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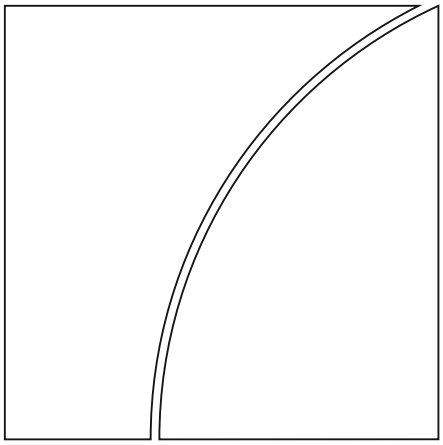

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Understanding the role of debt in the financial system

by Bengt Holmstrom, comments by Philipp Hildebrand and Ernst-Ludwig von Thadden

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Foreword

The 13th BIS Annual Conference took place in Lucerne, Switzerland on 27 June 2014. The event brought together a distinguished group of central bank governors, leading academics and former public officials to exchange views. The focus this year was on debt. The papers presented at the conference and the discussants' comments are released as BIS Working Papers 479 to 482.

BIS Papers No 80 contains the opening address by Jaime Caruana (General Manager, BIS) and a keynote address by Benjamin Friedman (Harvard University) and remarks by Stephen King (HSBC) and Masaaki Shirakawa (Aoyama Gakuin University).

Understanding the role of debt in the financial system

Bengt Holmstrom[1]

Abstract

Money markets are fundamentally different from stock markets. Stock markets are about price discovery for the purpose of allocating risk efficiently. Money markets are about obviating the need for price discovery using over-collateralised debt to reduce the cost of lending. Yet, attempts to reform credit markets in the wake of the recent financial crisis often draw on insights grounded in our understanding of stock markets. This can be very misleading. The paper presents a perspective on the logic of credit markets and the structure of debt contracts that highlights the information insensitivity of debt. This perspective explains among other things why opacity often enhances liquidity in credit markets and therefore why all financial panics involve debt. These basic insights into the nature of debt and credit markets are simple but important for thinking about policies on transparency, on capital buffers and other regulatory issues concerning banking and money markets.

JEL classification: E32, E52, G01, G15, G18, G20, G21, G28, G29

Keywords: financial crisis, liquidity, money markets, shadow banking, debt, information sensitivity, pawn shops, bailouts, banking regulation

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1. Introduction

A lot of progress has been made in understanding the financial crisis since it erupted in full force after Lehman's fall in September 2008. But there is still limited consensus on what caused the crisis. Many blame Wall Street greed and wrong incentives as well as the ratings agencies that appeared seriously off the mark. Others blame the government for subsidising subprime lending. Still others find the problem in the new originate-and-distribute model of mortgage lending, which was at the core of the rapidly growing shadow banking system. What appears so puzzling in hindsight is that a slew of new complex and opaque products appear to have been so poorly understood even by the experts on Wall Street. As Michael Lewis wonders in his best-seller *The Big Short*: How could Wall Street trade in securities that they knew so little about? Why did no one ask questions?

Many believe the purpose of opaque securities was to deceive investors. But it is hard to believe that investment bankers would be colluding to defraud investors. After all, much of the trading took place within Wall Street. The risk that someone in that massive collusion would have pulled the plug seems too big to make this theory plausible. It is equally hard to believe that hard-nosed profit-hungry investment bankers and traders would be ignorant out of ignorance.[2]

So what could explain the silent, high-volume trading in debt securities? I will argue that a state of "no questions asked" is the hallmark of money market liquidity; that this is the way money markets are supposed to look when they are functioning well.[3] The near-universal calls for pulling the veil off money market instruments and making them transparent reflect a serious misunderstanding of the logic of debt and the operation of money markets. This misunderstanding seems to be rooted in part in the public's view that a lack of transparency must mean that some shady deals are being covered up. Among economists, the mistake is to apply to money markets the lessons and logic of stock markets.

The key point I want to communicate today is that these two markets are built on two entirely different, one could say diametrically opposite, logics. Ultimately, this is because they serve two very different purposes. Stock markets are in the first instance aimed at sharing and allocating aggregate risk. To do that effectively requires a market that is good at price discovery. By price discovery I do not mean that the market has to discover the true fundamentals – we will never observe whether that is the case. I mean the same as the Efficient Market Hypothesis (EMH) posits: that no one can legally have a very substantial informational advantage for a long time and not at all without paying a commensurate price for the effort of obtaining such an advantage. Information will quickly be reflected in prices and, since prices are common knowledge, beliefs will not be biased one way or the other to permit someone with just the knowledge of prices to make money.

Invoking the empirical success of the EMH (in a variant they call relative EMH), Gilson and Kraakman (2014) among others have advocated that the same recipes be

[2] But it appears that they did trade on very limited information in money markets; see Hellwig (2009).

[3] "Money markets" is a very broad term covering a range of securities as Stigum's (1989) classic book with that title makes clear. My main focus is on liquidity provision and intermediation in money markets.

applied to money markets as have worked so well for stock markets. Foremost among them is the recommendation that transparency about asset values should be a high priority in regulatory reforms. This is supposed to provide market discipline and also warn about impending build-ups of systemic risk.

But the logic behind transparency in stock markets does not apply to money markets. The purpose of money markets is to provide liquidity for individuals and firms. The cheapest way to do so is by using over-collateralised debt that obviates the need for price discovery. Without the need for price discovery the need for public transparency is much less. Opacity is a natural feature of money markets and can in some instances enhance liquidity, as I will argue later.

Why does this matter? It matters because a wrong diagnosis of a problem is a bad starting point for remedies. We have learned quite a bit from this crisis and we will learn more. There are things that need to be fixed. But to minimise the chance of new, perhaps worse mistakes, we need to analyse remedies based on the purpose of liquidity provision. In particular, the very old logic of collateralised debt and the natural, but sometimes surprising implications this has for how information and risk are handled in money markets, need to be properly appreciated. It is possible that recent developments in global money markets have altered this logic requiring a fundamentally new perspective but, if so, the starting point should be the traditions of money markets rather than stock markets.

2. Pawn shops to repos

Let me begin by talking about the pawn shop, one of the oldest providers of liquidity. The earliest documents on pawning date back to the Tang dynasty in China (around 650 AD) and are described in the captivating book *On the Origins of Wealth* by William Goetzmann and Geert Rouwenhorst (2005, pp 54–64). The practice appeared widespread a hundred years later. This early evidence of collateralised debt is a lot older than the emergence of joint stock companies (in France and Sweden early in the 13th century) and of the stock exchange (in Amsterdam early in the 17th century). The point of mentioning these dates is that any institution that has survived nearly intact for so long must be based on very robust and efficient economic principles. The explosive growth in shadow banking is the most recent testimony to the enduring logic of collateralised lending as illustrated by the pawn shop.

The borrower brings to the pawn shop items against which a loan is extended. The pawn shop keeps the items in custody for a relatively short (negotiable) term, say one month, during which the borrower can get back the item in return for repayment of the loan. It sounds simple, but it is a beautiful solution to a complex problem.

The beauty lies in the fact that collateralised lending obviates the need to discover the exact price of the collateral. A person that runs into a liquidity problem can sell an asset, a watch say, but selling the watch requires that an agreeable price be established. There may be a market for used watches, but it is unlikely to be very efficient at price discovery. If the watch is unique the price would have to be negotiated in bilateral bargaining. It may be costly to come to an agreement. And

the highest value user of the watch could be the owner, so a sale will imply a potentially large liquidation loss or there may be no trade.

The dilemma is solved by pawning the watch. In that case the parties do not have to agree on the value of the watch. The right to redeem the watch at the same price at a later date, hopefully when the borrower's liquidity problem has passed, reduces bargaining costs. The information needed to reach an agreement on the price of the watch (the loan) is relatively small. The broker will offer a price that entails a big enough haircut so that she can recover her money by selling the watch if the owner does not come to redeem it. A safe lower bound is all that is needed. There is no price discovery in the sense that the price is close to what the watch would fetch in an arms-length bargaining process.

Today's repo markets, which play such a prominent role in shadow banking and also in the crisis, are close cousins of pawn brokering with similar risks for the parties involved. In a repo the buyer of the asset (the lender) bears the risk that the seller (the borrower) will not have the money to repurchase the asset and just like the pawnbroker, has to sell the asset in the market instead. The seller bears the risk that the buyer of the asset may have rehypothecated (reused) the posted collateral and cannot deliver it back on the termination date.[4] In today's repo markets repo fails on both sides are relatively rare, but they happen, especially in times of stressed markets.[5] Interestingly, the risk that a pawnbroker may sell or lose the pawn was a big issue in ancient times and could explain why the Chinese pawnbrokers were Buddhist monks. Their morality served to alleviate fears of absconding with the collateral.

There is one significant functional difference between pawning and repo. In pawning the initiative comes from the borrower who has a need for liquidity. In repo the motive is often the opposite: someone with money wants to park it safely by buying an asset in a repo (or reverse repo as it is called from the lender's perspective). This feature played a key role in the rapid rise of shadow banking that preceded the crisis, as I will discuss later.[6]

3. Money markets versus stock markets

In this section I want to contrast money markets with stock markets, showing how different they are in most respects. Table 1 provides an overview. I will also try to explain how the features in each system display a coherent internal logic that reflects its purpose.

[4] I will come back to reasons why the seller may agree to rehypothecation.

[5] In October 2014, lenders failed to return hundreds of billions of dollars of collateral per week, because of a shortage of treasuries.

[6] According to Temin and Voth (2006), modern banking started with investors saving with goldsmiths that eventually transitioned into bankers.

Two entirely different systems Table 1

Stock markets	Money markets
Risk sharing	Liquidity provision/lending
Price discovery	**Obviating price discovery**
Information sensitive	Information insensitive
Transparent	Opaque
Big investments in info	Modest investments in info
Many traders (exchanges)	Few traders (bilateral)
Trading not urgent	Trading urgent
Volatile volume	Stable volume

Money markets

The purpose of money markets is to provide liquidity. Money markets trade in debt claims that are backed, explicitly or implicitly, by collateral. Often the collateral is itself debt for a reason that I think we understand well. I will suggest a robust logic for using debt as collateral a bit later. For now, let me take debt as given and focus on the simple fact that, if the collateral used for trading in repo markets, for instance, is itself debt, price discovery is going to be even more difficult. By design, there was no need to discover the exact value of the collateral backing up the initial debt. And, now that this debt is used as collateral for the repo, it will be even more difficult to discover the underlying value. Gorton (2009) describes in detail the debt pyramiding that took place in structuring securitised products before the financial crisis, emphasising the information that gets lost at each new layer of the pyramid.

I do not believe obfuscation was the purpose of building complex structured products, but it was a beneficial or at least benign feature of debt until the crisis struck. The most highly rated AAA tranches were highly liquid even when the underlying collateral was subprime mortgages. Billions of AAA subprime tranches were issued and traded in repo and other parts of the money markets before the summer of 2007.

People often assume that liquidity requires transparency, but this is a misunderstanding. What is required for liquidity is symmetric information about the payoff of the security that is being traded so that adverse selection does not impair the market. Without symmetric information adverse selection may prevent trade from taking place or in other ways impair the market (Akerlof (1970)).

Trading in debt that is sufficiently over-collateralised is a cheap way to avoid adverse selection. When both parties know that there is enough collateral, more precise private information about the collateral becomes irrelevant and will not impair liquidity. We saw this in the pawn contract. It did not matter that the pawnbroker's valuation of the watch was different from the borrower's. It sufficed that the pawn broker felt confident that he could recover the loan by selling the watch, while the borrower was protected by the right to redeem the watch. The same logic underlies structured products in money markets: the highest-quality tranches are sufficiently over-collateralised so that no traders have any significant

informational advantage with regard to payoffs, even though some traders may have more information or may have the ability to acquire such information.

From here it is a short step to see that obfuscation may be beneficial. When neither side has an informational advantage to start with, the market will be free of fears of adverse selection and therefore very liquid. This blissful state of "symmetric ignorance" may be broken by public information that makes some traders' private information relevant (see eg Holmstrom (2009), and Pagano and Volpin (2012)). Expert traders who can interpret publicly released information better than the average trader may gain an informational advantage that results in adverse selection and reduced liquidity. I will provide some examples later on.

The desire to circumvent price discovery is a natural consequence of lending. Lending is a bilateral contract. As the pawning example suggests, price discovery in a bilateral setting is typically very costly (bond markets are different, but even they are quite illiquid). Gross characteristics, such as credit ratings, the term of the loan and the amount of the loan are, of course, essential for agreeing on a price. So are reference prices. Traders talk to each other a lot. Trading screens provide information on past trades that are similar, though it is usually hard to find an exact match. This type of information acquisition is best described as due diligence. Traders want to make sure that when someone approaches them with an offer, the price is in the right ball park. There is no precise price discovery in the sense of stock markets. Even bonds that are traded on exchanges suffer from thin trading, so posted prices are often proxies for what a bond could be sold for. The spreads are big.

Information-sparseness in money markets manifests itself in other ways too. There are no analysts monitoring money markets and relatively few that follow bond markets. The information of most interest in bond markets concerns interest rates and prepayment risks. Interest rates are available continuously and prepayment risks are not a source of adverse selection even though traders use different models for evaluating such risks. When new bonds are issued, the issue is typically sold in a day or less. Little information is given to the buyers. It is very far from the costly and time-consuming road shows and book-building that new stock issues require in order to convey sufficient information.

Stock markets

The main purpose of stock markets is to share and allocate risk. The first stock market was set up in Amsterdam to share the risk of dangerous voyages to the Far East. Over time, stock markets have come to serve other objectives too, most notably governance objectives, but the pricing of shares is still firmly based on the cost of systemic risk (or a larger number of factors that cannot be diversified). Discovering the price of systemic risk requires markets to be transparent so that they can aggregate information efficiently. The Efficient Market Hypothesis posits that information will be reflected rapidly in share prices and as a first approximation this seems to be empirically true.

Unlike money markets, which tend to involve few participants with large unit trades, stock markets benefit from having a large number of small investors. The average volume of daily trade on the New York stock exchange is of the order of $100 billion with substantial volatility. The value of each order is small. By comparison, the daily turnover in repo markets is several trillion dollars, though

much of it entails rolling over short-term contracts. There is very little volatility in the volume.

Stock markets are not a significant source of funding for firms underscoring their role for risk sharing. Start-ups, family businesses and other companies that list themselves for the first time on a stock exchange do raise substantial amounts of money at times, but little of it goes into the firm. The purpose is usually to allow entrepreneurs and family members to reduce their risk exposure, or resolve conflicts of interest that are common among closely held firms with large shareholders.

Colin Mayer's (1990) study of investments by private firms over the period 1970–85 in five developed countries shows the limited role of equity financing. He finds that equity issues are a very small percentage (less than 5%) of the aggregate funding of net investments. The principal source of funding comes from retained earnings (about 70%) and from bank loans and bonds (about 25% split equally). These numbers vary quite a bit across countries and years, but the common denominator is that equity markets play a minor role in funding. Not infrequently, there are years when equity markets drain companies of funds. In the United States, this was the case in the 1980s when stock repurchases grew big.

The importance of price discovery in stock markets goes hand in hand with the traders' incentives to acquire information. Every piece of information about the value of a firm is relevant for pricing its shares. This is reflected in the billions of dollars that investment banks and other analysts and individuals spend on learning about firms. A continuous flow of information is brought into the stock market, maintaining the relevance and accuracy of prices. Equity is information-sensitive while debt is not.

In summary, stock markets are in almost all respects different from money markets as shown in Table 1: risk-sharing versus liquidity provision, price discovery versus no price discovery, information-sensitive versus insensitive, transparent versus opaque, large versus small investments in information, anonymous versus bilateral, small unit trades versus large unit trades. To this should be added the important difference that money markets operate under much greater urgency than stock markets. There is generally very little to lose if one stays out of the stock market for a day or longer. This is one reason the volume of trade is very volatile in stock markets. In money markets the volume of trade is very stable, because it could be disastrous if, for instance, overnight debt would not be rolled over each day. In some cases, such stoppages can trigger crises, as was the case with Bear Stearns and Lehman Brothers.

In organisational design language, the different sets of attributes that characterise stock markets and money markets form two coherent systems; (see Milgrom and Roberts (1990)). The systems are carefully designed so that the parts fit together as in a vehicle. The attributes in the money market column of Table 1 reinforce each other as do those in the stock market column. Recognising the linkages between the attributes of money markets provides a holistic view of the crisis that is of the essence in diagnosing what went wrong and how the problems may be remedied. For instance, before insisting on more transparency in money markets, it would be wise to understand the central role played by information-sparseness in money markets and the difficulty of getting investors interested in paying for information about debt.

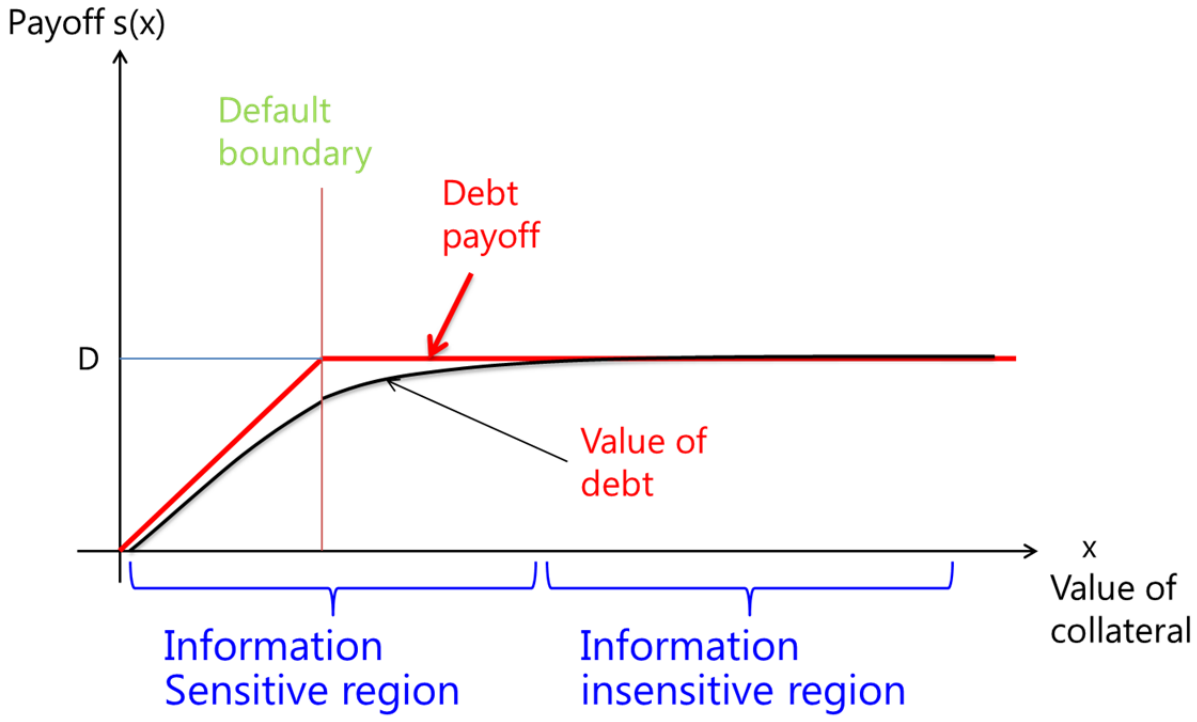
4. The optimality of debt.

Default and contingent price discovery

The pawn shop example highlighted that lending against collateral has low information costs because there is no need for precise price discovery. Is debt the optimal contract and, if so, in what sense? I want to be a bit more formal about this question, because there are several senses in which debt incurs low information costs. It is important to distinguish between them in order to understand the multiple reasons why debt is cheap. Some are especially relevant for trading debt and using debt as collateral as is done extensively within shadow banking.

In Figure 1, I have drawn in red the payoff of a collateralised debt contract at the time of expiration. It has the familiar shape of an inverted hockey stick. The horizontal axis measures the payoff of debt on termination, denoted by x.[7] The vertical axis measures the value of debt. The hockey stick has the functional form s(x) = Min[D,x], where D is the face value of the debt.

Debt and information sensitivity — Figure 1



[7] The picture fits precisely the case where there is a project with a terminal cash payoff at a date that coincides with the term of the debt. In reality, the situation is more complicated. The borrower has cash and collateral and the two are not perfect substitutes. I am assuming that the borrower converts collateral to cash as needed to pay off debt. I omit strategic considerations as discussed in control theoretic models such as that of Hart and Moore (1995).

Before the date of expiration, the value of the debt contract (to the lender) is less than at expiration, because of the risk of default. This is represented by the black line in the figure. The shape of the line is the familiar shape of an inverted put option. In asset pricing theory, the debtor has a put option, so one could use a standard option pricing formula to value the put. Here the match is imperfect, because the debt is typically not traded and the borrower may value the collateral more highly than the lender. I will ignore this complication.

It is important to note that a real debt contract never makes any reference to a payoff x, because there typically is no such payoff that both parties observe. Instead, the debt contract simply states that if the borrower pays D on termination there are no further obligations and the collateral is returned (if it is held by the lender). The reason for being particular about this point is that it underlines a second information-related benefit of collateralised debt. Not only does it avoid a precise assessment of the collateral value at the time the contract is signed. It also avoids the cost of price discovery whenever the debt is paid in full. Only default will trigger a value assessment, usually through a bankruptcy process that can be quite costly. In other words, default can usefully be thought of as *contingent price discovery*.

The celebrated Costly State Verification (CSV) model of Townsend (1979) and Gale and Hellwig (1985) shows that debt is an optimal contract for funding an investment, precisely because debt minimises the cost of price discovery.[8] If one were to write a contract that instead of having a flat part like debt would be strictly increasing in x like a share of equity then the execution of such a contract would be a lot more expensive since it would always require an assessment of the payoff at termination. One could use a reference index to determine the payments to be made (as in a revenue bond), but an index could often induce considerable risk into the contract in addition to making it more costly to price the security in the initial trade. Debt is information-insensitive both ex ante and ex post.

Information-sensitivity of debt in trade

If a debt contract ends up being traded, for instance because a repo fails or because someone wants to hedge against a future liquidity shock by buying a bond, there are two additional concerns that arise. First, how well does debt preserve its value as new, public information arrives? Second, how well does debt fare against potential private information that a buyer may acquire?

Let me take the second question first.[9] If we go back to the hockey stick in Figure 1 it is clear that debt is information insensitive to private information if it is deep in the money, that is, the distribution of the payoff x is so far out in the right tail that the market value of debt at the time of a future sale will equal its face value D with high probability (the black line hugs the red line). On the other hand, if the distribution is concentrated closer to the kink of the hockey stick, it may pay the buyer to acquire information about underlying collateral of debt before buying; debt has become information-sensitive. I have marked a hypothetical range of the mean of the distribution where debt is information-sensitive. I have in mind that the

[8] In the CSV model the borrower observes x for free and reports it truthfully if the contract is debt. Among all contracts, debt minimises the cost for the other party to investigate x.

[9] This discussion builds on the model in Dang et al (2012).

distribution of x moves along the x-axis without changing its shape so the mean identifies how information-sensitive debt is.

There is a precise measure that captures the information sensitivity of debt to information acquisition: it is the expected savings to the buyer from avoiding a loss-making purchase if she acquires information. Call this measure IAS (Information Acquisition Sensitivity). If IAS is larger than the cost of information acquisition C, the buyer will acquire information; if IAS is smaller than than C, she will refrain from acquiring information. She will, of course, buy only if the information reveals that the price is less than the expected payoff.

This definition can be applied to any contract, not just debt. It is natural to ask which contract has the lowest IAS among all contracts with the same expected value. The answer is debt. Put differently, if some arbitrary contract s(x) with expected value V = E[s(x)] does not trigger information acquisition neither will a debt contract with the same expected value V. Debt is the least information-sensitive contract in the sense that it is most resilient to information acquisition.

How is the information sensitivity of debt (IAS) affected by changes in parameters?

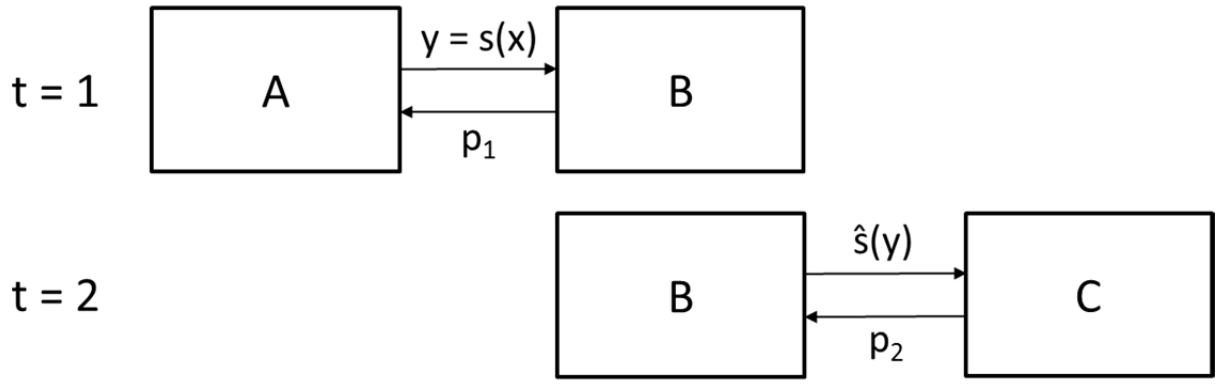
- Assuming the debtor values debt like a put option, the lender's value (the black line) is concave according to the standard option pricing formula. Therefore, less risky collateral (in the sense of a mean-preserving concentration – the opposite of spread) implies a higher value of debt: the black line (the "market value" of debt) will get closer to the red line (the final payoff of debt). This expands the information-insensitive region of debt. But it also increases the value of information close to the kink, because the shift in value is more rapid close to the kink, once the black line is close to the red line.
- The effects are similar (and for much the same reason) when the duration of debt is reduced. The value of debt increases uniformly as the duration gets shorter. Short-term debt which is sufficiently well in the money is less information-sensitive than long-term debt with the same face value, but this comparison reverses itself once the debt value gets close to the kink. The regime switch will be more dramatic for short-term debt than long-term debt.
- A reduction in the face value of debt, keeping collateral the same, will expand the region where debt is information-insensitive. This happens for two reasons: the black line will get closer to the red line and the flat part of the stick will become longer. With more of a buffer, debt will naturally be safer, but there will be less of it. This trade-off is relevant when one thinks of higher capital requirements. Conceptually, one can imagine that the collateral in Figure 1 is the aggregate value of all collateral in the economy. If one "issued" safer debt by lowering the amount of debt in Figure 1 that safety could only come by issuing less such debt. If one argues for more equity in the banking system, as Admati and Hellwig (2013) have done, there is a potential price to pay because the amount of safe assets will be reduced. It is true that the debt will be safer, but it is unclear how to compare less of safer debt with more of riskier debt.
- Finally, if more collateral is added, debt will be safer and there will be more of it (in the sense that one can issue more debt with the same level of safety).

Let me elaborate on the first bullet which states that less risky collateral makes debt less information-sensitive. It hints at the main result in Dang et al (2012). In that paper we study a setting where a person wants to invest in a security today in

order to provide for liquidity needs tomorrow (see Figure 2a). To meet her liquidity needs, the person plans to sell the security tomorrow. Between today and tomorrow, public information (news) will arrive that affects the value of the security. This raises the concern that the security becomes information-sensitive as discussed above. In case of bad news, the buyer may want to acquire information. It may then be best for the seller to use the initial security as collateral for another security that is less information-sensitive and consume any balance that remains at the final date.

Trading game

Figure 2a



t = 1 : Symmetric information. Distribution of x is F(x)

t = 1.5 : Public information z arrives → F(x|z)

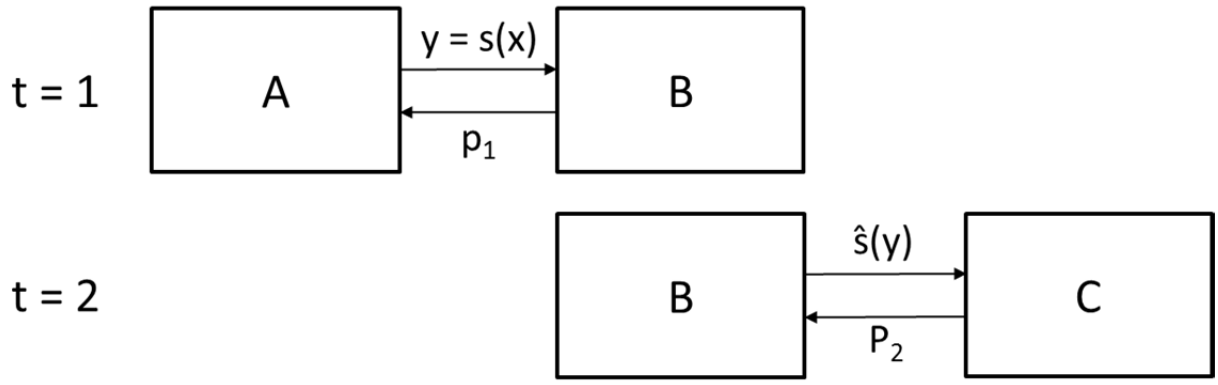
t = 2 : Agent C can learn x at cost c before accepting contract

(Interpretation: lower c = higher transparency)

Source: Dang et al (2012)

Debt on debt is optimal

Figure 2b



t = 1 : A sells debt tranche to B for p1 = w

t = 2 : (i) Good news. B resells tranche to C

(ii) Bad news case I: B resells tranche to C worth p2 (z) < p1

(iii) Bad news case II: B cannot sell all of debt to C, because it would trigger information acquisition. Double whammy.

(iv) Bad news case III: Adverse selection. Limited trade.

Sources: Dang et al (2012).

We know from the earlier discussion that whatever the initial security that the seller buys today, the optimal contract to issue tomorrow (to a buyer that may acquire information) is debt. The question is what kind of security the consumer should buy today, considering that she may want to use the security as collateral for debt issued tomorrow?

The answer is again debt. Debt is the best collateral, because the value of debt is also least sensitive to public information. Its value varies less than any other contract with the same initial expected value. This, then, is a third sense in which debt is information insensitive. This simple, but remarkable result can be found in DeMarzo et al (2005).[10] It is an important step for the main result in Dang et al (2012), which states that debt-on-debt is optimal (see Figure 2b). It is optimal to buy debt as collateral to insure against liquidity shocks tomorrow and it is optimal to issue debt against that collateral tomorrow. In fact, repeating the process over time is optimal, too, so debt is in a very robust sense the best possible collateral.[11] This provides a strong reason for using debt as collateral in the shadow banking system.

Figure 2b also describes the optimal strategy for the buyer if she needs to sell the asset at the middle date. She will, as just noted, always sell debt. The interesting part is that if the news is bad enough she will either have to risk no trade because of adverse selection or sell less of the debt to prevent information acquisition. Bad news leads to a "double-whammy" for liquidity support: first the value of the original debt contract falls and on top of that, not all of it can be sold.

The optimality of debt-on-debt in the trading game described above also suggests a reason why banks use debt on both sides of their balance sheets. We can interpret agent B in Figure 2 as a bank that invests in A and issues liabilities to C. Both legs use debt. Banks should hold assets that have the lowest sensitivity to public information, which includes debt without traded equity such as mortgages, and they should issue debt on the liability side, because such liabilities will be least likely to trigger information acquisition. Dang et al (2014) provides a more detailed model of why banks should keep secrets and why low-risk assets are more desirable (see also Breton (2007)).[12]

5. Purposeful opacity

Because debt is information-insensitive as just discussed, traders have muted incentives to invest in information about debt. This helps to explain why few questions were asked about highly rated debt: the likelihood of default was perceived to be low and the value of private information acquisition correspondingly small.

Money markets also appear to be information-sparse by design. There are several papers that show that it may be desirable to be opaque and hide available

[10] Lemma 5.

[11] Matters are more complicated if the assets one can work with are differently sensitive to public information.

[12] Two earlier papers that explain why banks issue deposits and invest in debt are Kashyap et al (2002) and Breton (2007), though neither paper explains the optimality of debt.

information. For instance, if a bank does not show the composition of its assets in detail, news about the economy will have less of an effect on the trader's beliefs. The enhanced stability of bank debt can be socially valuable; see eg Kaplan (2006), Breton (2007), Dang et al (2014), and Monnet and Quintin (2013). Because liquidity provision is a form of insurance (Diamond and Dybvig (1983)) the arguments in these papers can be seen as variations on Hirschleifer's (1971) celebrated result that public information destroys insurance opportunities.

Intentional opacity is a rather ubiquitous phenomenon. Here are some examples that explain why transparency can be bad.

- *De Beers* sell "wholesale" diamonds in a way that does not give its buyers the opportunity to inspect diamonds on offer in order to pick out the best ones to buy (Milgrom and Roberts (1992)). Buyers submit orders for "envelopes" of diamonds with certain gross characteristics (weight, colour, shape, quality). The diamonds in an envelope are not homogenous so conditional on the gross characteristics, inspection would be profitable, but De Beers does not allow inspection for that purpose. Buyers are allowed to check that the gross characteristics have been accurately presented. If mistakes are found they are corrected. But the buyer has to accept the envelope and price (adjusted for mistakes) or else be excluded from future trading.

  One purpose of this system is to prevent adverse selection that might arise if buyers were allowed to pick and choose among the diamonds. The (partial) opacity of the system is supported by De Beers' reputation for honest trading and the rents that flow from long-term relationships with the buyers. Over time, variations in quality will wash out leaving the benefits from inspection time saved and avoidance of the costs and consequences of information acquisition.

- *Car auctions*. A related example is offered by the wholesale used cars market in which cars are auctioned to dealers (Genesove (1993)). Buyers are allowed to inspect the cars externally before the auction, but they cannot open the doors or the hood. Mileage, options, year and make will be known at this stage. When a car goes on the block, buyers can open the doors and the hood to do some additional checks. But these are perfunctory: the total time a car is on the block (including the bidding) averages about a minute and a half.

  One virtue of this auction is speed. A second virtue is that limited information alleviates the winner's curse by reducing the advantage that expert bidders may have in interpreting more detailed information such as service records. It is also important that the value of cars, conditional on the gross characteristics, is approximately the same across the buyers.

Purposeful opacity can enhance liquidity in money markets, too. Here are some examples.

- *Money market mutual funds* have daily information about their investment positions and the book value of these positions. The book values change constantly as the funds trade their portfolios and investors add and withdraw money from the fund. Yet, the funds do not have to report the daily NAV (Net Asset Value). They only have to file quarterly reports with the SEC and even then the reported value is not the current NAV, but the NAV 30 days ago. It is a purposeful effort to avoid a continuous flow of information into the market. Why? The likely rationale is that opacity gives MMMFs time to adjust to fluctuations in the daily NAV so that investors are unable to judge whether the

fund is close to "breaking the buck," which might trigger a run. Breaking the buck is a highly disruptive event, because debt holders are suddenly put in the position of equity holders as Figure 1 illustrates. The fact that investors seem unconcerned about swings in interest rates, which could be much larger than the 50 basis point decline allowed before the buck has to be reported broken, but may run when the principal of their investment is threatened, can be viewed as evidence of the information view presented here. Randomness in the income is not as critical as uncertainty about the underlying collateral.

The funds have objected to a "floating" NAV, a practice that European MMMFs have to follow. The industry has argued that MMMFs would not be able to supply liquidity needs as efficiently with a floating NAV. The clientele would probably change because the MMMFs would no longer appear as safe as banks. This may well be true, since transparency would eat into the "moneyness" of MMMF deposits. In other words, transparency would reduce liquidity – the opposite conclusion to what one would draw from the value of transparency in stock markets. That said, reduced liquidity or "moneyness" may be a reason to make MMMFs more transparent. Even though opacity is purposeful for the MMMFs, it does not mean that opacity is socially desirable. Indeed, opacity would aggravate the calamity once the buck is broken.[13]

- *Coarse bond ratings* provide another example of what appears to be purposeful opacity. Credit ratings could certainly be less coarse. Finer credit ratings would increase the frequency of re-rating bonds and therefore add costs, but given the relatively infrequent re-ratings in normal times, this argument seems weak. Coarseness is more likely an effort to make approximately equal collateral look equal in the eyes of the investors.[14] Coarse ratings promote "commonality of beliefs," in the language of Morris and Shin (2006). They show theoretically, that commonality is desirable because it reduces problems of adverse selection. Furthermore, because an investor does not merely care about her own views of value, but also about the views of other investors and their views about her views and so on, as in Keynes's famous beauty contest, even small disruptions in commonality of beliefs (technically, departures from common knowledge) can result in big swings in market outcomes and could potentially trigger a run.
- *Money* itself is very opaque about the underlying collateral. No one knows what exactly backs up government issued money. "The full faith and credit of the government" is a very vague promise. But the beauty of money is that even if I do not know the exact value of the collateral backing my government's promise, neither does anyone else. So we are "symmetrically ignorant" – a blissful state in money markets.
- *Bubbles*. By definition, in a bubble the price of an asset rises well above its fundamental value. Even though investors may be aware that they are riding a bubble and therefore expects the price to collapse sometime in the future, no one is likely to have private information about when this will happen. The more detached the price is from the fundamental value of the asset, the more

[13] Since this was written, the reporting rules for MMFs have changed, but this is not relevant for my argument that opacity was purposeful.

[14] The empirical evidence in Adelino (2009) suggests that this has not been entirely successful; investors have valuable information beyond ratings.

symmetric the traders' information becomes. Symmetric ignorance can make bubbles a safe place to park money, at least for short periods of time. If this view is correct, bubbles can be expected to arise especially when there is a shortage of "safe" collateral; see Caballero and Farhi (2012), Farhi and Tirole (2012) and Martin and Ventura (2014).

- *Clearing houses*. An example that is especially interesting in light of the European move to a banking union is the private organisation of bank clearing houses that were common in the second half of the 19th century (see Gorton (1985)). These organisations cleared checks, but they also provided mutualised insurance in times of crisis. During panics, clearing houses would close ranks and make individual debt the shared obligation of all their member banks. The clearing house issued loan certificates which individual banks could buy in exchange for their impaired assets; something that sounds quite similar to the interventions by the Fed and the ECB in the recent crisis. At the same time, the clearing house would no longer report on individual data of its member banks. The data were sparse to begin with – gross statistics of the kind that is typical in money markets – but shutting down all information still increased the level of opacity. When the crisis was over (when the loan certificates traded at par again), the clearing house would revert to its pre-crisis state of organisation and reporting. The interesting question is why? As a single entity, the clearing house appeared stronger than when the banks were separate. Gorton and Mullineaux (1987) argue that it improved incentives for monitoring the banks both within the clearing house and by the depositors. Another argument is that even if the clearing house might have been stronger as a single organisation, the consequences of default would have been more dramatic. With a run on the clearing house rather than just one bank there would be no one that could come to rescue. The decentralised system provided a solvent backstop and the first bank to fail an early warning sign of trouble.

6. Panics: The ill consequences of debt and opacity

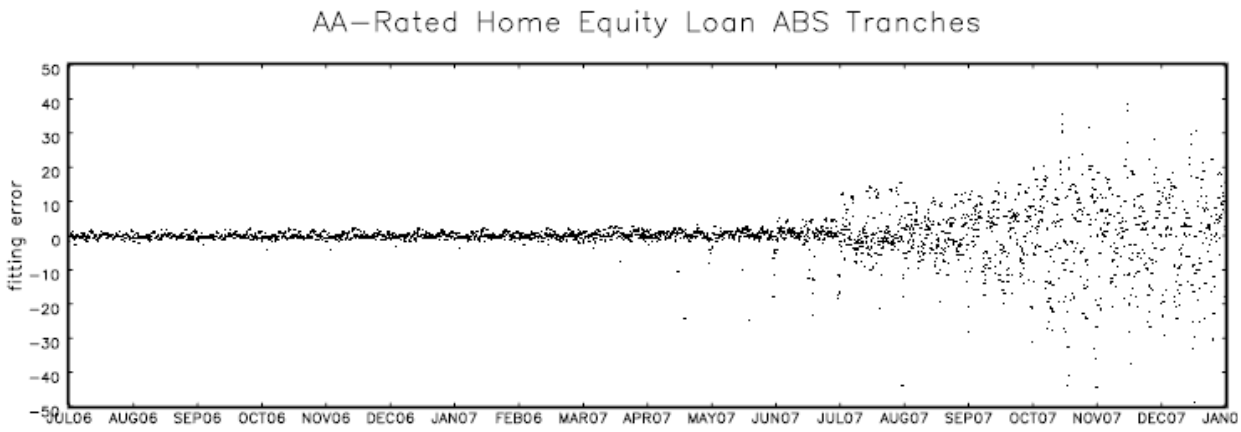
Over-collateralised debt, short debt maturities, reference pricing, coarse ratings, opacity and "symmetric ignorance" all make sense in good times and contribute to the liquidity of money markets. But there is a downside. Everything that adds to liquidity in good times pushes risk into the tail. If the underlying collateral gets impaired and the prevailing trust is broken, the consequences may be cataclysmic.

The occurrence of panics supports the informational thesis that is being put forward here. Panics always involve debt. Panics happen when information-insensitive debt (or banks) turns into information-sensitive debt as in Figure 1. A regime shift occurs from a state where no one feels the need to ask detailed questions, to a state where there is enough uncertainty that some of the investors begin to ask questions about the underlying collateral and others get concerned about the possibility (see Dang et al (2012) and Gorton and Ordonez (2014)). This can lead to reduced liquidity and rapid drops in prices. These events are cataclysmic precisely because the liquidity of debt rested on over-collateralisation and trust rather than a precise evaluation of values. Investors are suddenly in the position of equity holders looking for information, but without a market for price discovery. Private information becomes relevant, shattering the shared understanding and

beliefs on which liquidity rested (see Morris and Shin (2012) for the general mechanism and Goldstein and Pauzner (2005) for an application to bank runs).

I want to show some evidence that supports the view that panics are information events. Look at Figure 3 taken from Perraudin and Wu (2008). The picture represents the residuals from fitting a complex forecasting model to data on prices of bilateral trades in AA-rated tranches of subprime home equity loans (HEL) over the period August 2006–January 2008. The picture is striking. In June 2007, two Bear Stearns Funds, heavily exposed to subprime home equity loans, were besieged by investors and collapsed. Before the collapse investors appear to have had a shared view of pricing. I suspect that traders mainly relied on ratings and, if they checked reference prices, it was mostly from common sources using the same valuation models rather than trying to find out private information about the underlying collateral. Herding around the same information is certainly indicated by the picture. Once news about the troubles at the two Bear Stearns Funds surfaced and quickly spread, everything changed. The scatter suggests that private information became relevant in the sense that everyone tried to make the best of their understanding of the situation, based on their experience and expertise. The event shows that significant new public information caused beliefs to diverge rather than converge to a common, lower price level.

Residuals of prices of AA Home Equity Loan tranches Aug 2006-Jan 200 Figure 3



Source: Perraudin-Wu (2008)

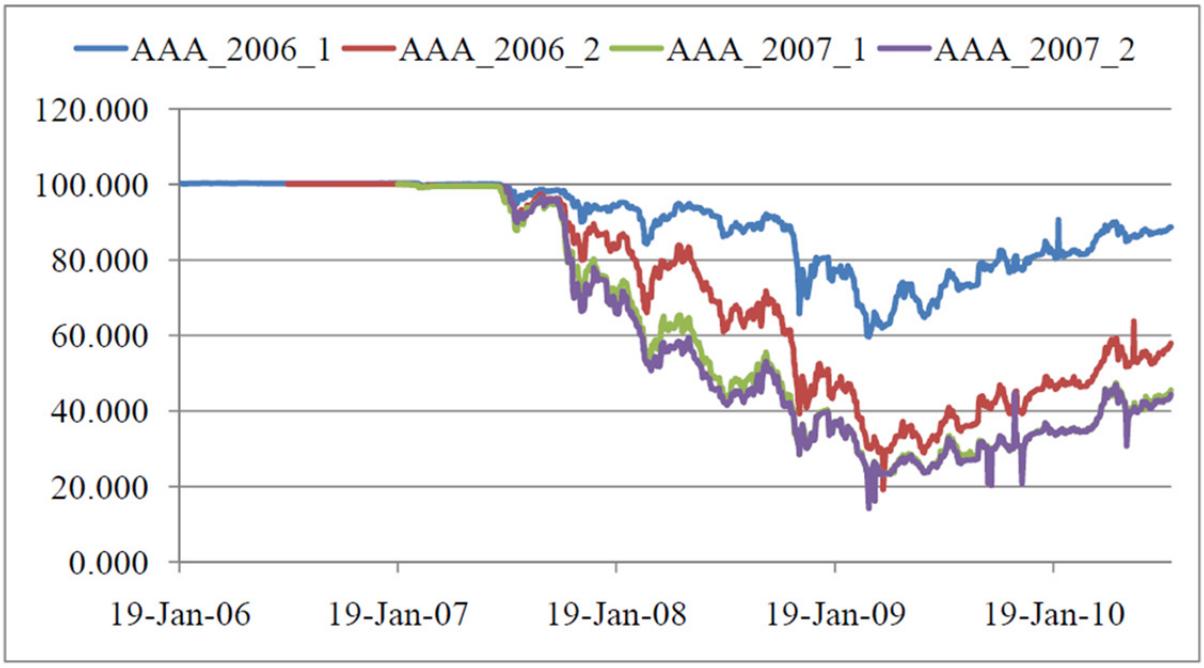
Figure 4 provides corroborating evidence. It describes spreads in high-grade subprime tranches of the ABX index as reported by Stanton and Wallace (2011). These tranches traded essentially at par until the Bear Stearns funds collapsed and they fell further after the BNP Paribas funds collapsed in August 2007. Issuance of asset-backed securities also dropped sharply across the board (Figure 7).

As described in Covitz et al (2013), these events started a run in the asset-backed commercial paper market (ABCP). Multiple reinforcing factors come into play once a run gets started (Brunnermeier (2009)). Information contagion, fire sales, domino effects, interlinked balance sheets all contribute to the course of the panic.

At that point, it is hard to disentangle what drives what.[15] My main purpose has been to show that the panic is consistent with an information event (not necessarily a dramatic one) which starts with debt becoming information-sensitive.[16]

ABX Spreads

Figure 4



Source: Stanton-Wallace (2011)

Would transparency have helped contain the contagion?

A strong believer in the informational efficiency of markets would argue that, once trading in credit default swaps (CDS) and then the ABX index began, there was a liquid market in which bets could be made both ways. The market would find the price of systemic risk based on the best available evidence and that would serve as a

15 Martin et al (2014) analyse a model of repo runs and panic triggers that is detailed enough to allow them to interpret the relative calm in the tri-party repo market until the collapse of Lehman with the slow run in the OTC repo market as described in Gorton and Metrick (2012). The tri-party repo market was more opaque because haircuts did not adjust by design as in the OTC market. Instead funding was withdrawn entirely as in the case of Lehman. This is another illustration of the trade-off between increasing liquidity in the tri-party market but then triggering a bigger collapse.

16 One can generate a significant discontinuity in prices without asymmetric information, using a model where the price of the security evolves behind a veil: investors only observe whether the price drops below a critical barrier or stays above it. When the price crosses the barrier in such a model, price drops discontinuously due to "trapped information" being released. Caplin and Leahy (1994) provide a model of this kind based on herding and social learning. But that type of model cannot explain the complete collapse in issuing of new tranches that we see in Figure 7 or the dispersion in prices in the Perraudin-Wu picture. Gorton and Ordonez (2014) present a model of the run-up and collapse of collateral values based on Dang et al (2012).

warning of an imminent crisis. Pricing of specific default swaps might even impose market discipline on the issuers of the underlying debt instruments.

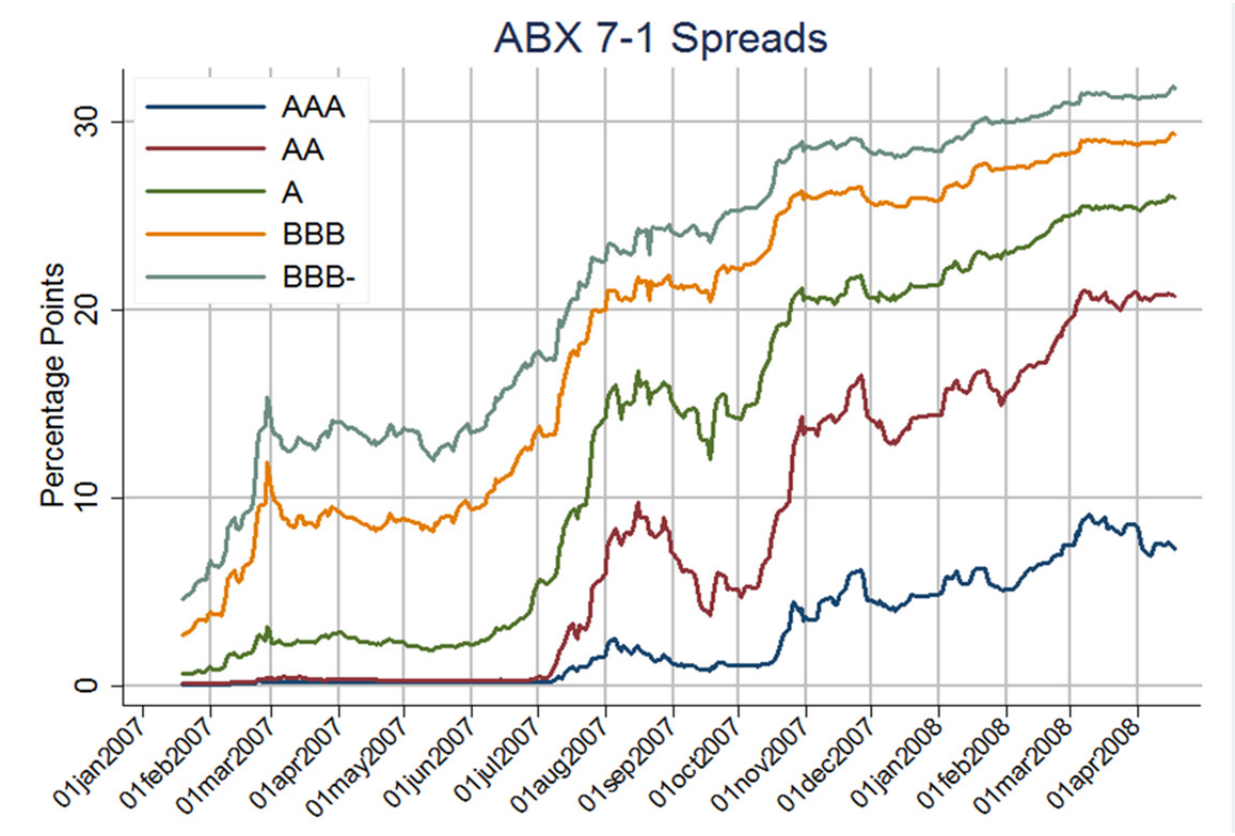
There is evidence that traders were sensitive to some risk factors. Figure 4 shows the prices of the four vintages of the AAA tranche of the ABX.HE index CDS that traded before the ABX market closed (Stanton and Wallace (2011)). Vintages are six months apart. All vintages traded at par until the July 2007 collapse of the Bear Stearns funds, consistent with the Perraudin-Wu evidence (Figure 3.) The January 2006 vintage held up much better than the later vintages, with the last vintage (July 2007) performing the worst. This may reflect the structure of tranches, but also the quality of the assets.[17] As Gorton (2009) explains subprime securitisation used dynamic buffers: initially, the buffer was very thin, but with time, as housing prices rose and refinancing took place under favourable conditions, some of the incoming cash was channelled to strengthen the buffer. For this reason, the older tranches were better protected than the younger ones. They may also have been of higher quality to begin with because demand for collateral forced later tranches to use more marginal collateral (see Benmelech and Dlugosz (2010)).

We can also see from Figure 5 that ABX pricing was sensitive to the rating of tranches. It is conceivable that risk was accurately priced conditional on the sparsely available evidence (see, however, Adelino (2009)). However, the contagion from the Bear Stearns and the BNP Paribas events also suggest that substantial amounts of information had been hidden from the markets.

As for crisis forecasting, the continued impairment of subprime tranches as measured by ABX spreads did nothing, really, to forecast systemic risk. Figure 6, taken from Gorton (2009), superimposes the development of an average (across tranches) of ABX subprime spreads (in red) on the path of the Libor-OIS spread (in blue), which is a widely used measure of systemic risk. At no point does the blue line show a clear warning of an imminent crisis, though the Libor-OIS spread did jump to a somewhat higher (some would say more normal) level after the summer of 2007. This appears typical of the way contagion develops. The fire first spreads around the periphery (see Figure 5) until some significant event like Lehman's collapse gets people to realise that the core is at risk. For quite a while Europe was confident that the financial crisis would be contained within the United States, showing how little traders knew about the depth of the European involvement in the US shadow banking system and the interdependencies that between the US and the European financial markets that this created.

[17] The main point in Stanton and Wallace (2011) is that the drops in CDS prices were far too severe to be rational. The CDS market did recognise differences in quality, but had a hard time with accurate price levels. The authors conclude that even CDS with double-sided bets are not reliable indicators of systemic default risk.

ABX spreads by class January 2007 – April 2008 Figure 5



Source: Gorton (2009)

ABX aggregate (BBB tranche) versus LIOS spread Figure 6

Note: ABX is for the 2006-1 BBB tranche. LIOS is on left-hand side y-axis. ABX spreads are on right-hand side y-axis.

Source: Gorton (2009)

7. Shadow banking

The rapid growth of shadow banking and the use of complex structured products have been seen as one of the main causes of the financial crisis.[18] It is true that the problems started in the shadow banking system, but before we jump to the conclusion that shadow banking was based on unsound, even shady business practices, it is important to try to understand its remarkable expansion. Wall Street has a hard time surviving on products that provide little economic value. So what drove the demand for the new products?

It is widely believed that the global savings glut played a key role. Money from less developed countries, especially Asia, flowed into the United States, because the US financial system was perceived to be safe (Caballero et al (2008)). More importantly, the United States had a sophisticated securitisation technology that could activate and make better use of collateral (Caballero (2009)). Unlike the traditional banking system, which kept mortgages on the banks' books until maturity, funding them with deposits that grew slowly, the shadow banking system was highly scalable. It was designed to manufacture, aggregate and move large amounts of high-quality collateral long distances to reach distant, sizable pools of funds, including funds from abroad.

Looking at it in reverse, the shadow banking system had the means to create a lot of "parking space" for foreign money. Securitisation can manufacture large amounts of AAA-rated securities provided there is readily available raw material, that is, assets that one can pool and tranche. The United States did have a large latent pool of assets: housing. Any house that was debt-free or underleveraged was potential raw material for securitisation. Put more colourfully, a house without debt was an ideal parking spot for foreign money searching for a safe home – literally. Underleveraged homes were depriving foreigners of the opportunity to store wealth at low risk. Accordingly, home equity loans (HEL) exploded. At their peak, 50% of ABS issues came from HELs (Figure 7), a massive amount of new parking space.

The lengthy chains of intermediaries that make up the shadow banking system – hedge funds, dealer-brokers, money market mutual funds, as well as government-sponsored entities (GSEs) –are seen by some as far too complex. I am suggesting that it was an efficient transportation network for collateral that was instrumental in meeting the global demand for safe parking space. Figure 8, taken from Krishnamurthy et al (2014), gives a schematic overview of the system; see also Copeland et al (2010, 2014).

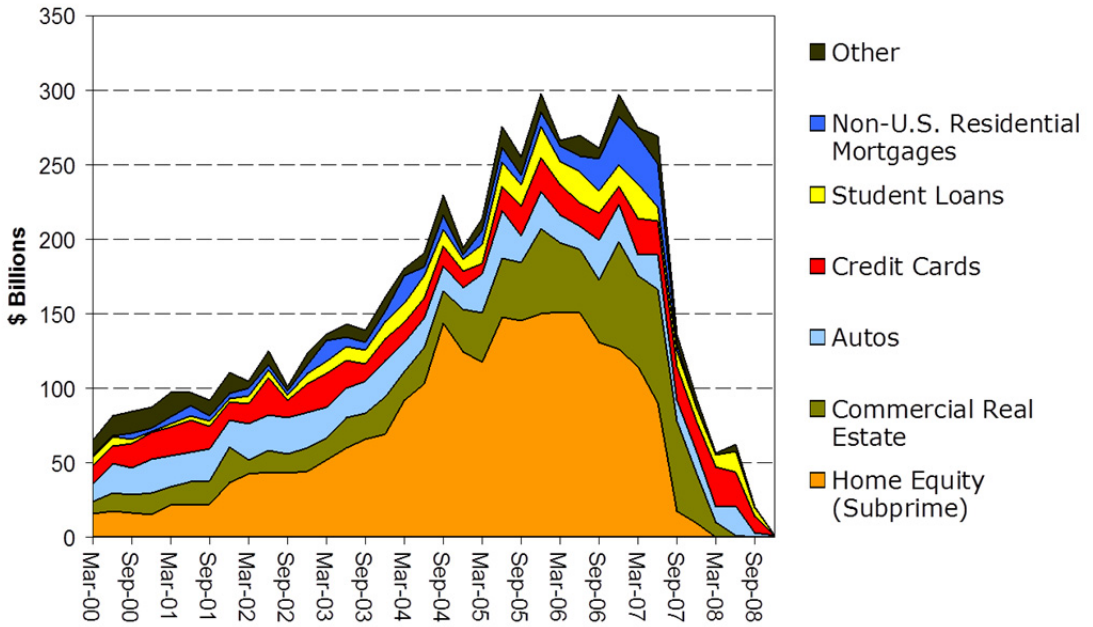
The distribution of debt tranches throughout the system, sliced and diced along the way, allowed contingent use of collateral. Like a parking space that is shared by many cars, depending on the time of the day or the week, state-contingent use of capital is more efficient than keeping mortgages on the books of the originating banks.[19] Collateral has been called the cash of shadow banking

[18] Shadow banking constituted roughly 10% of the financial intermediation sector in 1980; by 2008 it was more than half of it at 60%. See Potszar et al (2010).

[19] Collateral on the books of a bank is also continuously redeployed as depositors change and money is lent to new projects; but not to the extent of the collateral in shadow banking. More importantly, banks are local, while shadow banking was global.

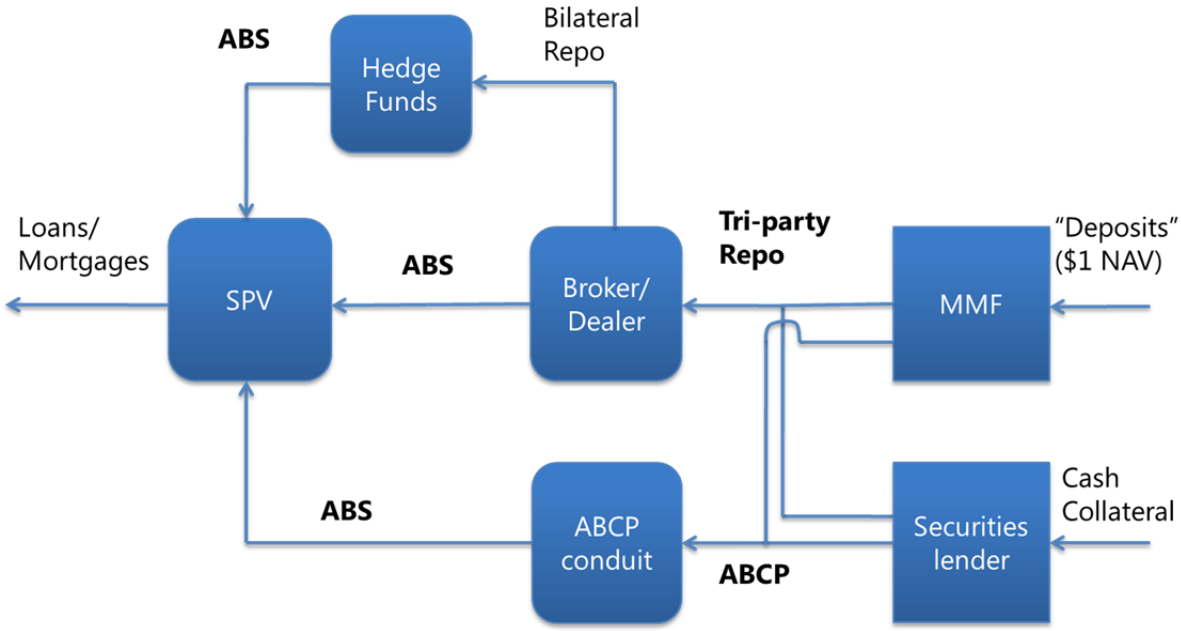
(European repo council (2014)). It is used to secure large deposits as well as a host of derivative transactions such as credit and interest rate swaps.

New Issuance of Asset Backed Securities (previous three months) Figure 7



Source: JP Morgan

Intermediation in shadow banking Figure 8



There is a relatively recent, but rapidly growing, body of theoretical research on financial markets where the role of collateral is explicitly modelled and where the distinction between local and global collateral is important; see for example

Geanakoplos (1996, 2010), Holmstrom and Tirole (1997, 1998, 2011), Caballero and Krishnamurthy (2001), and Rampini and Viswanathan (2010). My work with Tirole highlights the contingent use of collateral. We employ a model where firms cannot pledge the full income to investors because of moral hazard or enforcement problems. Only the pledgeable income of firms can serve as collateral. In each state of nature there is a limited amount of aggregate collateral determined by the total pledgeable income from all the firms' investment plans. In some states, there is a shortage of aggregate collateral much as there appears to be a shortage of private safe assets in the market today. In such states collateral earns a liquidity premium. This premium, in turn, will determine the firms' optimal investment and reinvestment plans. In equilibrium, prices and plans will match and the aggregate collateral in each state will be distributed according to need. In a dynamic version of the model (Holmstrom and Tirole (2001)), collateral is reallocated as uncertainty unfolds. The equilibrium outcome is constrained efficient, so contingent pricing and use of collateral is socially desirable. Moreover, when there is a serious enough shortage of collateral, the government will find it optimal to alleviate the situation by supplying collateral that is backed up by taxpayer money. This is more efficient than having the private sector invest in safe assets to cover exceptional severe shortages. The advantage of the government is that it can act ex post, when it is clear that such a shortage is at hand. No funds are tied up in advance.

Viewed through this theoretical lens, the rise of shadow banking makes perfectly good sense. It expanded in response to the global demand for safe assets. It improved on traditional banking by making collateral contingent on need and allowing it to circulate faster and attract more distant capital. In addition, securitisation created collateral of higher quality (until the crisis, that is) making it more widely acceptable.[20] When the crisis hit, bailouts by the government, which many decry, were inevitable. But as just discussed, the theory supports the view that bailouts were efficient even as an ex ante policy (if one ignores potential moral hazard problems). Exchanging impaired collateral for high-quality government collateral, as has happened in the current crisis (as well as historically with clearing houses), can be rationalised on these grounds.

8. Some policy implications

The design of money market policies and regulations should recognise that money markets are very different from stock markets. Lessons from the latter rarely apply to the former, because markets for risk-sharing and markets for funding have their own separate logic. The result is two coherent systems with practices that are in almost every respect polar opposites.

Debt and institutions dealing with debt have two faces: a quiet one and a tumultuous one. This is evident in the behaviour of individual debt contracts as

[20] There seems to be a misunderstanding among the public that AAA tranches cannot be created out of subprime assets. In fact, massive amounts of AAA tranches were produced under the assumption that risks were relatively independent as they had been since the Great Depression. There is nothing unsound with creating AAA tranches through securitisation. But the amounts proved excessive given an unexpected aggregate shock (see Coval et al (2009)).

illustrated by the hockey stick (Figure 1), and seems to apply equally, though much less frequently, at the system level. The shift from an information-insensitive state where liquidity and trust prevails because few questions need to be asked, to an information-sensitive state where there is a loss of confidence and a panic may break out is part of the overall system: the calamity is a consequence of the quiet. This does not mean that one should give up on improving the system. But in making changes, it is important not to let the recent crisis dominate the new designs. The quiet, liquid state is hugely valuable.

As an application of these general thoughts, consider the concrete question how to get out of a crisis. In the fall 2008, the US government was planning to spend its emergency fund on purchasing toxic assets. It did seem wrong-headed at the time and I think in hindsight as well. A crisis ends only when confidence returns. This requires getting back to the no-questions-asked state. This will not happen by removing the bad assets from the balance sheet of banks and financial institutions, because enough people would have to be convinced that the clean-out is sufficiently complete, a monumental task as Morris and Shin's (2005) work suggests. Even if toxic assets had been bought in large quantities, people might have wondered about the quality of the remaining assets on the balance sheets of banks. The logic of debt also suggests that this road is too expensive in a setting where no institutional infrastructure exists for price discovery. Transparency would likely have made the situation worse.

Fortunately it was not the path the United States chose. Instead, the core of the banking system was recapitalised. The process was somewhat transparent, because a large enough share of the public had to be convinced that enough was added to the banks' balance sheets to eliminate further questions. The stress tests, and the degree of transparency, were instrumental in getting us back to the liquid, no-questions-asked state.

The European stress tests in the summer of 2011 were not successful, partly because they did not consider the scenario of Greece defaulting, which led to implausibly small recapitalisation needs. In response to this, detailed information about the balance sheets of banks was made available for review, so that investors could make their own judgments about the likelihood and costs of a Greek default. As one could have expected, transparency alone did nothing to calm markets. On the contrary, transparency may have aggravated the subsequent increase in European sovereign spreads. In all fairness, Europe may not have had the funds to recapitalise the European banking system, but transparency without remedial action is a prescription for disaster.

What did eventually calm the European money markets? Governor Draghi's statement "we will do whatever it takes – and you better believe it is enough". This is as opaque a statement as one can make. There were no specifics on how calm would be re-established, but the lack of specific information is, in the logic presented here, a key element in the effectiveness of the message. So was the knowledge that Germany stood behind the message – an implicit guarantee that told the markets that there would be enough collateral, but not precisely how much. A detailed, transparent plan to get out of the crisis, including rescue funds, which were already there, might have invited differences in opinion instead of leading to a convergence in views. Explicit numbers can be put into spreadsheets and expertise and ingenuity can be applied to evaluate future scenarios. "Whatever it takes"

cannot be put into a spread sheet and therefore promotes liquidity of the "symmetric ignorance" variety.

By now, the methods out of a crisis appear relatively well understood. Government funds need to be committed in force (Geithner (2014)). Recapitalisation is the only sensible way out of a crisis. But it is much less clear how the banking system, and especially shadow banking, should be regulated to reduce the chance of crisis in the first place. The evidence from the past panic suggests that greater transparency may not be that helpful. As an early warning signal, the ABX market did not seem to work: it reacted strongly to the Bear Stearns shock in July 2007, but it did not give advance warning (see Section 6). Relying on market discipline and price discovery is unlikely to be effective in money markets generally. Letting the successful pricing of systemic risk in stock markets be a guide for money markets seems misguided.

The logic of over-capitalisation in money markets leads me to believe that higher capital requirements and regular stress tests is the best road for now. Should stress tests be transparent or be kept secret? Schuermann (2013) and Goldstein and Leitner (2011) provide insightful and comprehensive reviews of the pros and cons. Transparency can provide some market discipline and give early warning of trouble for individual banks. But it may also lead to strategic behaviour by management. The question of market discipline is thorny. In good times market discipline is likely to work well. The chance that a bank that is deemed risky would trigger a panic is non-existent and so the bank should pay the price for its imprudence. In bad times the situation is different. The failure of a bank could trigger a panic. In bad times it would seem prudent to be less transparent with the stress tests (for some evidence in support of this dichotomy, see Machiavelli (1532)).

9. Concluding remarks

Does the rise of shadow banking mean that the ancient logic of pawning is about to be replaced? The growing enthusiasm for covered bonds could be a harbinger of what lies ahead. Covered bonds are quite transparent. Banks are obliged to report regularly and in detail on the cash flow and substitutions in the asset pools that secure covered bonds. I see this development as a reflection of the general principle that financial intermediaries substitute information for collateral when collateral is expensive and do the reverse when collateral is cheap (Holmstrom and Tirole (1997)). Over-collateralisation is becoming more expensive, because there are fewer safe assets in the aftermath of the crisis. At the same time, the cost of monitoring is shrinking due to better information technology. More intensive monitoring is the logical consequence. This may shift the balance towards more transparent, more globally traded assets. Whether this is a permanent shift or a temporary one remains to be seen. The expense associated with running information-intensive money markets is likely to curb their use. Information-sparse debt is unlikely to disappear any time soon.

Covered bonds are coming under closer scrutiny, because of the risk shifting. They give the big banks better access to global, hence cheaper, funding. Also, the assets used to cover the bonds have to be of highest quality or else they would not be accepted on the international markets. This eats into the fabric of traditional banking; the remaining collateral that backs up unsecured depositors is poorer. This

is a concern for governments, because it raises the risk in the national banking system and the implicit cost of deposit insurance. Regulators will surely put caps on what fraction of assets can be carved out, which is another reason why high-quality, transparent debt is unlikely to dominate debt markets.

Let me close by noting that I have said very little about systemic risk. I have explained why money markets function the way they do and that most of it makes perfect sense. The errors were not so much in the design as they were in the implementation and scale. But as the unpleasant trade-off emphasised, there is a danger in the logic of money markets: if their liquidity relies on no or few questions being asked, how will one deal with the systemic risks that build up because of too little information and the weak incentives to be concerned about panics. I think the answer will have to rest on over-collateralisation, stress tests and other forms of monitoring banks and bank-like institutions. But my first priority has been to exposit the current logic and hope that it will be useful for the big question about systemic risk as we move forward.

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Comments by Philipp Hildebrand

Regulatory measures taken since the global financial crisis have impacted the structure of financial markets as well as the capital and liquidity requirements of financial institutions. For example, the recent adoption in Europe of the Capital Requirements Directive IV and the Bank Recovery and Resolution Directive has brought about higher capital requirements for banks and has put in place recovery and resolution regimes for failing financial institutions. These regulatory developments have changed the risk profile of debt investments in financial institutions.

The capital structure of banks will now be capable of absorbing losses on a going or gone concern basis, subject to certain trigger conditions. The bail-in-able nature of bank capital structures going forward makes the risks assumed by investors more dynamic – at times debt investors will face equity-type risks. Furthermore, the changes in market structure that have served to restrict the ability of banks to disintermediate risk, coupled with regulatory changes that increase the demand of banks for high-quality collateral, will – ceteris paribus – increase financial asset volatility. For investors in highly levered institutions, this increase in asset volatility is unwelcome and it is important that they properly ascertain the level of unencumbered assets available to satisfy claims in the event of a firm's resolution. This dynamic and the nascent capital structure mean that it is rational for debt investors to seek increased transparency to gauge the risk of encountering losses and to understand the levels to which they may be impaired.

Comments by Ernst-Ludwig von Thadden[21]

Bengt Holmström's paper is a response to the Great Financial Crisis of 2007–09, a crisis that started in the US mortgage market, almost brought down the world economy and led to the European debt crisis of 2009–12, which is still holding much of Europe in its grip. This crisis has been one of the most dramatic economic events of the last 100 years, and it poses considerable challenges to economists and economics. Different from what media and politicians sometimes suggest, economic theory has a lot to say in order to understand what went wrong, but considerable questions remain, and whole subfields of economics are slowly changing their focus and their relative importance in the overall discipline.

Very few scholars are as qualified to take stock and ask basic questions about these developments as Bengt Holmström. His work about incentives, institutions and market failures has shaped economics since 1979, when his first paper on moral hazard and observability was published. In the light of what has happened in financial markets since 2007, the economic profession, finance professionals and regulators would have been well advised if they had taken Holmström's work even more seriously.

Holmström's theme in his present paper is basic in the best sense of the word and goes right to the heart of finance. He argues that collateralised debt, the cornerstone of the financial system, is highly beneficial and dangerous at the same time. It is beneficial because it enables financial transactions at the lowest possible information cost most of the time, and it is dangerous because the informational advantage can turn into a severe disadvantage in adverse conditions.

His argument is based on work on optimal security design with Dang and Gorton (in particular, Dang et al (2011) – the references to this line of research are somewhat opaque). This research shows that debt is optimal in a framework where an economic agent wants to buy a security knowing that she may later have to sell the security, after the possible arrival of new information. In this framework debt is optimal because it is least information-sensitive. This is true in the even more general security design problem, where the initial buyer of the security can use this security to design a new security in the future: she will want to buy debt today in order to issue collateralised debt tomorrow. Hence, "debt on debt" or hypothecation chains in the shadow banking world of the 2000s are optimal responses to information asymmetry or information acquisition incentives. They are optimal precisely because they minimise informational requirements along the contracting chain. Therefore debt is opaque for as long as "the music is playing", as the famous saying by Charles Prince, the CEO of Citigroup, went in 2007.

This argument that debt is the optimal financial security in response to informational problems between borrowers and lenders has been made in several other contexts: debt economises on information collection costs at the contract execution stage (Townsend (1979)), debt economises on liquidation costs of collateral (Hart and Moore (1998)), debt mitigates managerial moral hazard (Innes (1990)), debt is an optimal response to private information at the contracting

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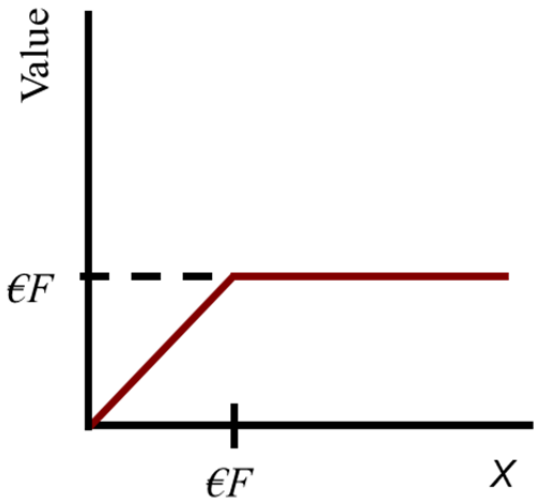
stage (Nachman and Noe (1994)), debt is least information-sensitive to ex post public information (DeMarzo et al (2005)) and debt can optimise information collection if lenders screen borrowers at the contracting stage (Inderst and Müller (2006)). All these are, or can be cast in terms of, information-based theories of debt. This list is not exhaustive, and Dang et al add an important new element to the list, which is particularly relevant for the recent experience of shadow banking. In the present paper, Holmström builds on the whole list of information-based theories of debt, to emphasise that the informational advantage of secured debt, very generally, comes at a necessary cost: at times when returns are bad, markets that are not well equipped to deal with information processing get overloaded and can become dysfunctional.

Underlying this general argument is the general feature of debt expressed in the classic picture of the inverted hockey stick in Figure 1: if the value *X* of the asset underlying the debt contract (project cash flow or collateral) is sufficiently high, then debt is trivial and mechanic; if it is low, then the value of debt depends very strongly on the underlying asset value, because the payout is given by the 45-degree line in the diagram.

The inverted hockey stick — Figure 1



This fundamental feature of secured debt, that it economises on information production and facilitates trade, leads to a clustering of attributes of debt markets that are structurally very different from those of equity markets. Some of these features are collected in Table 1, but the list is by no means exhaustive. This view of debt markets is likely to be very important for policy, but also intellectually fascinating. Although this analogy is not drawn in the paper, it is reminiscent of Holmström's and Milgrom's (1994) work on the theory of the firm. In that work, they argue that the firm should be understood as a cluster of complementary attributes. The current paper can be viewed as an attempt to carry this kind of reasoning further into the organisation of markets.

Features of debt and equity markets Table 1

Debt	Outside equity
Opaque	Transparent
Collateralised	Unsecured
Funding purpose	Risk-sharing purpose
Bilateral	Anonymous
Large average trades	Small average trades

However, this information-based view of debt characteristics ignores one crucial aspect of debt that, in my view, is particularly important for understanding financial crises. This is the fact that debt is usually provided for a limited, fixed period of time, while equity is committed forever. As a consequence, equity requires only a (variable) period return to investors, while debt requires a (less variable) period return to investors *and* the repayment of the principal at maturity. Hence, equity concerns only the period returns of a specific project or investment, while with debt the whole structure is at stake. This makes a big difference, because period returns are an order of magnitude smaller than the principal.

To see this point simply and clearly, let us remind ourselves of the basic valuation formula for a cash flow of €1 accruing from next period until the end of times, if the period interest rate *r* is constant:

(1) $$\sum_{t=1}^{\infty}\left(\frac{1}{1+r}\right)^{t}=\frac{1}{r}$$

Thus, for example, even with a rate of interest of 5% (which in Europe would raise nostalgia in the today's era of Draghian monetary economics), the principal of an investment is 20 times larger than the coupon payment, if the investment is financed by infinite-maturity straight debt. With this difference in magnitudes, the fact that debt is less outcome-contingent than equity becomes less relevant. Let me make that case by constructing two different artificial securities that combine debt and equity characteristics somewhat differently from what we are used to.

The first security is an infinitely lived debt security (a consol), which repays a fixed amount of cash each period forever, with no repayment of principal. The second security is a finitely lived equity security, which repays *x*% of EBIT plus principal after one period. Comparing these two securities, the debt security is indeed very information-insensitive, while the equity security is very information-sensitive, just like in Holmström's taxonomy. However, the debt security is the one that provides stability and is not likely to trigger crises, because it concerns only a very small part of the investment's value, while the equity security creates fragility rather than absorbing risk, because it puts the whole investment at stake every period.

The point here is, of course, the rollover risk usually associated with debt. This rollover risk may be due to information concerns, but does not have to be. To put this differently, if fundamentals turn bad and a debt security becomes information-sensitive, then this concerns the 45-degree line of the whole investment in the picture of Figure 1. An equity security will always be sensitive to the underlying fundamental value, but this concerns only the returns generated by the investment,

not the investment itself. That investment is never called into question by equity (the manager's fate is a different story). In a first-best world, this is all equivalent, and securities are refinanced if and only if this is warranted by the long-term cash flow fundamentals. In fact, formula (1) provides the simplest version of the link between the investment and its future cash flow stream. But, of course, we are discussing a second-best world here.

Even in practice, this distinction may not matter most of the time. But the Great Financial Crisis has shown that collateralised short-term debt used as an instrument to fund longer-term investments in the shadow banking sector suddenly ceased to function according to the usual routine. Investors who believed that they were far out on the horizontal part of the inverted hockey stick, because they had regularly received their flow returns, suddenly believed that they were at the very bottom of the stick and that their whole investment was at stake. This happened in several key market segments, such as with ABS conduits after August 2007, in the triparty repo market after March 2008 and in money market funds after September 2008. In all three market segments, this change of mind led to precipitous losses of funding during these key moments of the crisis and ultimately to more or less complete disintermediation in the autumn of 2008.

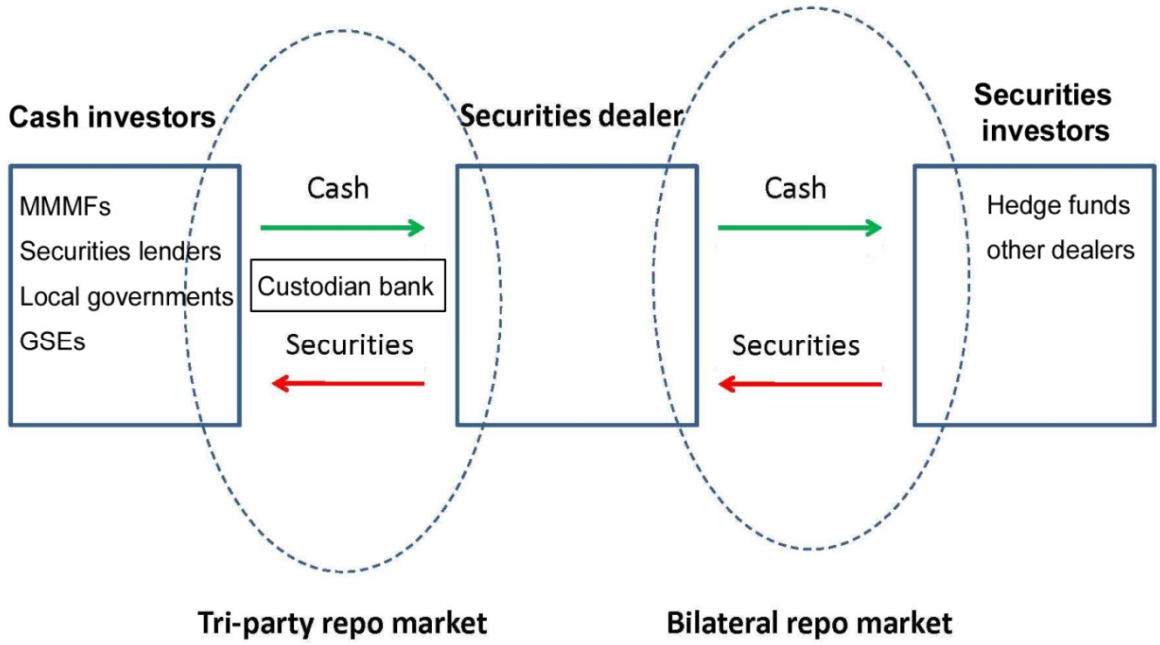
This discontinuous unravelling of short-term debt markets is not part of Holmström's story, although it is not inconsistent with it. In Martin et al (2014a,b), we propose a theory that addresses precisely this issue and propose a theory of the fragility of secured short-term funding markets due to rollover risk, which has liquid and profitable borrowers in normal times along with the possibility of precipitous funding losses in crisis times.

The theory is cast in an infinite horizon model of overlapping investors with one good that can be stored, consumed or invested. There are two classes of agents. First, "investors" who receive endowments each period, have no investment opportunities of their own and are subject to liquidity shocks; and, second, "borrowers" (broker-dealers, investment banks etc) who are long-lived, have heterogeneous profitable long-term investment opportunities, but no endowment of funds.

Figure 2 provides a stylised description of the hypothecation chain in repo markets. The model applies to the left-hand part of that chain, where the triparty repo market is central, and equally to the right-hand part, which pictures the bilateral repo market. But the model is sufficiently general to also cover other institutions, such as borrowing and lending by money market mutual funds (which would be located to the left of the chain in the figure).

In the equilibrium of the model, investors lend short-term to borrowers against sufficient collateral, where collateral is necessary to give borrowers the incentive to repay. The amount of collateral is not pinned down in equilibrium, as long as it is sufficiently large, and it does not enter equilibrium payoffs, because collateral is never liquidated. This is exactly as in Holmström's pawn shop, where borrower and lender do not have to assess the value of the watch as long as it is clear that the value is sufficiently large. Borrowers invest long-term and make positive profits. The reason why competition between borrowers does not erode profits is that if borrower profits were too low, they would have no incentives to borrow and would rather invest internal funds, such that the market for loanable funds would not clear, which is inconsistent with equilibrium. Hence, borrowers generate endogenous liquidity each period, which gives them the ability to withstand liquidity shocks.

A typical hypothecation chain Figure 2



Equilibrium therefore results in an endogenous maturity mismatch of borrower balance sheets, which provides a formal underpinning for Gorton and Metrick's (2012) interpretation of repo and related markets as shadow banking. Investors have no fundamental reason to worry about this mismatch, because they obtain positive short-term returns and can roll over the principal, but the situation is fragile in the sense that the borrowers' equilibrium liquidity buffers may not be sufficient to guarantee all outstanding stocks of loans.

The balance sheet mismatch now can give rise to runs. These are collective decisions of investors not to continue lending and/or not to provide new funds. They can be triggered by the (self-fulfilling) anticipation of future runs, as argued by He and Xiong (2012), by sunspots, by new public information about collateral quality (which is not equilibrium-relevant, as noted above) or by investor sentiments such as in Gennaioli et al (2013). Two conditions are necessary for a run on a borrower to occur. First, the borrower must not survive the run, because runs don't occur if individual claims are not in jeopardy. Second, the run must be self-enforcing for investors in the sense that individual investors find it optimal to participate if sufficiently many other investors participate.

We show that both conditions may be satisfied, but need not, and this depends on borrower characteristics, equilibrium behaviour and the microstructure of the market under consideration. In particular, there is a sense in which the bilateral repo market is more resilient than the triparty repo market, which is consistent with the experience of 2008.

Unlike some other models of multiple equilibria, the debt model sketched here does have some predictive content:

- The model makes sharp predictions about who is prone to runs and why.
- The model can differentiate the impact of market microstructure on the determinants of runs (Martin et al (2014a)).
- The model can be used to evaluate contractual and regulatory responses to fragility.
- The model can distinguish between individual borrower illiquidity and market illiquidity (Martin et al (2014b)).

Like Holmström's theory of debt, the theory sketched above emphasises that collateralised debt provides stable funding for beneficial financial activity in "normal times" and that debt can become dangerous if new public information arises and/or market perceptions change. However, it does not emphasise the dangers of the slippery 45-degree line and of private information acquisition in the build-up of crises, but rather the danger looming in the stock of short-term debt when expectations change: a shift of stocks of debt outstanding can be more dangerous than a change in flows. This perspective may be a useful addendum to the brilliant broad-brush overview that Bengt Holmström has offered us in his paper.

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