-insensitivity. For example, according to Best (2015), most new investment-grade bond issues are announced and sold the same day. “New-issue order books can close as soon as 15 minutes after the transaction announcement, while some may stay open for several hours. The average tends to be in the 1-2 hour range . . . ” (p. 9). There is little due-diligence: “From the time issues are announced (usually early to mid-morning New York time), investors

⁷ The data for dollar volume of U.S. corporate bonds traded starts in 2002 because in July 2002 the SEC mandated TRACE system (Trade Reporting and Compliance Engine) was initiated, requiring the mandatory reporting on over-the-counter secondary market trades in bonds. See <http://www.finra.org/industry/trace> .

⁸ See Benmelech and Bergman (2018b) and Benmelech, Frydman, and Papanikolaou (2016).

generally have a short period to analyze the issue, review covenant protections, and decide if they are comfortable participating at indicated price guidance” (p. 9).

Equity is different. Initial public offering underwriting books must be built over time and initial public offerings are underpriced. Rock (1986) studies a new issue equity market model in which there are some informed agents and some uninformed agents. If new shares are priced at the expected value (conditional on public information), then the informed agents will buy when the true value (based on their private information) is greater than the expected value and they will not buy if the true value is below the expected value. Rock (1986) shows that in order to ensure that the uninformed will participate the price of the shares must be set at a discount to entice the uninformed to participate. This discount or haircut creates an excess demand for the shares so that rationing occurs. As a result, weighting the returns by the probability of obtaining an allocation delivers a rate of return to the uninformed that is immune from adverse selection. But, when the stock is issued and is trading on an exchange, analysts follow the company and the price is “efficient”. Consequently, new seasoned equity offerings (offerings by firms that already have issued stock in the past) do not display any discount to the market price (see Loderer, Sheehan, and Kadlec (1991)).

Bond have ratings; equity is not rated. Bond ratings indicate distance from the kink. See Figure 3. But ratings are very coarse. They are certainly not fine enough to be useful for assessing risk. Coarse ratings result in buckets of equivalent collateral. Collateral rated AAA/Aaa for example. In this way beliefs are coordinated. Coarse ratings promote “commonality of beliefs,” in the language of Morris and Shin (2006) (MS). MS show that such commonality is desirable because it reduces problems of adverse selection.

Are corporate bonds information-insensitive or -sensitive? Kwan (1996) studies the correlations between individual firms’ changes in their bond’s yields and the firm’s own stock returns. Kwan estimates the following empirical specification:

$$\Delta Y_{jt} = \beta_0 + \beta_1 \Delta T_{jt} + \beta_2 R_{j,t+1} + \beta_3 R_{jt} + \beta_4 R_{j,t-1} + \varepsilon_{jt}$$

where ΔY_{jt} is the change in bond j ’s yield-to-maturity from $t-1$ to t ⁹; ΔT_{jt} is the change in a similar maturity U.S. Treasury bond yield from $t-1$ to t ; R_{jt} is the return on bond j ’s issuing firm’s stock from $t-1$ to t and so on; ε_{jt} is the error term. The specification includes a lag of stock returns and a future return, in addition to the current return. The β coefficients could be either positive or negative depending on the type of information about future stock returns, the mean or variance of the distribution of firm fundamentals. The key question is whether there is any relation between the change in bond yields and (future, current, or lagged) stock returns of the same firm’s equity? Is the change in bond yield purely driven by own firm news about fundamentals, captured its own stock returns, or by discounting, changing mostly when the term structure of Treasury returns changes?

If the information contained in stock returns is, on average, about changes in the mean of expected future cash flows, then “bad news”, i.e., low stock returns should be negatively correlated with the change in the firm’s own bond yields. Stock returns go down, so bond yields go up. Table 2 shows Kwan’s results by

⁹ Return data was not available because coupon dates for the bonds was not available.

rating category.¹⁰ We observe that AAA bond yield changes are driven by Treasury yield changes only. There is no relation with information in the firm's own stock returns. AAA bonds are information-insensitive. AA bonds are a bit less sensitive to Treasury yield changes, and a bit more sensitive to own-stock returns. A-rated and BBB-rated bonds follow suit, with the differences between bond ratings monotonic: less sensitive to Treasury yield changes as the rating drops and more sensitive to own stock returns as the rating drops. Finally, note that bonds below investment-grade are information-sensitive. The change in BB bond yields is not related to the change in Treasury yields. They are only correlated with own stock returns. Junk bonds are fundamentally different from investment-grade bonds; see Gorton and Metrick (2010). Junk bonds' fundamentals put their value near the kink, and in fact junk bonds typically trade on the NASDAQ stock exchange. Schaefer and Strebulaev (2008) show similar results.

So, corporate bonds appear to have degrees of information-sensitivity. But, they are information-insensitive enough to trade over-the-counter rather than on a centralized exchange. And, the evidence of information-insensitivity is more visible with respect to how they are priced once issued. The prices of corporate bonds and asset- and mortgage-backed securities are somewhat constant. Corporate bonds and structured bonds are "priced" for purposes of marking portfolios to market by "matrix pricing". That is, the price is an estimate or guess since these instruments do not trade very often. Typically this is done by tying the bond yield to a benchmark bond index by a spread in basis points determined by the dealer bank.¹¹ As a result, there is no single "price" of a bond.

Since bonds are infrequently traded over-the-counter, there is no price discovery—the "price" is not an aggregation of many agents' information and cannot be seen in any central place. So, how hard is it to "mark" them to market? Cici, Gibson, and Merrick (CGM) (2011) look at the dispersion of month-end valuations placed on identical bonds held by different bond mutual funds. The marks differ. This is not surprising since the prices to mark the bonds are supplied by dealers using different matrix prices. Table 3 reproduces some of the Cici, Gibson, and Merrick (2012) results. The table shows the interquartile range based on the price per \$100 face. So, for example, an interquartile range of 0.364 means, for example, that prices run between 96.00 and 96.364. The fact that debt instruments are traded over the counter, and that the price of any single bond can vary, is consistent with the idea that liquidity in those markets is based on information-insensitivity.

B. Information Production about Corporate Bonds

When is it profitable to produce information about corporate bonds? DGH predict that the closer the collateral value backing the debt is to the kink of the hockey stick, see Figure 3, the more valuable information becomes and the more information will be produced. This is, indeed, the case for corporate bonds. Johnston, Markov and Ramnath (JMR) (2009) study 5,920 debt reports produced by sell-side debt analysts from 15 brokerage firms that cover 822 companies. The sample period is 1999-2004. They find

¹⁰ The bond data are from Merrill Lynch. Weekly closing bid yields were calculated from the price of the last transaction.

¹¹ The Bloomberg Barclays U.S. Aggregate Bond Index is the leading example of such an index. Bonds in the index are weighted by the size of the issue. Most investment-grade bonds are included. The average maturity is around five years.

that “. . . the amount of resources devoted to debt research depends on the debt’s price sensitivity to information about the value of the asset. Intuitively, the sensitivity of the price of debt determines how much one can profit from information about the company’s assets in the debt market” (p. 92). In other words, the π that we discussed above. The number of debt analysts’ reports monotonically increases in the 120-day prior to a rating downgrade. They find no similar pattern with respect to imminent rating upgrades (moving away from the kink). Further, the authors report that “we do not observe any debt reports for most company-years” (p. 99). In contrast to the debt coverage, equity coverage *decreases* with a higher probability of firm default (p. 101), i.e., near the kink. As the firm value nears the kink, the debt is increasingly becoming the firm’s equity.

So far, the empirical evidence is consistent with corporate debt being information-insensitive to some degree. Is there evidence consistent with the JMR finding that more information is produced when a bond’s fundamentals deteriorate (as measured by ratings in the JMR case)? Whatever the degree of information-insensitivity, Benmelech and Bergman (BB) (2018a) examine corporate bonds and provide evidence on the relationship between information and liquidity. If the perceived value of the underlying fundamentals of debt is high so that it is agreed that the bond value is on the flat portion of the hockey stick to the right, it is information-insensitive. But, if the fundamentals backing the bond deteriorate, then the debt starts to near the kink and becomes (more) information-sensitive and less liquid. This is what BB (2018a) examine.

BB focus on corporate bonds that recently dropped in price, cases where the fundamentals have arguably deteriorated.¹² They show a negative and nonlinear relation between measures of illiquidity and bond price. The nonlinearity is the kink. When the price drops, the bond becomes less liquid. They measure liquidity with the three standard measures in the literature.¹³

Their basic estimation equation is:

$$Illiquidity_{i,t} = \alpha + \beta_1 \times Yieldspread_{i,t-1} + \beta_2 X_{i,t-1} + \theta_i + \delta_t + \varepsilon_{i,t}$$

where *Illiquidity* is one of the three liquidity measures; *Yieldspread*_{*i,t-1*} is the bond yield spread over a maturity-matched Treasury; *X*_{*i,t-1*} is a vector of bond characteristics such as size and time since issuance. There are also time and cross-sectional fixed effects. Instead of the yield spread, they also look at the bond price.

They find (their Table 3) that there is a positive association between illiquidity and yield spread. The economic impact is sizeable: a one standard deviation increase in the yield spread results in an increase between 57 percent and 79 percent of the unconditional mean of the illiquidity measure.

What about the nonlinearity due to the kink? BB form ten deciles of bond price to non-parametrically look for the kink. They estimate:

¹² Also, see Benmelech and Bergman (2018b).

¹³ Those are the three standard, widely-used, measures: Gamma (see Roll (1984) and Bao, Pan, and Wang (2012)); Amihud (2002); and the Implied Round-Trip Cost (see Bao, Chen, Hou and Lu (2015)).

$$Illiquidity_{i,t} = \beta_0 + \sum_{k=1}^{10} \beta_k x PriceDecile_{i,t-1}^k + \mathbf{b}_i \gamma + \mathbf{c}_t \delta + \epsilon_{i,t}$$

where *Illiquidity* is one of the three liquidity measures; *PriceDecile* is the set of ten indicator variables based on the with-in year deciles of bond price. There are also bond fixed effects and a vector of either year or year-end-by-month fixed effects. As before, they find the negative relation between price and illiquidity using all three measures of bond liquidity. They also find evidence of the predicted nonlinearity, most easily seen in their Figure 2. “The predicted nonlinear, hockey-stick relation between illiquidity and price is readily observable . . .” (p. 14).¹⁴ They conclude that “bond liquidity is determined by the informational-sensitivity structure of debt contracts” (p. 21).

BB also look at maturity. Longer maturity (privately-produced bonds should be less liquid, because there is greater uncertainty about the final payoff. BB examine this hypothesis by defining five equal-sized quintiles of bond maturity and then examining the following regression specification:

$$Illiquidity_{i,t} = \beta_0 + \sum_{k=1}^{10} \beta_k x MaturityQuintile_{i,t-1}^k + \mathbf{b}_i \gamma + \mathbf{c}_t \delta + \epsilon_{i,t}$$

The results do indicate that longer maturity bonds are more illiquid.

Although corporate bonds have varying degrees of information-sensitivity, as shown in the Kwan (1996) results, still whatever their information-sensitivity, BB show that such investment-grade bonds become more illiquid when their price goes down.

BB and other studies of corporate bond markets use price data from the TRACE system (the Trade Reporting and Compliance Engine (TRACE) system). TRACE was introduced on July 1, 2002 by the National Association of Securities Dealers (NASD). The system was designed so increase post-trade transparency for corporate bonds, because for the first time all NASD members were required for the first time to report prices, quantities, and other information for all secondary market transactions in corporate bonds.

What happened when TRACE was introduced? With respect to information-sensitivity, the short answer appears to be: not much. TRACE started with BBB-rated bonds. Goldstein, Hotchkiss and Sirri (GHS) (2007) studied the effects on BBB-rated bonds, because these are the most information-sensitive. GHS report that: “both regulators and market participants believed the market for the highest rated and very large issues, which are less information sensitive and also have more close substitutes, would not behave in the same manner as lower rated or smaller issues. . .” (238-39). Consistent with Kwan (1996), as shown in Table 2, BBB-rated bonds are the most information-sensitive of the investment-grade bonds (junk bonds are information-sensitive). Looking at the BBB-rated bonds, GHS found that “. . . depending on trade size, increased transparency has either a neutral or a positive effect on market liquidity, as measured by trading volume or estimated bid-ask spreads. Measures of trading activity, such as daily trading volume and

¹⁴ To address the causality issue Benmelech and Bergman (2018a) also use instrumental variables, and confirm the findings.

number of transactions per day, show no relative increase, indicating that increased transparency does not lead to greater trading interest in our sample period” (p. 237).

C. The Information-Sensitivity of Bonds when the Information Environment Changes

The introduction of the new derivative instrument credit default swaps (CDS) into the bond market changed the information environment of bonds. As explained by Gorton (2010), CDS allows traders to take very large positions long or short on the credit risk of specific firms, much larger than the par value of a firm’s outstanding bonds. For example, a firm may have a bond with a par value of \$100 outstanding, but a single trader can trade CDS with a notional amount of \$1,000 or more. This can make it much more profitable to produce private information because for a fixed cost of producing information a larger position can be taken. A small benefit to producing information can become profitable if a large amount can be traded. It is also empirically consistent with the finding of Blanco, Brennan, and Marsh (2005) that CDS prices lead bond credit spreads. Price discovery occurs in the much more liquid CDS market.

CDS were introduced on some companies, larger ones, and not all at the same time. When CDS is introduced on a firm, then that firm’s bonds should become less liquid. This was essentially tested by Das, Kalimipalli, and Nayak (2014) who found that: “Using an extensive sample of CDS and bond trades over 2002-2008, we find that the advent of CDS was largely detrimental. Bond markets became less efficient, evidenced no reduction in pricing errors, and experienced no improvement in liquidity” (p. 495).

D. Municipal Bonds

Hammerling (2019) studies the U.S. market for municipal debt when the monoline insurers, the companies that insured many of the bonds in this market, were downgraded or went bankrupt. She adapts the Benmelech and Bergman (2018a) to analyze the effects on municipal debt. She provides a variety of evidence showing that following the events with the monolines municipal debt switched from information-insensitive to information-sensitive. Unlike BB, however, Hammerling can use a differences-in-differences approach to show that the switch occurred in early 2012. She finds that not only bonds that were previously insured, but also bonds that were previously uninsured, become information-sensitive.

Once the municipal bonds became information sensitive, Hammerling (2019) shows their prices become sensitive to information about municipalities’ debt service payments to tax revenues ratios, as well as pension commitments. Investors appear to use this information in pricing the bonds. And, municipalities showed an increased use of their financial disclosures, by for example changing the actuarial methods for valuing pension liabilities.

5. Conclusion

Money markets are not stock markets for a reason. The efficacy of money requires that its price not change, as it did during the U.S. Free Banking Era. By design the “price system” does *not* and *should not* work for money market instruments. Information-insensitivity is created by debt-on-debt. Money markets are primary markets. Equity trades in secondary markets. Table 1 summarizes the characteristics of money markets compared to stock markets. The differences are fundamental.

That the differences are fundamental has many implications. Since the money market price system is fixed at one-to-one with cash, other margins may need to adjust when there is bad news. Haircuts can rise, maturity can shorten, collateral may improve, but it may happen that quantities go to zero, a crisis. And further, when short-term debt becomes information-sensitive, few, if any, know what the price of the underlying collateral should be. Few are prepared to produce information about the collateral. There cannot be price discovery. As a result, in a crisis there are no markets for the collateral. Only the central bank or private bank clearinghouse can make a market for the collateral, via their discount windows. This is the risk with information-insensitive debt.

The central bank's response to a crisis is also instructive. Rather than implement transparency, central banks do the opposite. Emergency lending programs are put into place, and these programs are designed to make loans in secret, protecting the anonymity of borrowers in order to avoid identifying weak banks, which might then face runs. Borrowers become stigmatized if their name is revealed. Also, in an attempt to prevent revelation of weak financial institutions, the SEC instituted short-sale bans on the stock of 797 financial firms starting on September 18, 2008.

The idea of *reducing* information in a financial crisis has a long history. In the U.S. prior to the existence of the Federal Reserve Bank, private bank clearinghouses responded by financial crises cutting off information. Member banks were prohibited from publishing their financial information in the papers, which in normal times they were required to do. The clearinghouse operated an internal discount window, but the identities of borrowing banks was kept secret. See Gorton and Tallman (2018). The response of private bank clearinghouses and central banks to crises has been to make markets in the collateral for which there is no market and this involves *reducing* transparency in order to go back to a system of information-insensitivity. Reducing transparency is a way to try to recreate opacity so that short-term debt can maintain information-insensitivity. This is accomplished by increasing the collateral backing the short-term debt. In the case of private bank clearinghouses, all banks are responsible for the newly issued liabilities. With a central bank, the taxing power of the government is used to back the collateral.

Regulatory responses to financial crises often seem to try to impose stock market-like policies on money markets. Above we saw two examples of the policy responses that implemented more "transparency". We saw such policies implemented with regard to securitization in Europe and money market funds in the U.S. These policies backfired. Such policies destroy liquidity and moneyness. It follows from the informational view articulated here that intuitions and results from stock markets are not correct for money markets. The information characteristics that define these two markets are opposed. Thus, the notion of "market discipline", for example, is not necessarily a good idea with regard to the private production of short-term debt. Mandating that banks issue contingent convertible debt just makes banks more likely to become information-sensitive. And so on. Looking at Table 1, the goal cannot be for the money market column to look like the stock market column.

Short-term debt is an inherent feature of market economies. For the problems of transacting and storing value over short periods of time short-term debt is the solution, but it is also the problem.

References

- Adrian, Tobias and Hyun Shin (2009), "Money, Liquidity, and Monetary Policy," *American Economic Review: Papers & Proceedings* 99, 600-605.
- Amihud, Yakov (2002), "Illiquidity and Stock Returns: Cross-Section and Time-Series Effects," *Journal of Financial Markets* 5, 31-56.
- Anderson, Haelim and Adam Copeland (2019), "Information Management in Times of Crisis," Federal Reserve Bank of New York, working paper.
- Baghai, Ramin, Mariassunta Giannetti, and Ivika Jäger (2018), "Liability Structure and Risk-Taking: Evidence from the Money Market Industry," Stockholm School of Economics, working paper.
- Balakrishnan, Karthik, Aytakin Ertan, and Yun Lee (2019), "(When) Do Mandatory Disclosures Reduce Liquidity," London Business School, working paper.
- Bao, Jack, Jun Pan, and Jiang Wang (2011), "Liquidity of Corporate Bonds," *Journal of Finance* 66, 911-946.
- Bardertscher, Brad, Jeffrey Burks, and Peter Easton (2018), "The Market Reaction to Bank Regulatory Reports," *Review of Accounting Studies* 23, 668-731.
- Benmelech, Efraim and Nittai Bergman (2018a), "Debt, Information, and Illiquidity," Northwestern Kellogg, NBER Working Paper #25054.
- Benmelech, Efraim and Nittai Bergman (2018b), "Credit Markets Freezes," *NBER Macroeconomics Annual* 2017, vol. 32, edited by Martin Eichenbaum and Jonathan Parker (University of Chicago Press).
- Benmelech, Efraim, Carola Frydman, and Dimitris Papanikolaou (2016), "Financial Frictions and Employment during the Great Depression," *Journal of Financial Economics*, forthcoming.
- Berger, Alan and Sally Davies (1998), "The Information Content of Bank Examinations," *Journal of Financial Services Research* 14, 117-144.
- Best, Edward (2015), "Corporate Bond Underwriting and Distribution Practices," presentation to the U.S. Securities and Exchange Commission, July 1, 2015.
- Blanco, Roberto, Simon Brennan, and Ian Marsh (2005), "An Empirical Investigation of the Dynamic Relation between Investment-Grade bonds and Credit Default Swaps," *Journal of Finance* 60, 2255-2281.
- Brancati, Emanuele and Marco Macchiavelli (2019), "The Information-Sensitivity of Debt in Good Times and Bad Times," *Journal of Financial Economics* 133, 99-112.
- Brancati, Emanuele and Marco Macchiavelli (2018), "Endogenous Debt Maturity and Rollover Risk," *Financial Management*, forthcoming.

- Cici, Gjergji, Scott Gibson, and John Merrick (2011), "Missing the Marks? Dispersion in Corporate Bond Valuations across Mutual Funds," *Journal of Financial Economics* 101, 206-226.
- Cipriani, Marco and Gabriele La Spada (2018), "Investors' Appetite for Money-Like Assets: The Money Market Fund Industry after the 2014 Regulatory Reform," Federal Reserve Bank of New York Staff Report No. 816.
- Covitz, Daniel, Nellie Liang, and Gustavo Suarez (2013), "The Evolution of a Financial Crisis: Collapse of the Asset-Backed Commercial Paper Market," *Journal of Finance* 68, 815–848.
- Dang, Tri Vi, Gary Gorton, and Bengt Holmström (2018), "Ignorance, Debt and Financial Crises," Working Paper, Yale University.
- Dang, Tri Vi, Gary Gorton, and Bengt Holmström (2013), "Haircuts and Repo Chains," working paper.
- Dang, Tri Vi, Gary Gorton, Bengt Holmström and Guillermo Ordoñez (2017), "Banks as Secret Keepers," *American Economic Review* (2017) 107, 1005-1029.
- Das, Sanjiv, Madhu Kalimipalli, and Subhankar Nayak (2014), "Did CDS Trading Improve the Market for Corporate Bonds?," *Journal of Financial Economics* 111, 495-525.
- DeYoung, Robert, Mark Flannery, William Lang, and Sorin Sorescu (2001), "The Information Content of Bank Exam Ratings and Subordinated Debt Prices," *Journal of Money, Credit, and Banking* 33, 900-925.
- Friedman, Milton (1959), A Program for Monetary Stability (Fordham University Press; New York).
- Gallagher, Emily, Lawrence Schmidt, Allan Timmermann, and Russ Wermers (2018), "Investor Information Acquisition and Money Market Fund Risk Rebalancing during the 2011-2012 Eurozone Crisis," *Review of Financial Studies*, forthcoming.
- Gorton, Gary (2018), "Financial Crises," *Annual Review of Financial Economics*, forthcoming.
- Gorton, Gary (2017), "The History and Economics of Safe Assets," *Annual Review of Economics* 9, 547-586.
- Gorton, Gary (2015), "The Development of Opacity in U.S. Banking," *Yale Journal of Regulation*, 31:3.
- Gorton, Gary (2010), "Are Naked Credit Default Swaps Too Revealing?," *Investment Dealer's Digest*, June 4, 2010.
- Gorton, Gary (1999), "Pricing Free Bank Notes," *Journal of Monetary Economics* 44, 33-64.
- Gorton, Gary (1996), "Reputation Formation in Early Bank Note Markets," *Journal of Political Economy* 104, 346–397.
- Gorton, Gary (1988), "Banking Panics and Business Cycles," *Oxford Economic Papers* 40 (4), 751–81.

- Gorton, Gary and Andrew Metrick (2013), "Securitization," Chapter 1 in the Handbook of the Economics of Finance, volume 2, Part A, edited by George Constantinides, Milton Harris, and René Stulz, Elsevier, 2013, p. 1-70.
- Gorton, Gary and Andrew Metrick (2012), "Securitized Banking and the Run on Repo," *Journal of Financial Economics* 104, 425-451.
- Gorton, Gary and Andrew Metrick (2010), "Haircuts," Federal Reserve Bank of St. Louis, *Review* 92(6) (November/December 2010).
- Gorton, Gary, Andrew Metrick, and Lei Xie (2015), "The Flight from Maturity," working paper.
- Gorton, Gary and Guillermo Ordoñez (2019), "Fighting Crises with Secrecy," working paper.
- Gorton, Gary and George Pennacchi (1993), "Security Baskets and Index-Linked Securities," *Journal of Business* 66(1), 1-27.
- Gorton, Gary and George Pennacchi (1990), "Financial Intermediaries and Liquidity Creation," *Journal of Finance* 45(1): 49-72.
- Gorton, Gary and Nicholas S. Souleles (2006), "Special Purpose Vehicles and Securitization," chapter in The Risks of Financial Institutions, edited by Rene Stulz and Mark Carey (University of Chicago Press).
- Gorton, Gary and Ellis Tallman (2018), Fighting Financial Crises (University of Chicago Press).
- Hammerling, Sarah Ngo (2019), "Information, Insurance, and Interaction: The Municipal Bond Market after the Monolines," Yale working paper.
- Hanson, Sam and Adi Sunderam (2013), "Are There Too Many Safe Securities? Securitization and the Incentives for Information Production," *Journal of Financial Economics* 108, 565-584.
- Holmström, Bengt (2015), "Understanding the Role of Debt in the Financial System," BIS Working Papers, No. 479.
- Johnston, Rick, Stanimir Markov, and Sundaresh Ramnath (2009), "Sell-side Analysts," *Journal of Accounting and Finance* 47, 91-107.
- Kwan, Simon (1996), "Firm-Specific Information and the Correlation between Individual Stocks and Bonds," *Journal of Financial Economics* 40, 63-80.
- Loderer, Claudio, Dennis Sheehan, and Gregory Kadlec (1991), "The Pricing of Equity Offerings," *Journal of Financial Economics* 29, 35-57.
- McCulloch, Hugh (1879), Lectures on Finance and Political Economy, "The National Banking Era," Harvard University, May 1879; reprinted in *The Banker's Magazine* XIII, Third Series, No., 12 (June) 1879, p. 971-981.

- Mizrach, Bruce (n.d.), "Analysis of Corporate Bond Liquidity," FINRA Office of the Chief Economist, Research Note.
- Morris, S and H S Shin (2007): "Optimal communication", *Journal of the European Economic Association*, vol 5(2-3), pp 594–602.
- Pagano, Marco and Paolo Volpin (2012), "Securitization, Transparency, and Liquidity," *Review of Financial Studies* 25, 2417-2453.
- Perignon, Christophe, David Thesmar, and Guillaume Vuillemeys (2018), "Wholesale Funding Dry-Ups," *Journal of Finance* 73, 575-617.
- Ricardo, David (1816), Proposals for an Economical and Secure Currency (John Murray; London).
- Rock, Kevin (1986), "Why New Issues are Underpriced," *Journal of Financial Economics* 15, 187-212.
- Roll, Richard (1984), "A Simple Implicit Measure of the Effective Bid-Ask Spread in an Efficient Market," *Journal of Finance* 39, 1127-1139.
- Schaefer, Stephen and Ilya Strebulaev (2008), "Structural Models of Credit Risk are Useful: Evidence from Hedge Ratios on Corporate Bonds," *Journal of Financial Economics* 90, 1-19.
- Schuler, Kurt (1992), "The World History of Free Banking: An Overview," Chapter 2 in The Free Banking Experience, edited by Kevin Dowd (Routledge), 7-47.
- Stenzel, André (2013), "Security Design with Interim Public Information," University of Mannheim working paper.
- Sumner, William Graham (1896), A History of Banking in All Leading Nations (New York: The Journal of Commerce).
- Sunderam, Adi (2015), "Money Creation and the Shadow Banking System," *Review of Financial Studies* 28, 939-977.
- Townsend, Robert (1979), "Optimal Contracts and Competitive Markets with Costly State Verification," *Journal of Economic Theory* 21(2): 265-293.
- Xie, Lei (2012), "The Seasons of Money: ABS/MBS Issuance and the Convenience Yield," Working Paper, Yale University.

Table 1: Opposite Systems of Liquidity

Money Markets	Stock Markets
- For Liquidity Provision	- For Risk Sharing
System Characteristics	
No Price Discovery	Price Discovery
Information-insensitive	Information-sensitive
Opaque	Transparent
Primary (bilateral)	Secondary (exchanges)
Stable Volume	Volatile Volume
Cheap, stable liquidity	Expensive, risky liquidity

Source: Based on Holmström (2015).

Table 2: Individual Firm Bond Yield Changes and Own Stock Return Correlations

Variable	S&P Bond Rating (1986-1990)					
	AAA	AA	A	BBB	BB	B
$\Delta T_{j,t}$	0.5987 ^a	0.5513 ^a	0.5371 ^a	0.4923 ^a	-0.0506	-0.008
$R_{j,t+1}$	0.2173	0.0370	0.0551	0.0290	-0.2296 ^a	-0.0839
$R_{j,t}$	-0.1963	-0.0878 ^b	-0.1033 ^a	-0.3489	-0.5011 ^a	-0.4079 ^a
$R_{j,t-1}$	-0.2015	-0.1981 ^a	-0.2483 ^a	-0.3313	-0.3309 ^a	-0.1656 ^a
N	672	11,605	17,289	10,127	2,344	
R²	0.61	0.50	0.41	0.40	0.04	

ΔY_{jt} is the change in bond j 's yield-to-maturity from $t-1$ to t ; ΔT_{jt} is the change in a similar maturity U.S. Treasury bond yield from $t-1$ to t ; R_{jt} is the return on bond j 's issuing firm's stock from $t-1$ to t , and so on.

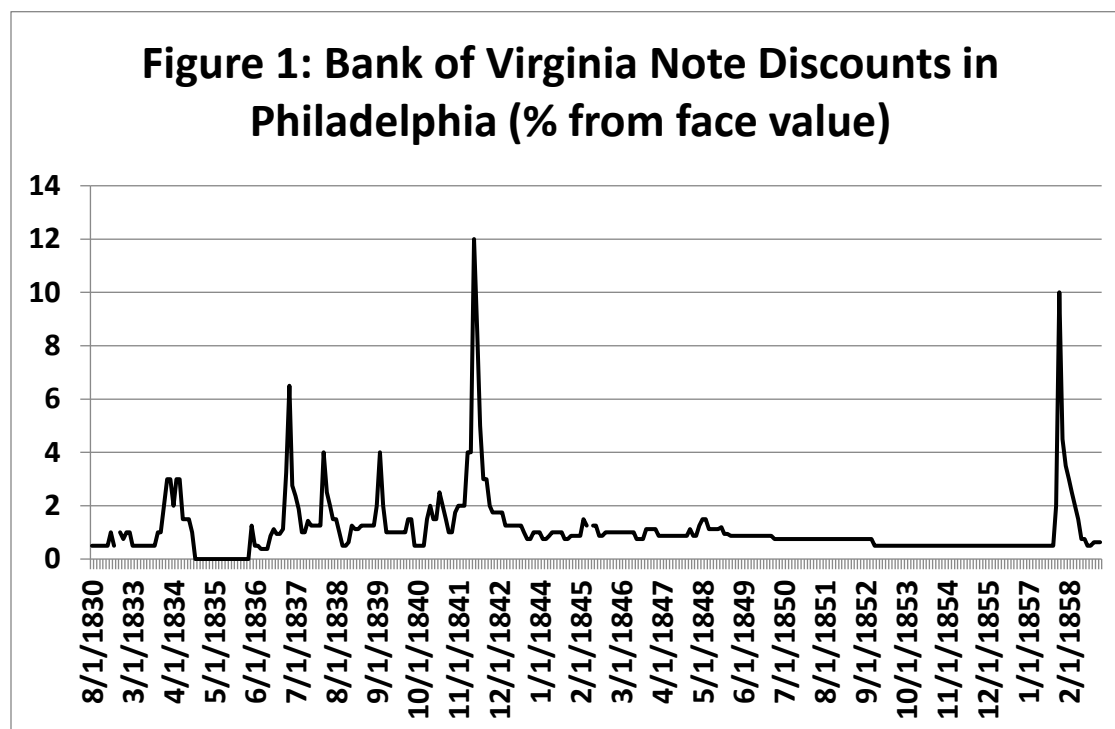
Source: Kwan (1996). a, b indicate significance at the 0.1% and 1% levels, respectively.

Table 3: Bond Price Dispersion

The table reports dispersion measures for bonds that are held by at least three mutual funds on the same date. Price dispersion is measured by the interquartile range of reported prices.

Credit Rating	All Funds' Prices	
	Price Dispersion	Number of Observations
AAA	0.228	4,211
AA	0.255	10,874
A	0.281	59,612
BBB	0.332	73,847
BB	0.542	32,831
B	0.554	46,754
CCC	0.604	11,350
CC	0.679	911
C	0.712	620
D	0.571	3,674
Investment Grade	0.303	148,544
High Yield	0.559	96,140

Source: Cici, Gibson, and Merrick (2011), Table 6.



Source: Gorton and Weber.

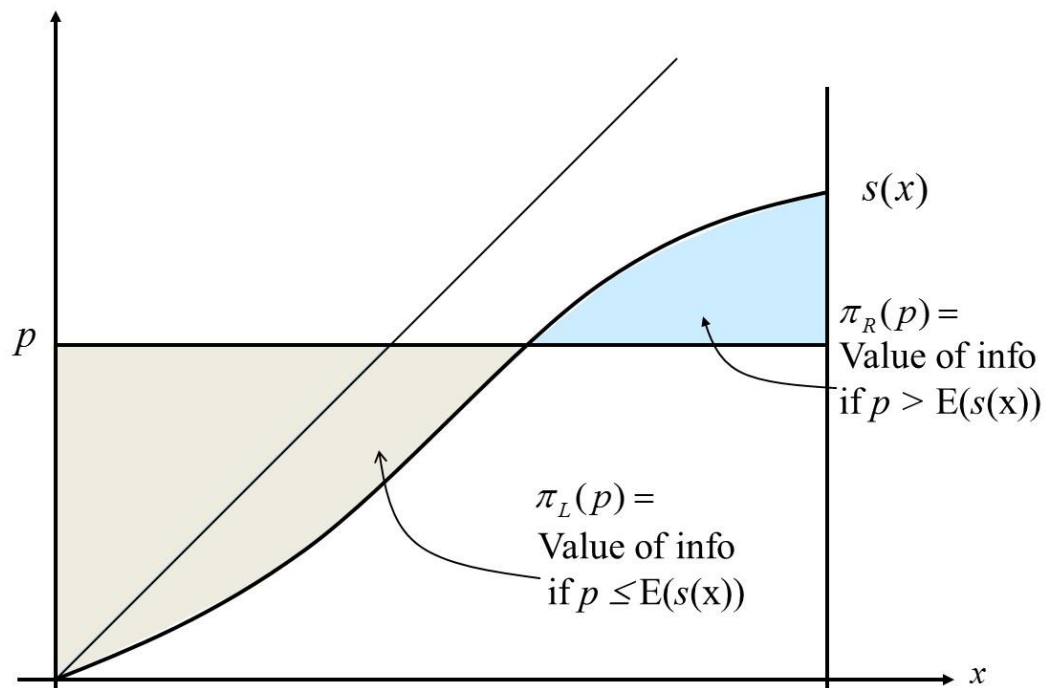
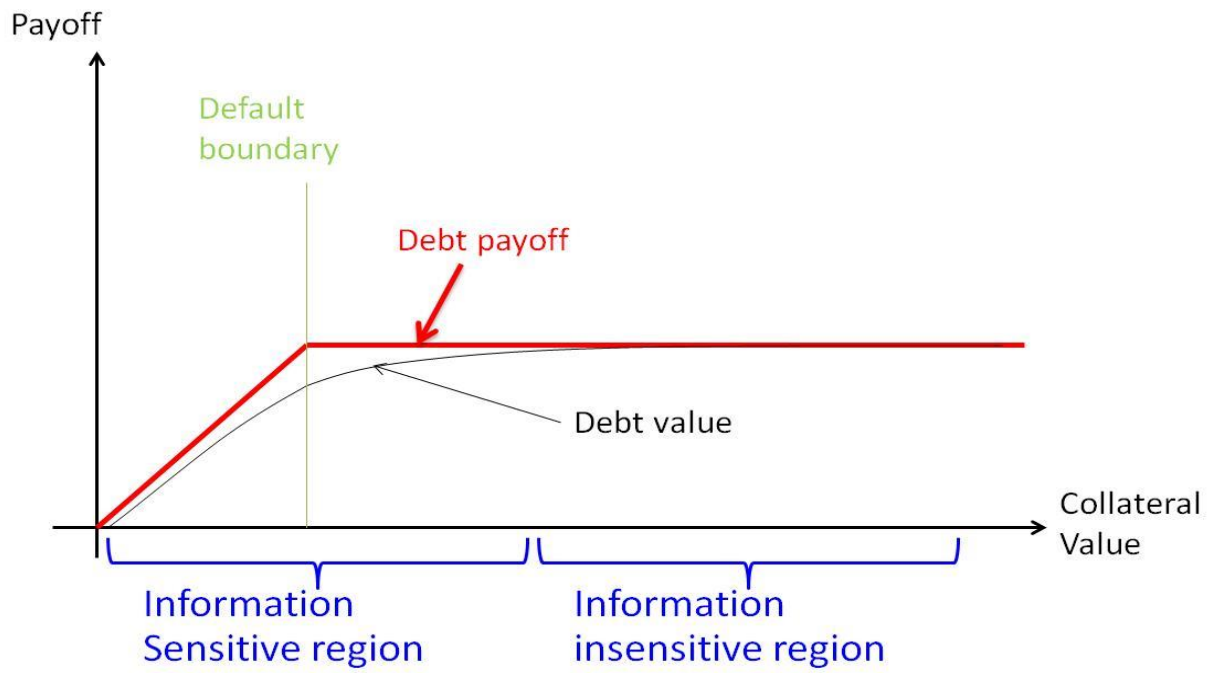
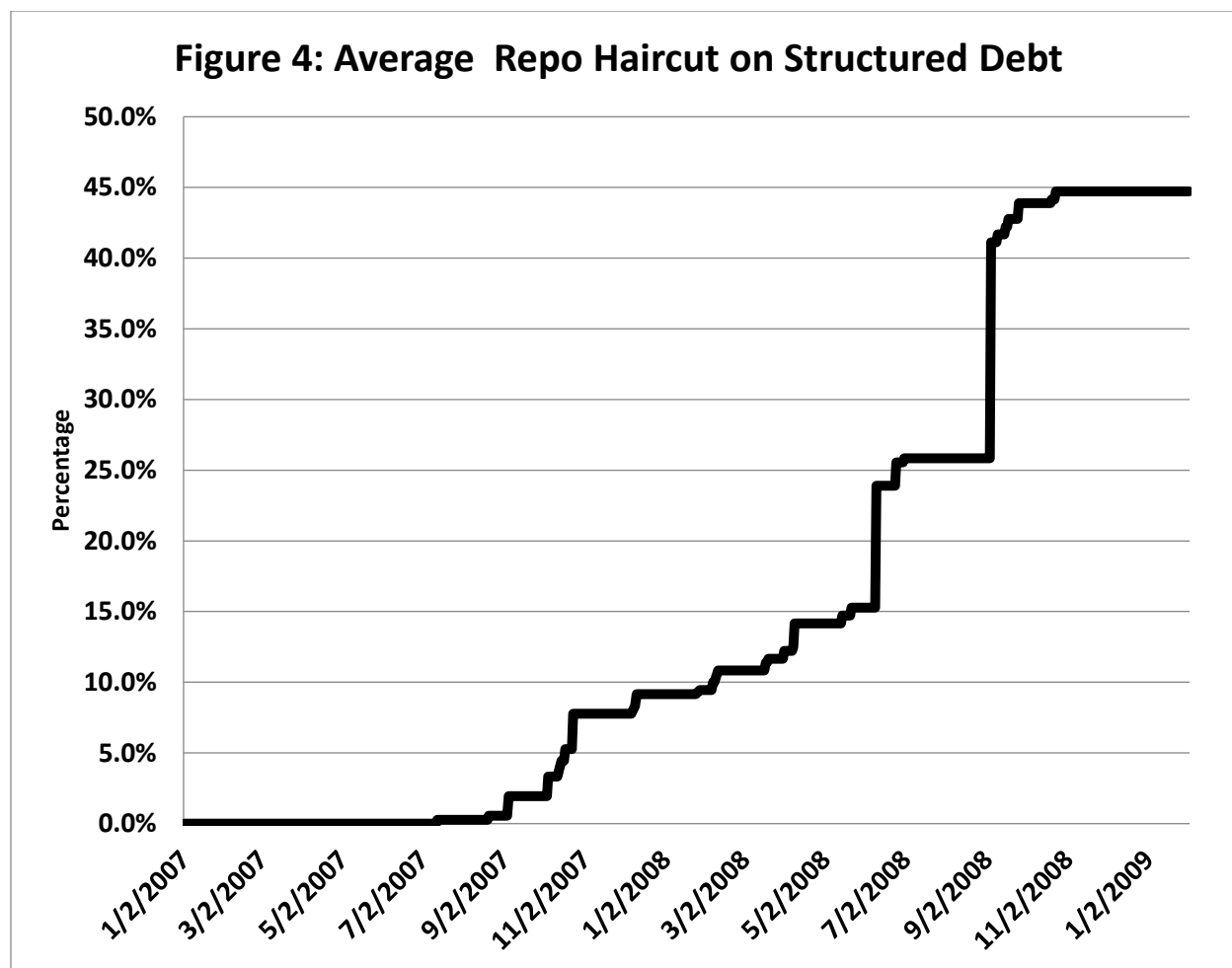
Figure 2: The Value of Information

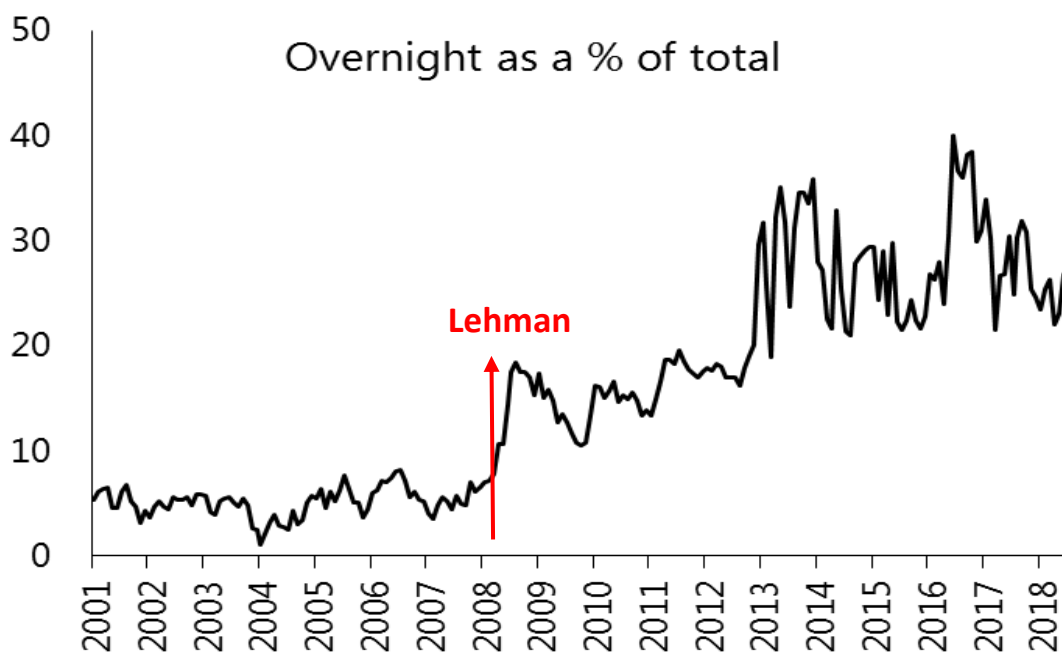
Figure 3: Contractual Payoff on Debt





Source: Gorton and Metrick (2012).

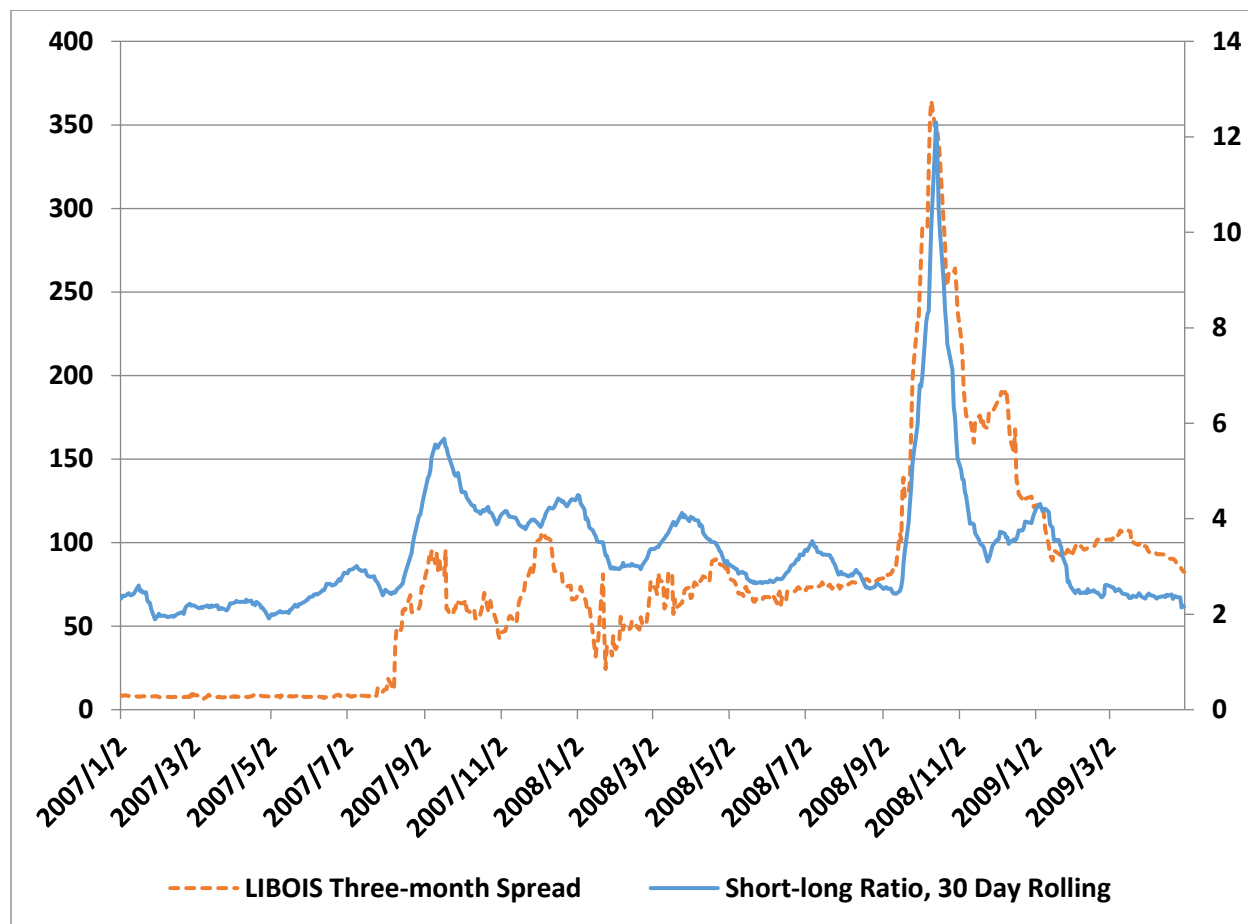
**Figure 5: Dealers' Overnight Securities as a % of the Total
[Difference between Securities OUT and Securities IN]**



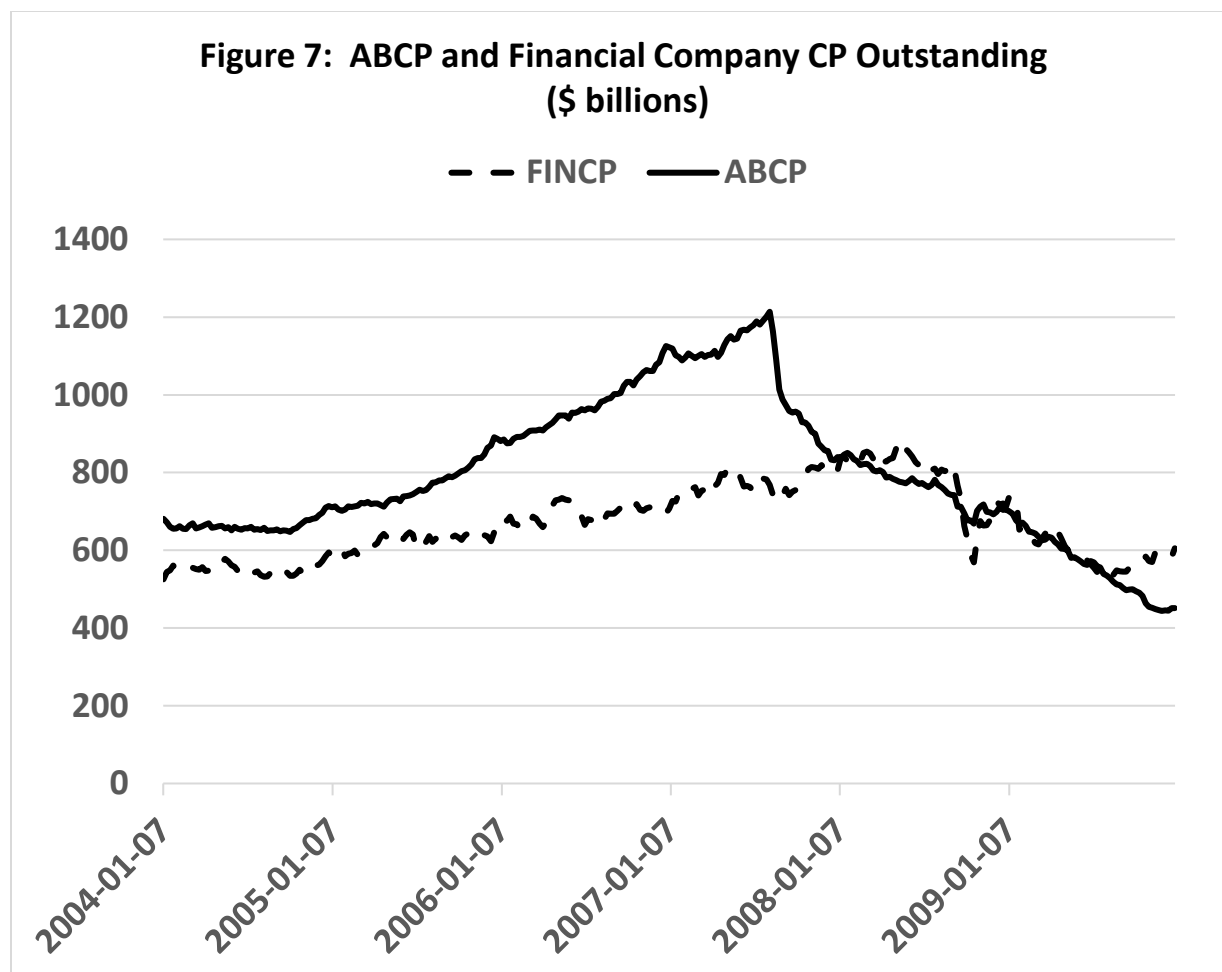
Source: Primary Government Securities Dealers Reports (Form FR2004), form C.

Figure 6: Counterparty Risk (bps) and CP Maturities

This figure plots the LIBOR minus overnight index swap three month spread and the short/long issuance ratio for AA asset-backed commercial paper. The ratio is defined as the ratio of the amount of CP issued with a maturity of less than 20 days (over a 30 day window) divided by the amount of CP issued with a maturity of 20 days or greater (over a 30 day window).



Source: Gorton, Metrick and Xie (2015).



Source: Federal Reserve

Figure 8: Monthly number of EDGAR views, by fund sophistication

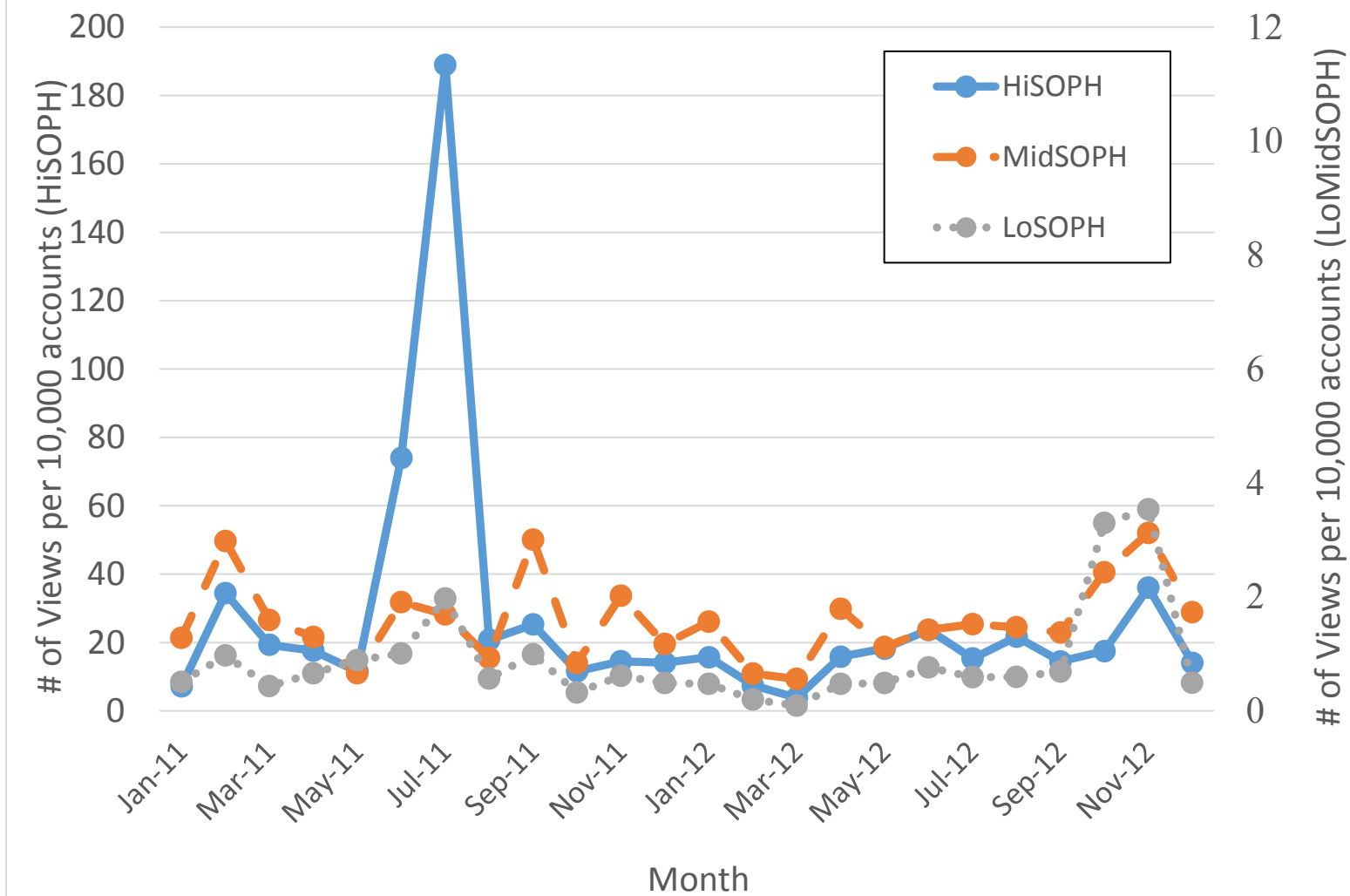
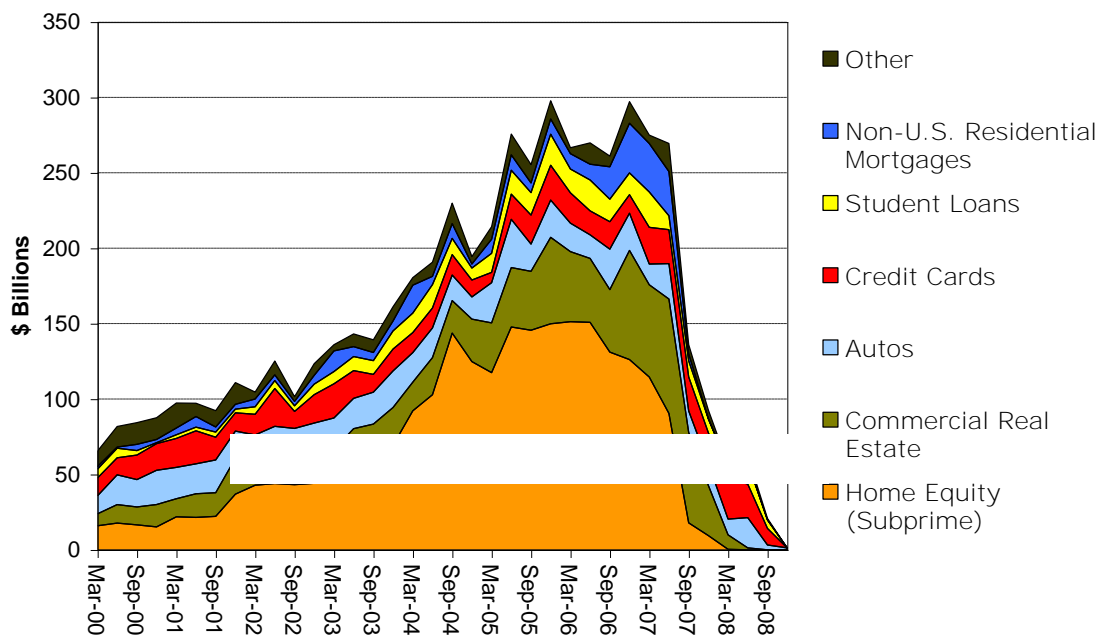
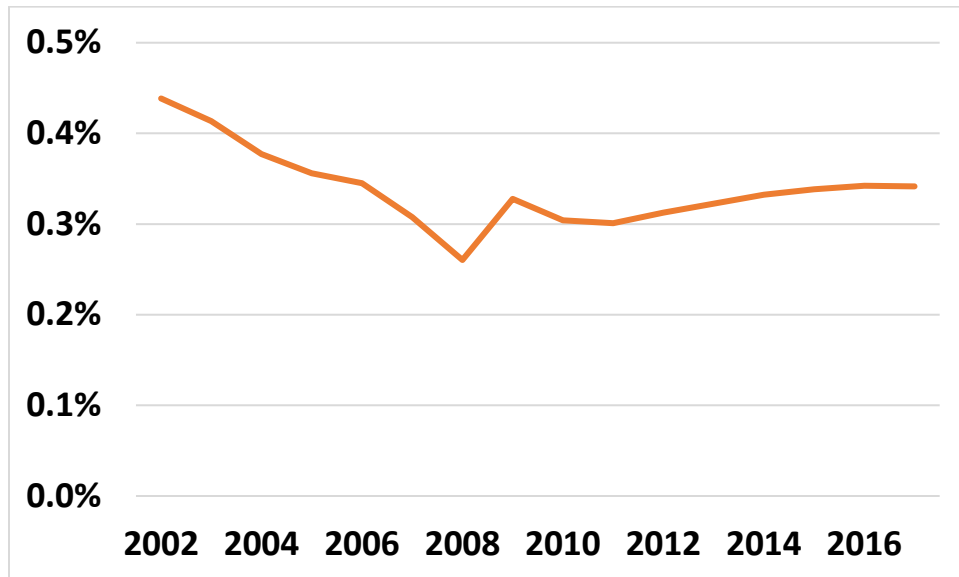


Figure 9: New Issuance of ABS and MBS in the Previous Three Months



Source: J.P. Morgan (via Adrian and Shin (2009)).

Figure 10: Percentage of Outstanding U.S. Corporate Bonds Traded per Year



Source: SIFMA.