Collateral Crises*

Gary Gorton† Guillermo Ordoñez‡

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PRELIMINARY AND INCOMPLETE

Abstract

Short-term, collateralized, debt is efficient if agents are willing to lend without producing costly information about the value of the collateral. When the economy relies on this informationally-insensitive debt, information is not renewed over time, generating a credit boom where firms with bad collateral start borrowing. We show a complex and opaque financial system is an optimal response to accommodate increasingly worse collateral and sustain more credit.

The longer an economy remains in an information-insensitive regime, the larger the fraction of collateral that looks similar. This creates fragility, since a small aggregate shock to collateral values is more likely to generate a large systemic collapse in output and consumption. Furthermore, if a crisis triggers information production, it renders expansionary policies less effective in speeding up recoveries.

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†Yale University and NBER (e-mail: gary.gorton@yale.edu)

‡Yale University (e-mail: guillermo.ordonez@yale.edu)

1 Introduction

The modern financial structure has been characterized by rising levels of complexity and declining transparency. After the recent financial crisis these elements have been at the forefront of the blame and the debate. Many regulatory changes have been proposed to induce more information production and transparency, regarding both the actions of financial intermediaries and the quality of financial instruments. Is the lack of transparency inherently pervasive? What are its costs and benefits? What determines the information available in an economy? How do information dynamics shape the size and likelihood of booms, crashes and recoveries?

In this paper we study the production and evolution of information in financial markets. We show that a complex and opaque financial system can be an endogenous optimal response of financial intermediaries to efficiently sustain more credit in the economy. These potential benefits come at the cost of increasing system fragility to aggregate shocks and the consequent size of crises and credit crunches. Furthermore, the evolution of information in the economy determines the speed of recoveries and the effectiveness of policies to deal with crises.

Financial intermediaries perform two key functions. On the one hand, they reallocate resources in the economy, from less productive agents to more productive ones. On the other hand, they provide efficient transactions services by designing their liabilities so that they can be used to trade without adverse selection. Examples are pre-Civil War bank notes (in the U.S.), demand deposits, and, of late, sale and repurchase agreements ("repo"). These bank liabilities can be used directly for transactions or can be transformed into a fixed amount of cash easily. In order to provide transaction services, bank liabilities are designed to be information-insensitive (i.e., it is not profitable for any agent to produce information about the backing assets) so that users do not face adverse selection. To accomplish this, bank money is "backed" by collateral (designated state bonds in the case of pre-Civil War free banks, or specific bond collateral that the depositor takes possession of in repo), or by a diversified portfolio of loans (in the case of demand deposits).

A crisis occurs when there is a shock causing bank liability holders to suspect that the backing collateral has deteriorated in value such that it has become information-sensitive. The bank debt holders then seek to withdraw their cash or they do not roll over the debt (e.g., in repo), causing a potential liquidation of the banking system. While the U.S. had an extraordinary period of quiet with respect to banking crises from 1934 to 2007, banking crises are, in fact, very common and very costly. There is a connection between recessions and financial crises. Financial crises tend to occur near business cycle peaks, when economic activity is starting to weaken and banking crises are often preceded by credit booms.[1]

In this paper we build on these micro foundations to investigate the role of such information-insensitive debt in a macro economy. We do not explicitly model the trading motive for short-term information-insensitive debt. We assume that households have a demand for such debt and, further, we assume that the short-term debt is issued directly by firms to households to obtain funds and finance efficient projects. The debt that firms issue is backed by collateral. We show that, while the lack of information acquisition improves trade and fuels credit booms, it also causes most collateral to look similar over time, increasing the potential losses in case of a crisis and slowing down a potential recovery.

The amount and nature of the borrowing depend on households' beliefs about the value of the collateral, and on the households' decisions about whether or not to produce information about the collateral value. Each firm's collateral can be either good or bad and its perceived quality is given by the probability that the collateral is good. To determine the real quality of the collateral is costly. If households have incentives to learn about the true quality of the collateral, firms may prefer to cut back on the amount borrowed to avoid costly information production, a credit constraint. However, firms whose collateral is of intermediate perceived quality may prefer to have information produced, and offer an interest rate that covers the cost of information production by households.

We show that if, the expected quality of the collateral available for a firm is low, then firms maximize borrowing by structuring the collateral so that is complex, increasing the cost of information acquisition (e.g., a complex structured mortgage backed security). As more credit is needed in an economy, and lower quality collateral is needed, more credit is obtained by making the collateral in the system more and more complex. When the increase in complexity is an endogenous response to the need to use

[1]See Gorton (1988), Desmirguc-Kunt and Detragiache (1998), and Reinhart and Rogoff (2008 and 2009), Caprio and Klingebiel (1996 and 1997) and Laeven and Valencia (2008).

lower quality collateral, it makes the system more sensitive to negative aggregate shocks to the expected value of collateral.

We focus on the dynamics of firms issuing information-insensitive debt and those issuing information-sensitive debt. If households know a firm has good collateral, they are willing to lend the optimal amount of capital that firms require. If they know a firm has bad collateral, they are not willing to make any loan to the firm. We assume all collateral changes quality with a certain probability, so if households do not renew the information, they decide on the loan based on the perceived collateral quality. When the perceived quality is high enough firms with good collateral can borrow, but in addition some firms with bad collateral can borrow. In fact, consumption is highest if there is no information production, because then all firms can borrow, regardless of their true collateral quality. In our setting opacity dominates transparency and the economy enjoys a blissful ignorance.

If there has been information-insensitive lending for a long time, there can be a significant depreciation of information in the economy and only a small fraction of collateral with known quality. In this setting we introduce aggregate shocks that may increase or decrease the average value of collateral in the economy. We show that the longer information about the collateral has not been renewed, the greater the credit boom but also the greater the fragility characterized by a larger drop in consumption when a negative aggregate shock hits. In other words, a shock of a given size can have a larger impact on consumption the longer the preceding credit boom. The reason is that a negative aggregate shock affects more collateral than the same aggregate shock when the value of collateral is known. Hence, the size of the downturn depends on how long debt has been information-insensitive in the past.

The crisis may trigger information production or not, having key implications for the speed of recovery after a crisis. If the negative aggregate shock does not trigger information production (firms reduce borrowing to avoid information acquisition) the recovery takes more time to occur. However, expansionary policies that intend to speed up the recovery are more effective if the crisis does *not* induce information production. In other words, information production speeds up recoveries if governments are not expected to react to the crisis, but delay recoveries if agents expect the government to take actions to improve the economic conditions.

Related Literature

This paper is related to two strands of literature: Financial intermediation and its effects on macroeconomics and business cycles. As suggested above, our starting point is that the raison d'être of financial intermediation is the production of short-term bank debt for transactions purposes. Gorton and Pennacchi (1990) argue that intermediaries exist to create trading securities that are immune to adverse selection when used by agents in markets. In their setting, the securities used were riskless debt securities, backed by bank assets. The notion of "liquidity" proposed was the idea that trade was facilitated by securities that were immune to adverse selection. Diamond and Dybvig (1983), on the other hand, view "liquidity" as consumption smoothing. While both papers assumed that debt was optimal, Dang, Gorton, and Holmström (2011) show that debt is in fact the optimal trading security. The debt need not be riskless, but its defining characteristic is that it is "information-insensitive," which means that it is common knowledge that it is not profitable to produce (costly) information about the payoff on the security.[2] There is no adverse selection when trading. A shock, however, can cause previously information-insensitive debt to become information-sensitive, possibly leading to a crisis.

As in Bernanke and Gertler (1989), Kiyotaki and Moore (1997) and Holmström and Tirole (1998), our paper focuses on the magnification and persistence effects of financial markets on real activity. However, unlike those papers, we focus on the dynamics of information acquisition and its effects on generating credit booms and magnifying crises. Differently than Kiyotaki and Moore (1997), collateral is not directly needed in production but helps to relax financial frictions in obtaining credit to produce. Endogenous information production determines the fraction of collateral that can be used to sustain credit and the fraction of collateral that suffers in case of negative aggregate shocks.

Our paper is also related to the literature that studies the role of uncertainty on booms, crises and recoveries. Bloom (2009) shows that uncertainty shocks can create recessions with delayed recoveries, since firms may freeze hiring and investment. Bachmann and Moscarini (2011) show that recessions can generate an increase in uncertainty, since firms are more willing to experiment with prices to learn about their true demand when economic conditions are poor. In this literature, uncertainty can be

[2]See also Andolfatto (2010) and Andolfatto, Berensten, and Waller (2011)

captured by the cross sectional dispersion of firms in variables such as stock returns. In our paper, a negative aggregate shock on the value of collateral also generates an increase in uncertainty, since information about collateral is acquired and there is more heterogeneity in the access to credit across firms.

Our paper is also related to the literature on leverage cycles developed by Geanakoplos (1997 and 2010). His work relies on low volatility and innovation for the buildup of leverage, and a jump in uncertainty for the sudden decline. In our paper, crises are generated by a negative aggregate shock in the expected value of collateral, which generates a jump in uncertainty. Furthermore, we explicitly derive real effects and welfare implications from endogenous regime change in terms of information production. Finally, the paper also adds to the literature on asymmetric cycles. Veldkamp (2005) and Ordonez (2009) study slow booms and sudden crashes generated by learning about endogenous economic conditions. Here, endogenous dynamics of information acquisition also generates asymmetric cycles, but from loosing information rather than processing it to learn.

In the next Section we present the model. In Section 3 we study debt decisions by a single firm. In Section 4 we study the aggregate and dynamic implications of information sensitiveness. In Section 5 we show a numerical simulation to illustrate our results. We consider the choice of collateral in Section 6 and policy implications in Section 7. Empirical evidence is briefly presented in Section 8. In Section 9, we conclude.

2 Model

In the economy, two overlapping generations coexist per period. Each cohort is composed by a mass 1 of individuals who live for two periods: "young" and "old". Each generation is risk neutral and there is no discounting. We interpret the "young" generation as "households", with income and no entrepreneurial ideas or managerial labor, and the "old" generation as potential "firms", with no income on their own but with managerial labor.

Each household is born with an endowment of the numeraire good, $\overline{K}$. This numeraire good is perishable and cannot be stored for consumption in the next period.

When getting "old", each household develops a fixed amount of managerial labor L^*. We interpret L^* as entrepreneurial ideas or managerial abilities, which does not generate any disutility. In the economy there is a mass 1 endowment of land X, which is non-perishable. A firm is defined as a combination of a unit of land, labor L^* and some amount of the numeraire good K used as capital that can produce Y units of numeraire good K with the following stochastic Leontief production function:

$$Y = \begin{cases} A \min\{K, L\} & \texttt{with prob. } q \\ 0 & \texttt{with prob. } (1-q) \end{cases}$$

where $A > 1$. Since firms do not have any endowment of K, they need to borrow from the households to produce. We assume that the expected marginal product of capital is higher than its marginal cost $qA > 1$, hence production is efficient. Naturally, given the Leontief production function, $K^* = L^*$ is the level of capital that maximizes profits and is the amount that each firm tries to borrow. We also assume $\overline{K} > K^*$, hence households have enough endowment to finance efficient production by firms.

The land has an alternative use besides production. It is possible to extract C units of K from a good unit of land each period, while it is not possible to extract any K from a bad unit of land. When the land is used alternatively it cannot be used to sustain production anymore.

In every period, with probability λ the true quality of each unit of land remains unchanged and with probability $(1-\lambda)$ there is an idiosyncratic shock that changes land quality. In this last case, land becomes good with a probability $\hat{p}$, independent of its current type. Even when the shock is observable, the realization of the new quality is not, unless a certain amount of the numeraire good γ is used to learn about it. The idiosyncratic shock and the realization are assumed independent of the idiosyncratic production shock q. Conditional on the whole history of idiosyncratic shocks and monitoring results, all agents in the economy share a belief p, which is the probability the land is good.[3]

Having discussed the technology, preferences and objectives that agents face, we need to discuss the characteristics of the market for land and the market for loans. In this environment, young households lend K to firms at the beginning of the period and

[3]We abstract from the possibility of asymmetric information, under which the firm may potentially know more about the collateral than the lenders.

buy land from firms at the end of the period to be used when becoming a firm in the next period, when old. On the other hand, firms who acquired land when young, borrow K at the beginnings of the period to produce and sell the land at the end of the period to the next cohort of firms.

With respect to the market for land, we assume that each buyer matches with one seller and buyers have all the bargaining power (they make a take-it-or-leave-it offer), which means sellers will be indifferent between selling or not, in which case they just obtain the alternative product from the land.[4] Hence the price of a unit of land which is good with probability p is pC, the expected consumption of using the land in the alternative activity. We also assume that at the time of the transaction, the buyer knows whether the land suffers an idiosyncratic shock that affects its type next period or not (this is whether the land remains with the same p or gets a new draw which is good with probability $\hat{p}$).

With respect to lending, we assume lenders cannot observe or seize the production of the firms they finance, which means there is no lending unless there is some collateral lenders can liquidate in case of no repayment. We assume the firm can use the unit of land X that is required to produce as collateral. We also assume that firms have all the bargaining power when borrowing, which means lenders will be indifferent between lending or not.[5]

The firm can decide to use a fraction x of land as collateral. In case the firm decides not to pay back its debt, the lender can seize a fraction x of the proceeds the firm obtains from selling the land at the end of the period, this is xpC. Recall, in the aggregate, the mass of firms is independent of the number of firms that can pay back the debt or not. This is because firms end up selling the collateral to households that become firms in the next generation, regardless of their results. This implies there are no fire sales in our environment.[6]

[4]It is straightforward to modify the model to sustain this assumption, for example if a small fraction of households not only develops L^* when becoming firms but also get an endowment of new land. In this case there will be more firms selling land than households buying land. Since sellers who do not sell just deplete their unsold land, the mass of land sustaining production in the economy is invariant.

[5]It is straightforward to modify the model to sustain this assumption, for example if only a fraction of households develops L^* when becoming firms there will be more potential lenders than potential borrowers every period.

[6]This is a key difference with Kiyotaki and Moore (1997). In their paper credit cycles are generated by cyclical fluctuations in the endogenous price of collateral. In this paper, they will be generated by cyclical fluctuations in the endogenous information available in the economy about the collateral.

In every period, the expected consumption of a household ("young" generation) that lends and buys land that is good with probability p is $\overline{K} - K(p) + E(repay|p) - pC$. The expected consumption of a firm ("old" generation) that borrows and sells land that is good with probability p is $E(Y|p) - E(repay|p) + pC$. This implies that aggregate consumption in each period is the sum of aggregate consumption of households and firms. This is

$$W_t = \overline{K} + \int_0^1 [E(Y|p) - K(p)]f(p)dp$$

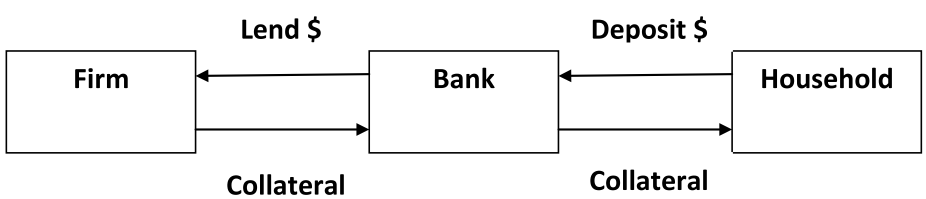
where $f(p)$ is the distribution of beliefs about collateral types in the economy. In the unconstrained first best all firms borrow and operate with K^*, regardless of beliefs p about the collateral. This implies that the unconstrained first best aggregate consumption in every period is

$$W^* = \overline{K} + K^*(qA - 1)$$

since $E(Y) = qAK^*$ in the first best.

The model is intended to capture the economic function of short-term debt, issued by financial intermediaries, e.g., demand deposits, sale and repurchase agreements, private bank notes, etc, in a completely self-contained macroeconomic model. The setting we have in mind is shown below in Figure 1.

Figure 1: Economic Function of Short-Term Debt



It is clear that our model has abstracted from the bank as we have the households lending directly to the firms. Furthermore, for simplicity, we have not modeled the transaction role of the short-term debt for the households, which is the focus of Dang, Gorton, and Holmström (2011). Instead we focus on the information dynamics. But, in so doing we do not want to be viewed as taking a stand on the role of the debt in lending, as opposed to its function as a transaction medium. When we look at some empirical tests, the model will be closer to the figure. But, for exposition in what follows we omit the banks.

We will proceed in three steps. First we analyze the borrowing decision of a single firm that has collateral which is good with probability p. Then, we study the aggregate output when the distribution of beliefs about the collateral quality in the economy has a constant mean $\hat{p}$ and an endogenously evolving variance. Finally, we introduce aggregate shocks that affect all collateral in the economy, in addition to the idiosyncratic shocks, changing the mean of that distribution.

3 A single firm

In this section we study the short-term debt contract between a single lender and a single firm and characterize the optimal debt the firm issues considering the possibility that the lender may want to produce information about the true quality of the collateral.

First we solve the optimal borrowing decision of a single firm that lives a single period, and decides whether to issue debt that triggers information production or not. Triggering information production (information-sensitive debt) is costly for the firm because it raises the cost of borrowing. However, not triggering information production (information-insensitive debt) is also costly because it may reduce the possible size of the loan. This trade-off determines the information sensitiveness of the debt and then the volume of information in the economy.

3.1 A Single Period

3.1.1 Information-Sensitive Debt

Lenders can learn the true quality of the land by paying an amount γ of the numeraire good. Since lenders are competitive and risk neutral, they break even based on the face value of the debt $R_{IS}(p)$ and the fraction $x_{IS}(p)$ of a land with expected price pC posted by the firm as collateral. This is, lenders should be indifferent ex-ante between producing information or not.[7] For simplicity we just denote the face value of debt

[7] We assume this interest rate R is not renegotiable after the lender finds out the collateral is good, otherwise there would never be incentives to produce information in the first place.

and the fraction of collateral posted as R and x.

$$p(qR_{IS} + (1-q)x_{IS}C - K) = \gamma \qquad \Rightarrow \qquad R_{IS} = \frac{pK + \gamma - (1-q)px_{IS}C}{pq}.$$

This equality shows the relation between R_{IS} and x_{IS}. However there is an additional condition that should be fulfilled, which is $R_{IS} = x_{IS}C$, this is debt is risk free because the firm should pay the same in case of success or failure. It is not possible that $R_{IS} > x_{IS}C$ because the firm would always prefer to hand in the collateral, also in case of success. Similarly, it is not possible that $R_{IS} < x_{IS}C$ because the firm would always prefer to sell the collateral directly in the market at a price C and give lenders R_{IS} rather than $x_{IS}C$ in case of failure. This condition pins down the fraction of collateral a firm which land is good with a probability p will post in equilibrium.

$$R_{IS} = x_{IS}C \qquad \Rightarrow \qquad x_{IS} = \frac{pK + \gamma}{pC}$$

with the natural restriction that $x_{IS} \leq 1$. This implies that the firm will be able to borrow the optimal K^* against a good collateral when $\frac{pK^*+\gamma}{pC} \leq 1$ (this is, for all collateral with $p \geq \frac{\gamma}{C-K^*}$). Otherwise the firm will be able to borrow less than K^*, even posting all the good collateral. In this case $\frac{pK+\gamma}{pC} = 1$ (this is $K = \frac{pC-\gamma}{p}$). Naturally, there is no lending, even if the firm post all the good collateral if $\frac{p0+\gamma}{pC} > 1$ (this is, for $p < \frac{\gamma}{C}$).

The expected profits from borrowing that triggers information production are

$$E(\pi|p, IS) = p(qAK - x_{IS}C) + pC$$

Plugging the equilibrium x_{IS} above, in case of borrowing K^*, expected profits are

$$E(\pi|p, IS) = pK^*(qA - 1) - \gamma + pC$$

The firm will decide to borrow rather than just sell the land if $pK^*(qA-1) \geq \gamma$, or $p \geq \frac{\gamma}{K^*(qA-1)}$. If $\frac{\gamma}{K^*(qA-1)} > \frac{\gamma}{C-K^*}$, or $qA < C/K^*$, the firm stops borrowing before the lender decides to lend less than K^* when discovering the land is good. Based on this assumption, expected profits are

$$E(\pi|p, IS) = \begin{cases} pK^*(qA-1) - \gamma + pC & \texttt{if } p \geq \frac{\gamma}{K^*(qA-1)} \\ pC & \texttt{if } p < \frac{\gamma}{K^*(qA-1)} \end{cases}$$

3.1.2 Information-Insensitive Debt

Another possibility for firms is to borrow without triggering information acquisition by lenders. Still it should be the case that lenders break even in equilibrium

$$qR_{II} + (1-q)px_{II}C = K \qquad \Rightarrow \qquad R_{II} = \frac{K - (1-q)px_{II}C}{q}.$$

As in the previous case, the condition $R_{II} = px_{II}C$ holds in equilibrium. Then we can obtain the optimal posting of collateral

$$R_{II} = x_{II}pC \qquad \Rightarrow \qquad x_{II} = \frac{K}{pC} \leq 1$$

Since $x_{II} \leq 1$, a restriction in borrowing without producing information is $K \leq pC$.

The problem the firm faces when issuing information insensitive debt is that lenders may decide to deviate, check the value of the collateral and ex-post decide whether to lend or not at the specified fraction x_{II}, before the firm gets to know such an information. Lenders want to deviate if the expected profits from acquiring information, evaluated at x_{II}, are greater than the cost of acquiring information γ. Hence, there are no incentives to deviate and acquire information if

$$p(x_{II}C - K) < \gamma \qquad \Rightarrow \qquad (1-p)px_{II}C < \gamma$$

that is, if the expected gains of producing information (learning the collateral is good allows the lender to sell it a higher price later $x_{II}C$ while lending the collateral is bad allows the lender not to lend) is smaller than the cost of producing information, γ.

It is clear from the previous condition that the firm can discourage information production about collateral, by reducing borrowing and output. If the condition is not binding, then there are no strong incentives for lenders to produce information and

$K = K^*$. If the condition is binding, the firm will borrow as much as possible given the restrictions of no triggering information acquisition,

$$K = \frac{\gamma}{(1-p)}.$$

Hence, information-insensitive borrowing is characterized by the following debt size:

$$E(K|p, II) = \min\left\{K^*, \frac{\gamma}{(1-p)}, pC\right\} \quad (1)$$

We focus on the case in which information-insensitive borrowing is characterized by three regions.[8]

$$K(p) = \begin{cases} K^* & \texttt{if } K^* \leq \frac{\gamma}{(1-p)} & \texttt{(no credit constraint)} \\ \frac{\gamma}{(1-p)} & \texttt{if } K^* > \frac{\gamma}{(1-p)} & \texttt{(credit constraint)} \\ pC & \texttt{if } pC < \frac{\gamma}{(1-p)} & \texttt{(collateral selling)} \end{cases}$$

The first kink is generated by the point at which the constraint to avoid information production is binding when evaluated at the optimal loan size K^*, this is when financial constraints start binding more than technological constraints. The second kink is generated by the constraint $x_{II} \leq 1$, below which the firm is able to borrow up to the expected value of the collateral pC without triggering information production.

Expected profits under information-insensitive borrowing are:

$$qAK - x_{II}pC + pC,$$

i.e., with probability q production is successful, the firm always pays back $x_{II}pC$ and the collateral has an expected value of pC. Then:

$$E(\pi|p, II) = E(K|p, II)(qA - 1) + pC \quad (2)$$

[8]This is the more natural case when $C > K^*$ and γ is not large (specifically $\gamma < \frac{K^*}{C}(C - K^*)$). If $C > K^*$ and $\gamma > \frac{K^*}{C}(C - K^*)$, then there are only two regions, where the middle region disappears. If $C < K^*$, then the first region is given by pC and not K^*, since pC is always smaller than K^*. In all cases the main conclusions we derive are the same.

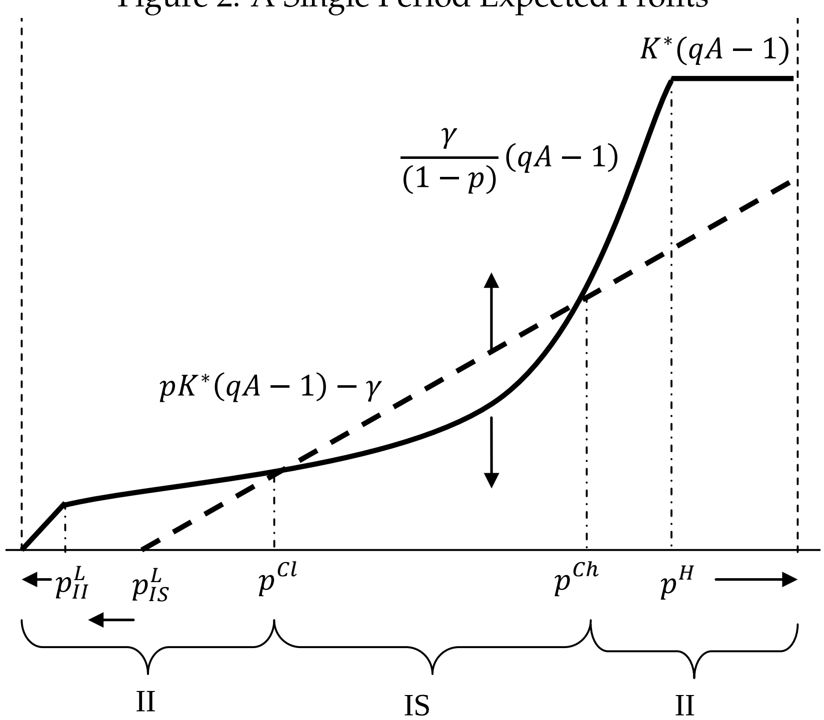
In the case we are focusing on, considering explicitly the kinks,

$$E(\pi|p, II) = \begin{cases} K^*(qA-1) + pC & \texttt{if } K^* \leq \frac{\gamma}{(1-p)} \\ \frac{\gamma}{(1-p)}(qA-1) + pC & \texttt{if } K^* > \frac{\gamma}{(1-p)} \\ pC(qA-1) + pC & \texttt{if } pC < \frac{\gamma}{(1-p)} \end{cases}$$

3.1.3 Optimal Debt

Figure 2 shows the profits under these two regimes for each possible p (after deducting the expected value of the collateral pC in all expressions). From the comparison of which one is larger we can obtain the values of p for which the firm prefers to borrow with an information-insensitive loan (II) or with an information-sensitive loan (IS).

Figure 2: A Single Period Expected Profits



The cutoffs highlighted in Figure 2 are determined in the following way: p^H is the p that generates the first kink of the profit function of an information-insensitive loan. This is the p below which firms have to reduce borrowing to prevent information production:

$$p^H = 1 - \frac{\gamma}{K^*}. \tag{3}$$

The cutoff p^L_{II} is obtained from the second kink of the profit function of an information-insensitive loan,[9]

$$p^L_{II} = \frac{1}{2} - \sqrt{\frac{1}{4} - \frac{\gamma}{C}}. \tag{4}$$

Similarly, the cutoff p^L_{IS} is obtained from the kink of the profit function of an information-sensitive loan:

$$p^L_{IS} = \frac{\gamma}{K^*(qA-1)}. \tag{5}$$

with the natural restriction that $p^L_{IS} = 1$ if $\gamma > K^*(qA-1)$.

Finally, the cutoffs p^{Ch} and p^{Cl} are obtained from equalizing the profit functions of information sensitive and insensitive loans and solving for the quadratic roots of:

$$\frac{\gamma}{(1-p)} = pK^* - \frac{\gamma}{(qA-1)}. \tag{6}$$

$$p^2 - p\left[1 + \frac{\gamma}{K^*}\frac{1}{(qA-1)}\right] + \frac{\gamma}{K^*}\left[1 + \frac{1}{(qA-1)}\right] = 0$$

There are only three regions of financing. Information-insensitive loans are chosen by firms with collateral with high and low values of p, while information-sensitive loans are chosen by firms with collateral with intermediate values of p.

To understand how these regions depend on the information cost γ, the four arrows in the Figure show how the different cutoffs and functions move as we reduce γ. In an extreme, when $\gamma = 0$, all collateral is information-sensitive (i.e., the IS region is $p \in [0,1]$), which is intuitive since information is free.

Contrarily, as γ increases, the two cutoffs p^{Ch} and p^{Cl} get together and the IS region shrinks until it disappears (i.e., the II region is $p \in [0,1]$) when γ is large enough (specifically, when $\gamma > \frac{K^*}{C}(C - K^*)$).

Having characterized how the information-sensitiveness of debt depends on collateral beliefs p, we can analyze expected consumption, which is our measure of welfare

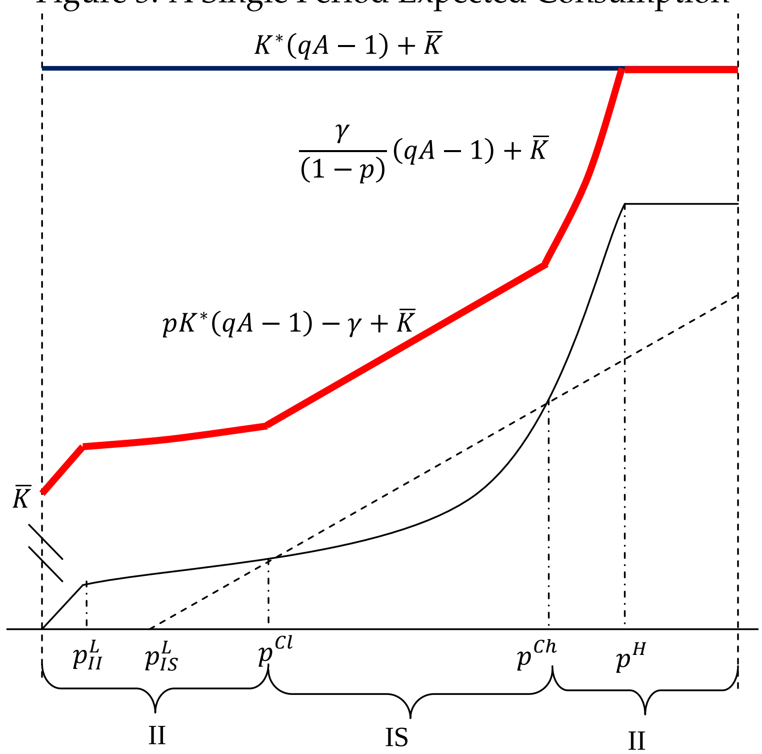
[9] The positive root for the solution of $pC = \gamma/(1-q)(1-p)$ is irrelevant since it is greater than p^H, and then it is not binding given all firms with a collateral that is good with probability $p > p^H$ can borrow the optimal level of capital K^* without triggering information production.

in the aggregate at a given period. By construction, at the cutoffs p^{Cl} and p^{Ch}, where the system changes from information-insensitive debt to information-sensitive debt, the expected consumption between the two regimes is the same. This is because, at the cutoffs

$$W_t^{IS} \equiv pK^*(qA-1) - \gamma + \overline{K} = K(qA-1) + \overline{K} \equiv W_t^{II}.$$

In Figure 3 we show how financial constraints reduce aggregate consumption when the perceived quality of the collateral p declines. Efficient consumption is the blue line and the financially constrained aggregate consumption is the red line.

Figure 3: A Single Period Expected Consumption



3.2 Optimal Information Production Costs

The cost of information production, γ, is fixed. However, we can study the case in which a planner can choose the optimal monitoring costs γ^* that maximizes aggregate consumption at each period t given financial constraints.

Proposition 1 *Optimal monitoring costs are $\gamma^* = \infty$ if $C > K^*$, $\gamma^* = [0, \infty)$ if $C = K^*$ and $\gamma^* = 0$ if $C < K^*$.*

Proof If $C > K^*$, as $\gamma \to \infty$, $E(\pi|p, II) = \min\{K^*, pC\}(qA-1) + pC$, which is greater than $E(\pi|p, IS) = \max\left\{pK^* - \frac{\gamma}{(qA-1)}, 0\right\}(qA-1) + pC$ for all p. As we reduce γ, $E(\pi|p, II)$ declines for values of p where $\frac{\gamma}{(1-p)} < pC$, reducing aggregate consumption since those collateral can borrow less. This implies that making the system information-insensitive for all collateral achieves a higher aggregate consumption than making it information-sensitive

If $C < K^*$, when $\gamma = 0$, $E(\pi|p, IS) = \max\{pK^*, 0\}(qA-1) + pC$, which is larger than $E(\pi|p, II) = 0$ for all p. As we increase γ, $E(\pi|p, II)$ can never increase above $pCqA$ which is smaller than $E(\pi|p, IS)$ for all p. This implies that making the system information-sensitive for all collateral achieves a higher aggregate consumption than making it information-insensitive

In the threshold, $C = K^*$, the firm chooses the maximum between $E(\pi|p, IS) = pC(qA-1) + pC$ and $E(\pi|p, II) = \min\left\{K^*, \frac{\gamma}{(1-p)}, pC\right\}(qA-1) + pC$, which cannot be greater than $E(\pi|p, IS)$. Hence any value of γ gives an aggregate consumption equal to the aggregate consumption of the information-sensitive regime. Q.E.D.

The intuition for this result is the following. When $C > K^*$, without producing information firms can borrow up to pC for sure. However, when producing information firms will borrow in expectation $pK^* < pC$ and spend γ. Hence, it is optimal to discourage information, even if information is free.

When $C < K^*$, without producing information firms can borrow up to pC for sure. When producing information firms will borrow in expectation $pK^* > pC$ and spend γ. Hence, it is optimal to make information production as cheap as possible.

4 Aggregate Results

In this section we characterize the evolution of information about the collateral and its impact on aggregate consumption. First, we study a case without aggregate shocks to collateral and discuss the effects of endogenous information production on the dynamics of credit booms. Then, we introduce aggregate shocks and study the effects of endogenous information on the size of crises and the speed of recoveries.

4.1 No Aggregate Shocks

Assume that initially (at period 0) there is perfect information about which collateral is good and which is bad. The probability each firm's collateral becomes good when it is hit by an idiosyncratic shock is always $\hat{p}$. In what follows we study the aggregate consumption in this economy as time evolves, for different values of $\hat{p}$, and we show that, as long as $\hat{p}$ is large enough consumption is growing with time since there is no information production about the collateral.[10]

First, for notational simplicity, we define borrowing depending on p, based on the analysis of Section 3:

$$K(p|\gamma) = \begin{cases} K^* & \texttt{if } p^H < p \\ \frac{\gamma}{(1-p)} & \texttt{if } p^{Ch} < p < p^H \\ pK^* - \frac{\gamma}{(qA-1)} & \texttt{if } p^{Cl} < p < p^{Ch} \\ \frac{\gamma}{(1-p)} & \texttt{if } P^L_{II} < p < p^{Cl} \\ pC & \texttt{if } \quad p < p^L_{II} \end{cases}$$

From the definition of the cutoffs, we know $K(p)$ is monotonically increasing in p.

The aggregate consumption of the economy at period t is defined by:

$$W_t = \int_0^1 K(p)(qA-1)f(p)dp + \bar{K},$$

where $f(p)$ is the distribution of beliefs about all the collateral in the economy. In the simple stochastic process for idiosyncratic shocks we assume, and in the absence of aggregate shocks, this distribution has a three-point support: 0, $\hat{p}$ and 1.

If $\hat{p} > p^{Ch}$ or $\hat{p} < p^{Cl}$, information is not reacquired and at period t, $f(1) = \lambda^t \hat{p}$, $f(\hat{p}) = (1-\lambda^t)$ and $f(0) = \lambda^t(1-\hat{p})$. Since $K(0) = 0$,

$$W^{II}_t = \left[\lambda^t \hat{p} K(1) + (1-\lambda^t) K(\hat{p})\right] (qA-1) + \bar{K}. \tag{7}$$

If $\hat{p} \in [p^{Cl}, p^{Ch}]$, information is reacquired in every period t for the fraction $(1-\lambda)$

[10] In this case, without aggregate shocks, the average quality of collateral in the market is given by $\bar{p} = \hat{p}$ in all periods.

of collateral that gets the idiosyncratic shock. Then $f(1) = \lambda\hat{p}$, $f(\hat{p}) = (1-\lambda)$ and $f(0) = \lambda(1-\hat{p})$. Considering $K(0) = 0$,

$$W_t^{IS} = [\lambda\hat{p}K(1) + (1-\lambda)K(\hat{p})]\,(qA-1) + \bar{K}. \tag{8}$$

Some interesting implications can be obtained from the previous equations. If the economy is in an information-insensitive regime (this is, $\hat{p} > p^{Ch}$ or $\hat{p} < p^{Cl}$), the evolution of aggregate consumption depends on $\hat{p}$. As can be seen, $W_0^{II} = \hat{p}K(1) + \bar{K}$ and $\lim_{t\to\infty} W_t^{II} = K(\hat{p})(qA-1) + \bar{K}$. If $\hat{p}K(1) = K(\hat{p})$, aggregate consumption is constant over time, which occurs when:

$$\frac{\gamma}{(1-\hat{p}^*)} = \hat{p}^* K^*,$$

which is fulfilled for $p^{Ch} < \hat{p}^* < p^H$.

For all $\hat{p} > \hat{p}^*$, aggregate consumption grows over time. In particular the case in which the average collateral does not introduce financial restrictions (this is, $\hat{p} > p^H$), is characterized by an aggregate consumption increasing over time (since $p^H > \hat{p}^*$). This is because more and more firms are borrowing, a credit boom.

Contrarily, if the average collateral implies information production (this is $p^{Cl} < \hat{p} < p^{Ch}$), aggregate consumption W_t^{IS} does not depend on t, being constant at the level at which information about the collateral that suffers idiosyncratic shocks is reacquired at every period .

4.2 Aggregate Shocks

In this section we introduce negative aggregate shocks that transform a fraction $(1-\eta)$ of good collateral into bad collateral. As with idiosyncratic shocks, the aggregate shock is observable, but which good collateral changes quality is not. This implies that when the shock hits, there is a downward revision of the perception about the quality of each unit of collateral. For example, collateral that has a $p = 1$, gets a new belief $p' = \eta$ after the aggregate shock. Similarly, all collateral with $p = \hat{p}$ get revised downwards to $p' = \eta\hat{p}$.

We also consider positive aggregate shocks that transform a fraction α of bad collateral into good collateral. In this case beliefs are revised up for all collateral. Collateral with $p = 0$ get revised to $p' = \alpha$ and collateral with $p = \hat{p}$ is revised to $p' = \hat{p} + \alpha(1 - \hat{p})$. In this section we focus on negative aggregate shocks and in the policy section we will discuss how policies that look like positive aggregate shocks can be constructed to deal with economic crises.

We will focus on the case where prior to the negative aggregate shock, the average quality of the collateral is good enough such that there are no financial constraints (that is, $\hat{p} > p^H$). Later we will justify why, allowing for endogenous choice of collateral, this is in fact the situation that naturally arises.

The next Proposition shows that the longer the economy did not face a negative aggregate shock, the larger the consumption loss when such a shock does indeed occur.

Proposition 2 *Assume $\hat{p} > p^H$ and a negative aggregate shock η in period t. The reduction in consumption $\Delta(t|\eta) \equiv W_t - W_{t|\eta}$ is non-decreasing in η and the time t elapsed previously in the absence of a shock.*

Proof Assume a negative aggregate shock of size η. Since we assume $\hat{p} > p^H$, the average collateral does not generate information production. The aggregate consumption before the shock is given by equation 7 and after the shock aggregate consumption is:

$$W_{t|\eta} = \left[\lambda^t \hat{p} K(\eta) + (1 - \lambda^t) K(\eta \hat{p})\right] (qA - 1) + \bar{K}.$$

Then we can define the reduction in aggregate consumption as $\Delta(t|\eta) = W_t - W_{t|\eta}$

$$\Delta(t|\eta) = [\lambda^t \hat{p}[K(1) - K(\eta)] + (1 - \lambda^t)[K(\hat{p}) - K(\eta \hat{p})]](qA - 1).$$

Since $K(p)$ is decreasing in p, $\Delta(t|\eta)$ is non-decreasing in η and t. Q.E.D.

The intuition for this Proposition is straightforward. If there is little information about collateral in the economy (that is, there is a small fraction of collateral with either $p = 0$ or $p = 1$), a negative aggregate shock affects a high fraction of collateral in the economy, reducing borrowing and consumption a lot.

This result goes beyond the mechanical effect in which more collateral is affected. After a negative shock to collateral, either a higher amount of the numeraire good should be used to produce information or borrowing is excessively restricted to avoid such information production.

Since the fraction of collateral with information about their true quality decreases over time in an information-insensitive regime, if we define *"fragility"* as the probability aggregate consumption declines more than a certain value, then the following corollary follows immediately from the previous Proposition.

Corollary 1 *Given a structure of negative aggregate shocks, the fragility of an economy increases with the number of periods the debt in the economy has been informationally-insensitive, and then increases with the fraction of collateral of unknown quality.*

The next Proposition shows that under a negative shock, information production speed up the recovery.

Proposition 3 *Assume $\hat{p} > p^H$ and a negative aggregate shock η in period t. The recovery is faster when information is produced after the shock if $\eta\hat{p} < \overline{\eta\hat{p}} \equiv \frac{1}{2} + \sqrt{\frac{1}{4} - \frac{\gamma}{K^*}}$, where $p^{Ch} < \overline{\eta\hat{p}} < p^H$. This is, $W^{IS}_{t+1} > W^{II}_{t+1}$ for all $\eta\hat{p} < \overline{\eta\hat{p}}$.*

Proof If the negative shock happens in period t, the distribution in period t is: $f(\eta) = \lambda^t\hat{p}$, $f(\eta\hat{p}) = (1-\lambda^t)$ and $f(0) = \lambda^t(1-\hat{p})$.

In period $t+1$, if information have been produced (IS case), after the idiosyncratic shocks the distribution of beliefs is $f_{IS}(1) = \lambda\eta\hat{p}(1-\lambda^t)$, $f_{IS}(\eta) = \lambda^{t+1}\hat{p}$, $f_{IS}(\hat{p}) = (1-\lambda)$, $f_{IS}(0) = \lambda[(1-\lambda^t\hat{p}) - \eta\hat{p}(1-\lambda^t)]$. Hence, aggregate consumption at $t+1$ if information is acquired is,

$$W^{IS}_{t+1} = [\lambda\eta\hat{p}(1-\lambda^t)K^* + \lambda^{t+1}\hat{p}K(\eta) + (1-\lambda)K(\hat{p})](qA-1) + \overline{K} \tag{9}$$

In period $t+1$, if information have not been produced (II case), after the idiosyncratic shocks the distribution of beliefs is $f_{II}(\eta) = \lambda^{t+1}\hat{p}$, $f_{IS}(\hat{p}) = (1-\lambda)$, $f_{IS}(\eta\hat{p}) = \lambda(1-\lambda^t)$, $f_{IS}(0) = \lambda^{t+1}(1-\hat{p})$. Hence, aggregate consumption at $t+1$ if information is not acquired is,

$$W^{II}_{t+1} = [\lambda^{t+1}\hat{p}K(\eta) + \lambda(1-\lambda^t)K(\eta\hat{p}) + (1-\lambda)K(\hat{p})](qA-1) + \overline{K} \tag{10}$$

Taking the difference between aggregate consumption at $t+1$ between the two regimes of information production.

$$W_{t+1}^{IS} - W_{t+1}^{II} = \lambda(1-\lambda^t)(qA-1)[\eta\hat{p}K^* - K(\eta\hat{p})] \tag{11}$$

This expression is non-negative for all $\eta\hat{p}K^* \geq K(\eta\hat{p})$, or which is the same, for all $\eta\hat{p} < \overline{\eta\hat{p}} \equiv \frac{1}{2} + \sqrt{\frac{1}{4} - \frac{\gamma}{K^*}}$. From equation (6), $p^{Ch} < \overline{\eta\hat{p}} < p^H$. Q.E.D.

The intuition for this Proposition is the following. When information is produced after a shock η that constrain credit a lot, information costs are spent at the time of the shock and then a fraction $\eta\hat{p}$ of collateral can sustain the maximum borrowing K^*. When information is not produced after a shock η that constrain credit, collateral that remain with belief $\eta\hat{p}$ should restrict credit in following periods, until beliefs move back to $\hat{p}$. This is equivalent to restrict credit proportional to monitoring costs all following periods as well. The Proposition generates the following Corollary.

Corollary 2 *There is a range of negative aggregate shocks big enough (η such that $\eta\hat{p} \in [p^{Ch}, \overline{\eta\hat{p}}]$) in which agents do not acquire information, but recovery would be faster if they do.*

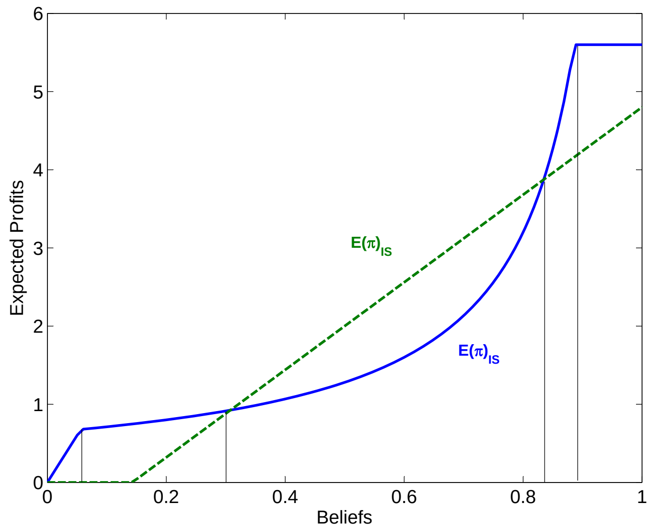
5 Numerical Simulations

We illustrate our main results with the following numerical exercise. We assume idiosyncratic shocks happen with probability $(1-\lambda) = 0.1$, in which case the collateral becomes good with probability $\hat{p} = 0.92$. Other parameters are $q = 0.6$, $A = 3$ (these two assumption imply that investing in the project generates a return of 80%), $\bar{K} = 10$, $L^* = K^* = 7$ (which means the endowment is enough to invest in the optimal project size), $C = 15$ and $\gamma = 0.8$.[11]

Given these parameters we can obtain the relevant cutoffs for our analysis. Specifically, $p^H = 0.89$, $p_{II}^L = 0.06$ and the sensitive information region is in the values $p \in [0.31, 0.83]$. As discussed above, these cutoffs are obtained from comparing expected profits from taking a loan producing information with one without producing information. Figure 4 plots these functions and the respective cutoffs.

[11] Recall these parameters fulfill the assumptions $qA < C/K^*$ and $\gamma < \frac{K^*}{C}(C - K^*)$ in the text.

Figure 4: Expected Profits and Cutoffs



Using these cutoffs we simulate the model for 100 periods. As in the main text, we assume that at period 0 there is perfect information about the true quality of every collateral in the economy. Over time there are idiosyncratic shocks that make this information vanish unless there is costly information acquisition about the realizations after idiosyncratic shocks.

We introduce a negative aggregate shock that transforms a fraction $(1-\eta)$ of good collateral into bad collateral in periods 5 and 50. We also introduce a positive aggregate shock that transforms a fraction $\alpha = 0.2$ of bad collateral into good collateral in period 30. We compute the dynamic reaction of consumption in the economy for different sizes of negative aggregate shocks, $\eta = 0.97$, $\eta = 0.91$ and $\eta = 0.90$. We will see that small differences in the size of a negative shock can have important dynamic consequences in the economy.

Figure 5 shows the average probability that collateral is good in the economy for the three possible negative aggregate shocks (this is the real collateral quality existing in the economy). While aggregate shocks have a temporary effect on quality of collateral, after aggregate shocks occur the average quality converges back to $\hat{p} = 0.92$. As can be seen, the negative aggregate shocks were constructed such that $\eta\bar{p}$ is above p^H when $\eta = 0.97$, is between p^{Ch} and p^H when $\eta = 0.91$ and is less than p^{Ch} when $\eta = 0.90$.

Figure 5: Average Quality of Collateral

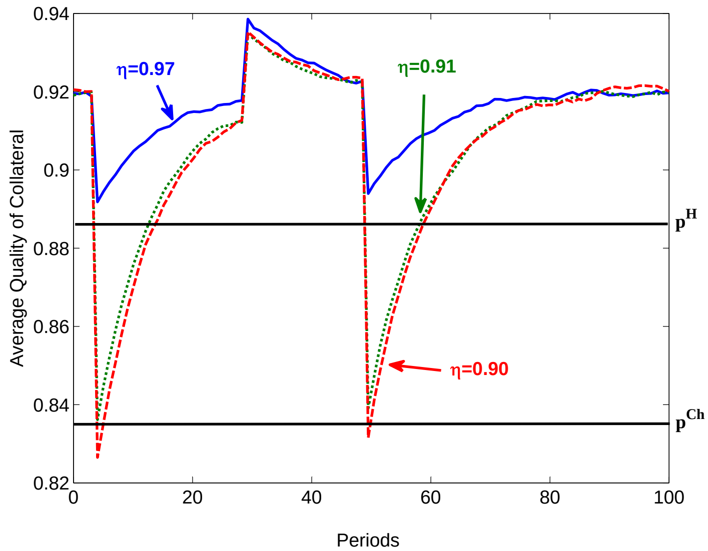
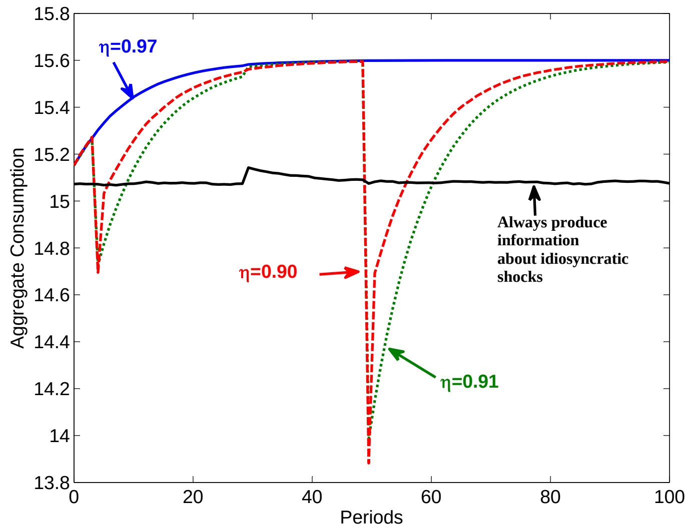


Figure 6 shows the evolution of aggregate consumption for the three negative aggregate shocks. The first result to highlight is that when $\eta = 0.97$, aggregate shocks do not affect the evolution of consumption at all. The reason is that shocks do not introduce financial constraints. The second result is that positive shocks do not affect the evolution of consumption and the reason is that $\hat{p} > p^H$, and hence improvements in the belief distribution do not relax the financial constraints even more. This introduces an asymmetry on how shocks affect aggregate consumption.

The third result is that the reduction in consumption from the negative aggregate shock in period 5, when not much information has vanished yet, is much lower than the reduction in consumption from the same size negative aggregate shock in period 50. The reason is that the shock reduces financing for a larger fraction of collateral which information has vanished over time but was good enough to finance projects successfully. This is the result proved in Proposition 2.

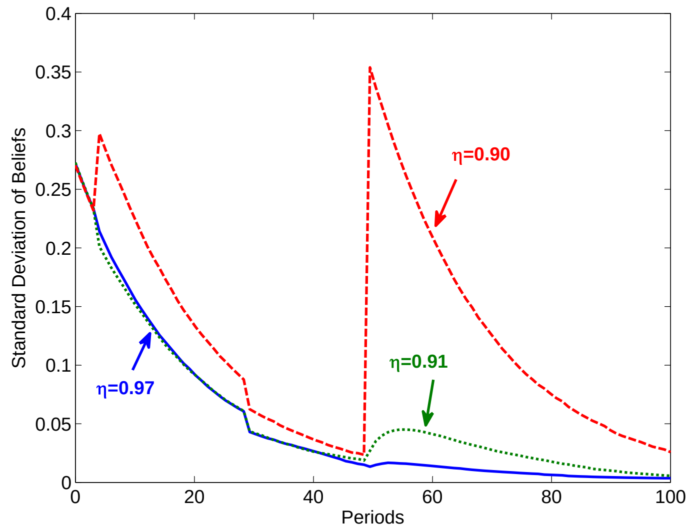
Figure 6: Welfare



In Figure 7 we illustrate that small differences in the size of shocks have very different consequences on the variance of beliefs about the collateral. A shock $\eta = 0.91$ does not trigger information production but a shock $\eta = 0.90$ does it. Given that after many periods without shock most collateral looks the same, these differences in information production implies that these differences have large consequences on the variance of beliefs and the information available about most collateral.

This effect of information acquisition implies that, even when the real quality of collateral is the same under the two shocks, a slightly larger shock that induces information acquisition implies a faster recovery, which is the result from Proposition 3.

Figure 7: Standard Deviation of Distribution of Beliefs



6 The Choice of Collateral

In this Section we study an environment with collateral heterogenous in two dimensions, the expected value of the collateral $\hat{p}$ and the cost of information acquisition γ. Firms can choose freely the characteristics of the collateral to use in order to maximize borrowing using such a collateral.

In previous sections we analyzed the effects of p on borrowing for a given cost of information acquisition γ. In that environment we obtained that borrowing was increasing in p. The proof relies on the monotonically increasing function of the borrowing function $K(p|\gamma)$.

Similarly, we can analyze borrowing for a given collateral with belief p, for different levels of information costs γ. In this case the amount borrowed critically depends on whether the collateral creates financial constraints or not and in case it does, whether the financial constraint locates the collateral in an information-sensitive or insensitive region. The next Proposition summarizes these results.

Proposition 4 *Take collateral characterized by the pair (p, γ), these are the expected probability the collateral has value C and the cost of information acquisition when the collateral is hit by an idiosyncratic shock.*

1. *Fix γ. After an idiosyncratic shock:*

    (a) *No financial constraint: Borrowing is independent of p.*

    (b) *Information-sensitive regime: Borrowing is increasing in p.*

    (c) *Information-insensitive regime: Borrowing is increasing in p.*

2. *Fix p.*

    (a) *No financial constraint: Borrowing is independent of γ.*

    (b) *Information-sensitive regime: Borrowing is decreasing in γ.*

    (c) *Information-insensitive regime: Borrowing is increasing in γ if higher than pC and independent of γ if pC.*

Proof Point 1 is a direct consequence of $K(p|\gamma)$ being monotonically increasing in p for $p < p^H$ and independent of p for $p > p^H$.

To prove the second point 2 we derive the function $\widetilde{K}(\gamma|p)$, which is the inverse of the $K(p|\gamma)$ and analyze its properties. Take a situation where information acquisition is not possible (or $\gamma = \infty$). In this case the limit to financial constraints is the point at which $K^* = pC$. This is because lenders will not acquire information but will not lend more than the expected value of the collateral pC. Then, the function $\widetilde{K}(\gamma|p)$ has two parts. One for $p \geq \frac{K^*}{C}$ and the other for $p < \frac{K^*}{C}$.

1. $p \geq \frac{K^*}{C}$:

$$\widetilde{K}(\gamma|p) = \begin{cases} K^* & \texttt{if } \gamma_1^H \leq \gamma \\ \frac{\gamma}{(1-p)} & \texttt{if } \gamma^L \leq \gamma < \gamma_1^H \\ pK^* - \frac{\gamma}{(qA-1)} & \texttt{if } \gamma < \gamma^L \end{cases}$$

where γ_1^H comes from equation 3. Then

$$\gamma_1^H = K^*(1-p) \tag{12}$$

and γ^L comes from equation 6. Then

$$\gamma^L = pK^* \frac{(1-p)(qA-1)}{(1-p)+(qA-1)} \tag{13}$$

2. $p < \frac{K^*}{C}$:

$$\widetilde{K}(\gamma|p) = \begin{cases} pC & \texttt{if } \gamma_2^H \leq \gamma \\ \frac{\gamma}{(1-p)} & \texttt{if } \gamma^L \leq \gamma < \gamma_2^H \\ pK^* - \frac{\gamma}{(qA-1)} & \texttt{if } \gamma < \gamma^L \end{cases}$$

where γ_2^H in this region comes from equation 4. Then

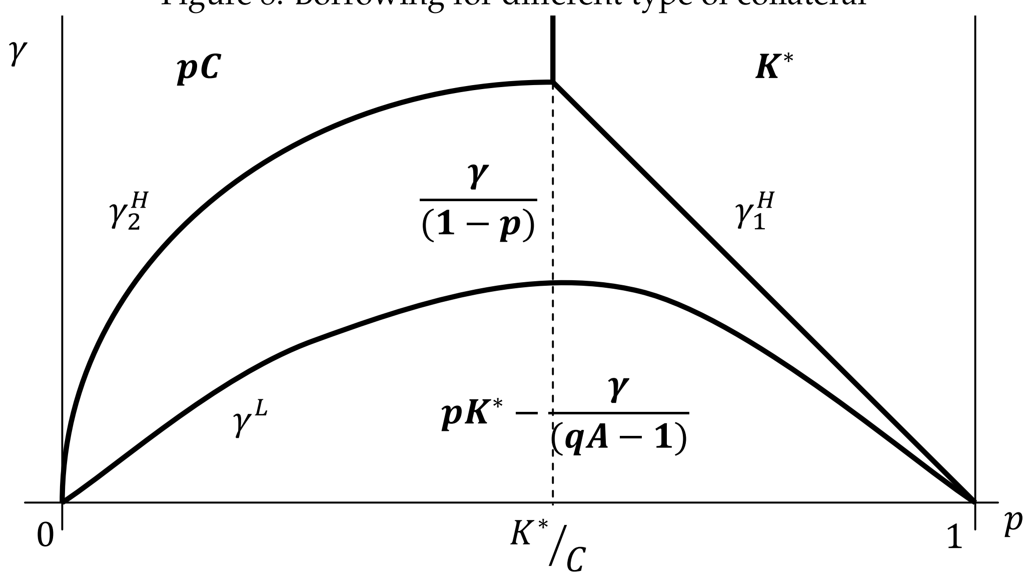
$$\gamma_2^H = p(1-p)C \tag{14}$$

and γ^L is the same as above.

It is clear from the function $\widetilde{K}(\gamma|p)$ that, for a given p, borrowing is independent of γ in the first region, it is increasing in the second region (information-insensitive regime) and it is decreasing in the last region (information-sensitive regime). Q.E.D.

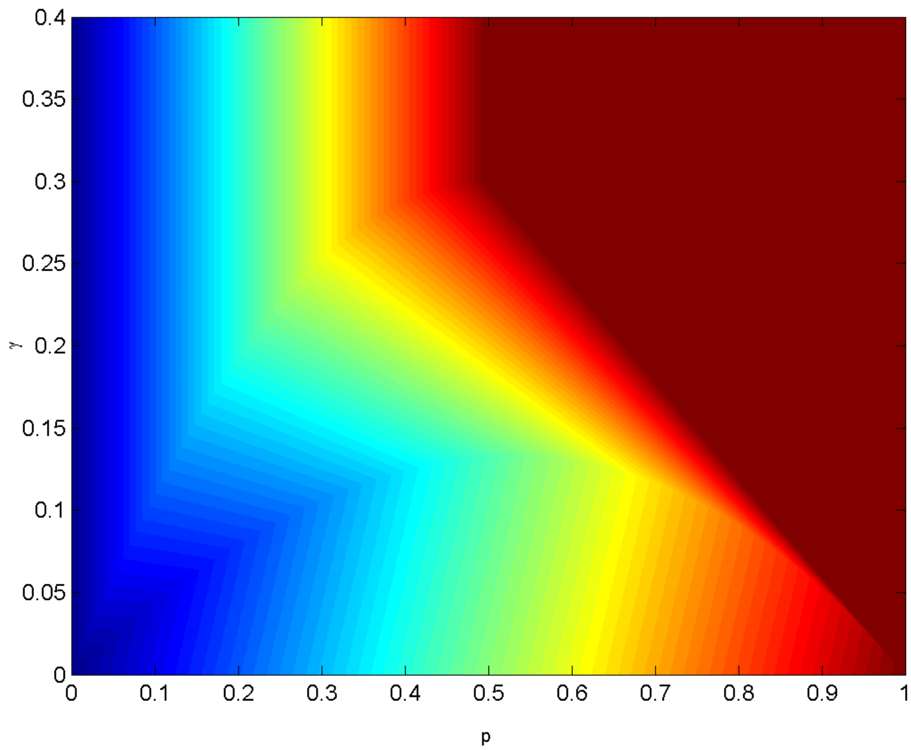
Figure 8 shows the borrowing possibilities for all combinations (p, γ). As a further illustration of how borrowing is affected by these two dimensions, Figure 9 shows different levels of borrowing from high (dark red) to low (blue).[12]

Figure 8: Borrowing for different type of collateral



[12]The numbers that created this Figure are $K^* = 2$, $C = 4$, $q = 0.7$ and $A = 3$.

Figure 9: Borrowing for different type of collateral - A numerical example



If we assume the price of collateral is the fair value pC, then firms would prefer to acquire collateral with the lowest possible price that maximize the borrowing size. In this sense firms would start using collateral with $p = \frac{K^*}{C}$ and $\gamma > \gamma_1^H$ evaluated at that p. Then they will use collateral with a slightly higher p and $\gamma > \gamma_1^H$ for that p.

This implies that endogenously the collateral used for borrowing will be biased towards relatively high $\hat{p}$ and relatively high γ. This way the first collateral firms use to borrow are those that most likely allow the firm not to be financially constrained, either because the collateral is very likely to be of high quality, or because it is very expensive to acquire information about its quality.

7 Policy Implications

In this section we discuss some policies the government may use to increase welfare, measured as

$$U_t = E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} W_t.$$

Unlike households and firms, the planner cares about the discounted utility of all generations. Hence, a planner takes into account the possibility of a crisis in the future. What can the government do to maximize welfare? This is, what can the government do to reduce the size of crises without reducing growth? What can the government do to speed up recoveries?

We explore three types of policies. Collateral policies, lending policies and information policies.

7.1 Collateral policies

This set of policies is intended to boost the expected quality of collateral ($\hat{p}$). After a negative aggregate shock η, the natural and trivial reaction of the government should be to eliminate such a shock by improving $\hat{p}$. The effectiveness of collateral policies depends on how fast the government is able to react to the negative shock, for example guaranteeing the quality of the collateral. This policy manifests itself as an α positive aggregate shock, one period after the negative aggregate shock.

The next Proposition shows that, if there is a positive aggregate shock after a negative aggregate shock that takes the average collateral $\eta\hat{p}$ to a higher new level above p^H, the recovery from the negative shock is faster if there was no information production as a response to the negative aggregate shocks.

Proposition 5 *Assume a positive aggregate shock of size α, immediately following a negative aggregate shock η, such that $p' = \eta\hat{p} + \alpha(1 - \eta\hat{p}) > p^H$. This policy is more effective in speeding recovery after a shock η that induces information acquisition if that information is* not *acquired. More specifically $\Delta^{II} > \Delta^{IS}$ (where $\Delta^{II} \equiv W^{II}_{t+1|\alpha} - W^{II}_{t+1}$ and $\Delta^{IS} \equiv W^{IS}_{t+1|\alpha} - W^{IS}_{t+1}$) for all $\eta\hat{p} \in [p^{Cl}, p^{Ch}]$.*

Proof As in Proposition 3, if the negative shock happens in period t, the distribution in period t is: $f(\eta) = \lambda^t \hat{p}$, $f(\eta\hat{p}) = (1-\lambda^t)$ and $f(0) = \lambda^t(1-\hat{p})$.

Without information production, in period $t+1$, after the idiosyncratic shocks, the distribution of beliefs is $f_{II}(\eta) = \lambda^{t+1}\hat{p}$, $f_{II}(\eta\hat{p}) = \lambda(1-\lambda^t)$, $f_{II}(\hat{p}) = (1-\lambda)$ and $f_{II}(0) = \lambda^{t+1}(1-\hat{p})$.

In case the government introduces a policy that transforms a fraction α of bad collateral into good, for example by guaranteeing they pay C even when they are bad, in the period $t+1$, following the negative shock that occurred in period t, beliefs change from η to $\alpha + \eta(1-\alpha)$, from $\hat{p}$ to $\alpha + \hat{p}(1-\alpha)$, from $\eta\hat{p}$ to $\alpha + \eta\hat{p}(1-\alpha)$ and from 0 to α. [13] The distribution of beliefs become: $f_{II}(\alpha + \eta(1-\alpha)) = \lambda^{t+1}\hat{p}$, $f_{II}(\alpha + \eta\hat{p}(1-\alpha)) = \lambda(1-\lambda^t)$, $f_{II}(\alpha + \hat{p}(1-\alpha)) = (1-\lambda)$ and $f_{II}(\alpha) = \lambda^{t+1}(1-\hat{p})$.

Since we assume $\hat{p} > p^H$ and $\eta > p^H$, the positive shock does not affect the borrowing of those beliefs. Since we assume $\alpha + \eta\hat{p}(1-\alpha) > p^H$, borrowing for firms that previously had a collateral with beliefs $\eta\hat{p}$ increase borrowing from $K(\eta\hat{p})$ to K^*. Similarly, borrowing for firms that previously had a collateral with beliefs 0 increase borrowing from 0 to $K(\alpha)$.

Since the distribution does not change, just the beliefs assigned to collateral, we can compute the aggregate consumption from the positive policy and compare it to the one without the positive policy, from equation 10. Then,

$$\Delta^{II} \equiv W^{II}_{t+1|\alpha} - W^{II}_{t+1} = \lambda(qA-1)[(1-\lambda^t)(K^* - K(\eta\hat{p})) + \lambda^t(1-\hat{p})K(\alpha)] \tag{15}$$

With information production, in period $t+1$, after the idiosyncratic shocks, the distribution of beliefs is $f_{IS}(1) = \lambda\eta\hat{p}(1-\lambda^t)$, $f_{IS}(\eta) = \lambda^{t+1}\hat{p}$, $f_{IS}(\hat{p}) = (1-\lambda)$, $f_{IS}(0) = \lambda[(1-\lambda^t\hat{p}) - \eta\hat{p}(1-\lambda^t)]$.

With the positive policy beliefs change from η to $\alpha+\eta(1-\alpha)$, from $\hat{p}$ to $\alpha+\hat{p}(1-\alpha)$, and from 0 to α. Also, beliefs 1 remain 1. Since we assume $\hat{p} > p^H$ and $\eta > p^H$, the positive shock does not affect the borrowing of those beliefs. Finally, borrowing for firms that previously had a collateral with beliefs 0 increase borrowing from 0 to $K(\alpha)$. We can compute the aggregate consumption from the positive policy and compare it to the

[13] The same results hold if the policy is introduced in subsequent periods.

one without the positive policy, from equation 9. Then,

$$\Delta^{IS} \equiv W^{IS}_{t+1|\alpha} - W^{IS}_{t+1} = \lambda(qA-1)[(1-\lambda^t \hat{p}) - \eta\hat{p}(1-\lambda^t)]K(\alpha) \tag{16}$$

Taking the difference between equations (15) and (16),

$$\begin{aligned} \Delta^{II} - \Delta^{IS} &= \lambda\left[(1-\lambda^t)[K^* - K(\eta\hat{p})] + [\lambda^t(1-\hat{p}) - (1-\lambda^t\hat{p}) + \eta\hat{p}(1-\lambda^t)]K(\alpha)\right] \\ &= \lambda(1-\lambda^t)\left[K^* - K(\eta\hat{p}) - (1-\eta\hat{p})K(\alpha)\right] \end{aligned}$$

In the range of interest, at which $\eta\hat{p} < p^{Ch}$ and there are incentives for information production, avoiding information production would imply $K(\eta\hat{p}) \leq \eta\hat{p}K^* - \frac{\gamma}{(qA-1)}$. This implies the government imposing the restriction of no information production borrowing should be lower than the borrowing level that induces information production. Using this upper bound to evaluate the expression above,

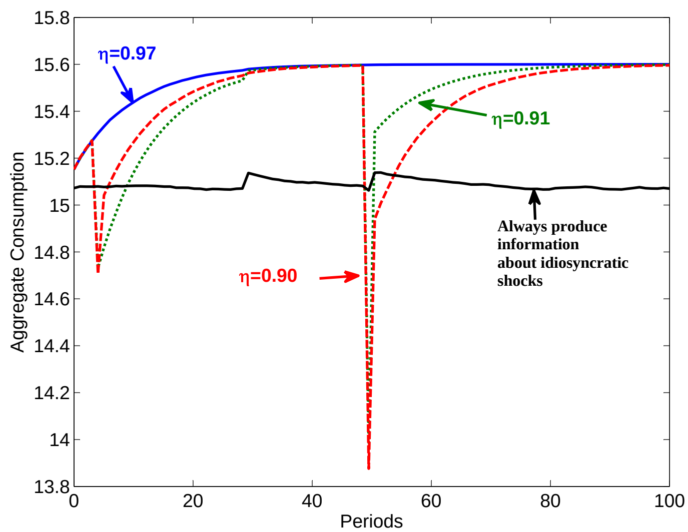
$$\begin{aligned} \Delta^{II} - \Delta^{IS} &\geq \lambda(1-\lambda^t)\left[K^* - \eta\hat{p}K^* + \frac{\gamma}{(qA-1)} - (1-\eta\hat{p})K(\alpha)\right] \\ &\geq \lambda(1-\lambda^t)(1-\eta\hat{p})\left[K^* - K(\alpha)\right] + \frac{\gamma}{(qA-1)(1-\eta\hat{p})} > 0 \end{aligned}$$

Q.E.D.

The intuition for this Proposition relies on the speed of recovery of information. If an aggregate negative shock does not generate information production, when in average the collateral quality recovers, borrowing can recover fast for the high fraction of collateral without information about their true quality. If an aggregate negative shock generates information production, then, even when in average the collateral quality recovers, the fact that bad collateral has been identified, restricts lending to such a collateral until they face idiosyncratic shocks.

Figure 10 introduces a shocks $\alpha =$ to the numerical simulation in period 51, right after the assumed negative shock. As can be seen the collateral policy that replenishes the confidence on the average collateral is more effective when the negative aggregate shock did not generate information than in the case in which the negative aggregate shock did generate information. This implies that, if the planner can use a collateral policy to deal with a crises, it will be more effective doing if the shock is such that it just creates a credit crunch where no information is produced. This is the effect discussed in Proposition 5.

Figure 10: Effectiveness of Collateral Policy



7.2 Lending policies

Information production after the negative aggregate shock renders less effective collateral policies that try to reintroduce confidence in the average value of collateral. The planner may discourage information production by introducing lending policies.

Assume $\hat{p} < p^H$ such that the shock reduces efficient borrowing, or even worse, assume $\hat{p} < p^{Ch}$ such that firms face a credit crunch where borrowing also triggers information production. The government can tax households and transfer to firms an amount $K^* - \frac{\gamma}{(1-p)}$ directly and let the firms borrow the remaining $\frac{\gamma}{(1-p)}$ such that firms can efficiently get the optimal K^*, and no information is produced.

7.3 Informational policies

Differently than the previous two options, informational policies are preventive in nature. Conditional on suffering a negative aggregate shock and not being able to make the economy recover without producing information, as was the objective of the previous two policies, informational policies may prevent huge crises by generating some information along the way to a credit boom. When there has been no information acquisition for a long time, and a negative shock hits, it affects most of the collateral in the economy, causing a large decline in production. Not only there is a reduction in production, but a lot of information is acquired at the same time. In fact, even when there is no information production (in the range between p^{Ch} and p^{H}), firms borrow as if there were information production.

The government can produce and release some information over time to reduce the potential size of the recession that a negative aggregate shock generates. The cost of such a policy is to reduce production in the period at which the policy is implemented. The benefit is to reduce the size of the potential shock and to speed up the recovery after such a shock. However, given the risk neutrality assumption this policy is typically not beneficial ex-ante, unless the government correctly predicts a negative aggregate shock is about to happen.

8 Some Empirical Evidence (Very Preliminary and Incomplete)

In this section we examine some of the model's predictions using U.S. historical data. The model predicts that:

1. The higher or longer the boom period during which output grows, the deeper the crash when a negative shock is realized
2. The deeper the crash, the faster the recovery conditional on acquiring information and no collateral policy is implemented.
3. The standard deviation of beliefs (about collateral quality) declines over the boom
4. The longer the decline in the standard deviation of beliefs the more sharply the standard deviation increases with a crash, because information is produced.

The first hypothesis is associated with the increasing credit build-up as more firms borrow based on $\hat{p}$. Since the average quality of the collateral that is the basis for borrowing is declining, when this is discovered when information is produced, more firms will be cut-off from credit. The second prediction states that if information is produced, then it is faster for the economy to recover when compared to the case where information was not produced. The third hypothesis relates the convergence of beliefs to $\hat{p}$ with the length of the boom. And finally, the fourth prediction is essentially the converse of the first one, beliefs move increasingly towards $\hat{p}$ over time until a negative shock is realized, possibly causing information to be produced.

To make tests operational, some definitions of terms like "higher" and "deeper" are needed. Also, the model distinguishes between negative shocks such that when they arrive information is produced (roughly, a depression) and shocks that cause firms to be credit-constrained (roughly, a recession), but where no information is produced. But, the shocks are unobservable, and whether information is produced or not is unobservable. In order to examine the hypotheses, we need a long time series so that there are a sufficient number of crises. We want to examine a period over which there is no central bank, so agents' beliefs and actions are not affected by expectations associated with possible central bank or government intervention, which could contaminate the empirical data. For this reason we first focus attention on the United States before the existence of the Federal Reserve System, that is, prior to 1915. We then examine the whole history of crises in the U.S. from 1815-2010, and the subperiod of 1915-2010, when the Federal Reserve is in existence.

8.1 The Pre-Federal Reserve Era

8.1.1 Data Description

To examine the pre-Fed period we will use the annual index of American industrial production, 1790-1915, produced by Davis (2004) and New York Stock Exchange stock price data for the period 1815-1925, collected by Goetzmann, Ibbotson, and Peng (2001). Davis (2004) uses annual physical-volume data on 43 manufacturing and mining industries to construct an index. In this subsection we use the industrial production and stock price series through the year 1914, after which the Fed is in existence. The Davis industrial production series can be used to examine the first two hypotheses. The third and fourth hypotheses concern the standard deviation of beliefs about collateral value. We will proxy for these beliefs using the cross section of stock returns. This is a measure of uncertainty which has been previously used by, e.g., Lougani, Rush, and Tave (1990), Brainard and Cutler (1993), and Bloom, Floetotto, and Jaimovich (2009). The idea here is that the standard deviation of the cross section of stock returns should decline during the credit boom, as more and more firms are borrowing based on collateral with a perceived value of $\hat{p}$. That is the firms are increasingly viewed as being of the same quality. The previous work cited above takes this measure of uncertainty as exogenous; we are trying to determine how it arises endogenously.

The focus of our empirical analysis is on the period prior to and just after a crisis, the time at which there is a negative shock. So, we examine business cycles. Davis's annual data results in a different business cycle chronology than the National Bureau of Economic Research (NBER); see Davis (2006). The NBER dating has not been revised since first announced (see the discussion in Davis (2004, 2006)). Table 1 below shows the NBER business cycle chronology and Davis' chronology. There are some NBER cycles that Davis does not include. Some of Davis' cycles do not display much of a downturn.[14] Where the NBER and Davis agree on the cycle existence, there is also agreement on the date of the peaks. There is most disagreement about the trough dates. The differences concerning the trough dates make dating the start of the recovery somewhat problematic.

We focus on Davis's chronology, as it is the most current. This gives us a sample of nineteen cycles, omitting the wartime cycles, which were somewhat special as the shock was arguably the start of the war rather than anything else.[15] Our basic strategy is to examine the four hypotheses over the business cycle, taking the date of the cycle peak as the date that the negative shock arrives. We also take the date of the cycle trough as the start of the recovery. Below, we discuss the trickier problem of the timing of information production after the negative shock.

The period from 1790-1915 includes the National Banking Era, 1863-1914, which was followed by the Federal Reserve System, starting in 1914. It also includes the Civil War period, and the period prior to the Civil War where banks were overseen by the states and issued their own private money. Broadly speaking we think of recessions

[14]With regard to the cycles with peaks at 1811, 1822, and 1836, Davis (2004, p. 1203) states that these cycles had losses "that do not exceed the minimum postbellum loss."

[15]Davis (2004, p. 1203) says of the wartime cycles: "Two Civil War cycles (1861 and 1865 troughs) are omitted. Although their inclusion would not meaningfully affect calculations."

that included a widespread bank panic as corresponding to instances where information was produced. Table 1 lists the major panics and minor panics, although there are many more events that some have classified as minor panics. There is no consensus as to which events constitute a panic in all cases.[16] Part of the problem is that some panics were regional rather than national. We will use all the cycles, whether there was a panic or not. But, it is notable that a panic involves households monitoring banks by demanding their money back, in other words, trying to produce information about their banks. Indeed, panics are associated with the deepest recessions.

At the onset of a banking panic, banks suspended convertibility, an event organized by clearinghouses during most of this period. During the period of suspension following a panic, some banks and firms would be discovered to be insolvent and would be closed. This raises two issues. First, the suspension of convertibility was organized by bank clearinghouses, which acted to stop production of information about banks; they suspended the release of bank-specific accounting information. See Gorton (1985). This institutional arrangement may have altered the predicted relations following the shock. Second, if there is information produced, about firms independent of the bank clearinghouses, then the question of the issue of the timing of information production arises. We assume that information is produced rather quickly, but this may not be correct.

Our basic empirical strategy is to look at these business cycles and measure three variables (measured in different ways) based on Davis' industrial production index. We will measure the boom by looking at the number of years from the last trough to the business cycle peak (BOOM1) and also by the cumulative output from the last trough to the peak (BOOM2). We will also look at measures of the decline in economic activity measured as the cumulative loss from the trough to the next year when the previous peak level was achieved (LOSS1), and also at the cumulative loss from peak to trough (LOSS2). Finally, we will measure economic recovery as the cumulative gain from the trough to the next peak (GAIN1). Another measure of the recovery is the cumulative industrial production gain from trough to two years after trough (GAIN2). Table 2 below lists the different variables names and their definitions.

As mentioned, we proxy for agents' beliefs using the standard deviation of the cross section of stock returns, based on the monthly stock price data from Goetzmann, Ib-

[16]Jalil (2009) compares the different panic dates produced by different authors.

botson, and Peng (2001). As they discuss, there are some missing values. Because Davis' data are annual, we convert the monthly standard deviations to annual by simple averaging.[17] There are two more substantive issues. The first issue concerns whether the cross section returns should be price-weighted (the only available measure for weighting). Goetzmann, Ibbotson, and Peng (2001) produce a return index that is price-weighted. Price-weighting dampens the variation in the cross section of returns.[18] We consider both price weighted and unweighted measures.[19] The correlation between the annual series of the standard deviation of the cross section of returns with and without price-weighting is 0.78. Secondly, although the stock price data starts in 1815, there are between eight and twenty stocks until 1833. The year 1837, following President Andrew Jackson's veto of the re-charter of the Second Bank of the United States, marks the beginning of the Free Banking Era, during which some states allowed free entry into banking. We will look at two periods, 1815-1914 and 1839-1914.

The Panic of 1893 was a major panic. Figure 11 illustrates some of the hypotheses that we will examine more closely below. The figure shows the period 1889-1897, which includes the business cycle with peak in 1892, trough in 1897, and the widespread banking panic in 1893. The cumulative loss in industrial production was 29.97 (Davis (2004)).[20] For purposes of the figure, both BELIEFS1 (standard deviation, not price weighted) and BELIEFS2 (standard deviation, price weighted) have been multiplied by 10,000. The figure shows the rise in the industrial production index (the solid line) and the drop starting in 1892. BELIEFS1 falls, as predicted, and then sharply rises, as predicted. This is followed by a decline. BELIEFS2 does not show a sharp rise. In

[17]When monthly values are missing, the annual average is the average over the remaining months. The entire year 1867 is missing; its annual value was interpolated.

[18]They argue that bid-ask bounce is a large potential problem; see Goetzmann, Ibbotson, and Peng (2001, p. 9).

[19]The price-weighted standard deviation of the cross section of returns is calculated as follows:

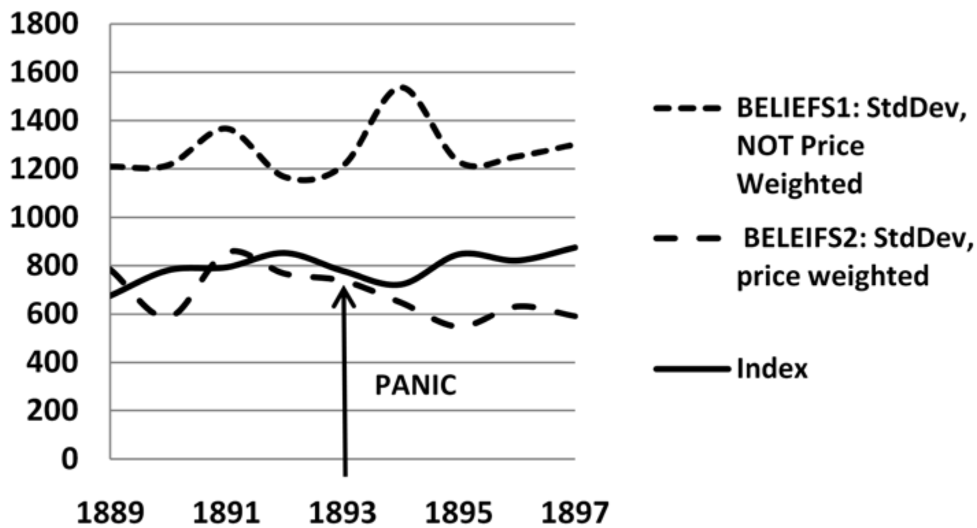
$$STD_{weighted,t} = \frac{n}{n-1}\left(\sum_{i=1}^{n} PRCWGT_{i,t} \times (ret_{i,t} - \bar{ret}_t)\right)^{1/2}$$

where $PRCWGT_{i,t} = \frac{price_{i,t-1}}{\sum_{j=1}^{n} price_{j,t-1}}$ is the weight, $\bar{ret}_t$ is the price-weighted average return for all stocks at time t. Note that the standard deviation is multiplied by $\frac{n}{n-1}$ because the sum of $PRCWGT_{i,t}$ is 1, but for a small sample the weights are adjusted to make estimation unbiased.

[20]Davis (2004) measures the cumulative loss as the "sum of percentage-point shortfalls in the logarithm of the index between peak and subsequent years below the peak" (p. 1203).

general, there is this large difference between the two measures of beliefs.

Figure 11: The Panic of 1893



8.1.2 Hypothesis Testing

We now turn to examining the hypotheses. Hypothesis (1) predicts that measures of the boom in output prior to the negative shock should be positively correlated with measures of the loss (measured as a positive number) following the shock. The correlations should all be positive, and Table 3 shows the evidence is mixed.

The second hypothesis states that the LOSS measures should be positively correlated with recovery (GAIN) in the absence of collateral policies. In the period pre Federal Reserve Bank this is indeed the case. Table 3 shows they are. There are, however, several potential problems with our recovery measures. The first, referred to above, is that the NBER and Davis seem to frequently disagree on the dating of the trough, which is the starting point for the GAIN measures. Another potential problem may be that we have two types of crashes: one where info is produced and one where no information is produced. This is not exactly captured by correlation.

The third hypothesis predicts that the cumulative change in the standard deviation of cross section of stock returns (BELIEFS) is negatively correlated with the rise in economic activity as more firms borrow BOOM. As the boom grows, the standard deviation of the cross section of stock returns (BELIEFS) should fall, as more firms are perceived to be of quality $\hat{p}$. The correlations are as predicted.

Table 3: Hypotheses 1, 2 and 3

	LOSS1	**LOSS2**	**BELIEFS1**	**BELIEFS2**
	Hypothesis 1		*Hypothesis 3*	
BOOM1	0.182	-0.013	-0.161	-0.317
BOOM2	-0.074	0.026	-0.190	-0.346
	Hypothesis 2			
GAINS1	0.389	0.154		
GAINS2	0.365	0.215		

Hypothesis (4) says the longer/larger the decline in the standard deviation of the cross section of beliefs prior to the shock, the more sharply the standard deviation is revised upwards following a crash, because information is produced. Beliefs are revised (R-BELIEFS), if information is produced. We first examine the related prediction that the standard deviation of the cross section of returns (R-BELIEFS) increases when shock arrives. That is, the average standard deviation of the change in the cross section of returns from the year just before the peak through the peak year should be positive. In fact, it is:

- BELIEFS1, NOT price weighted, average: 0.098.
- R-BELIEFS2, price weighted, average: 0.031.

Hypothesis (4) then predicts that the decline in BELIEFS prior to the shock, corresponding to the credit boom, should be negatively correlated with the increase in the standard deviation of the cross section of returns after the shock hits (R-BELIEFS), because of information production. BELIEFS goes down and R-BELIEFS goes up if there is information production. Also, measures of the recovery, from the trough onwards should be positive correlated with R-BELIEFS; both go up. We at look at these predictions over the two sample periods in Table 4.

Table 4: Hypothesis 4

1822-1913 (in parenthesis, 1839-1913)

	R-BELIEFS1	R-BELIEFS2
GAIN1	-0.127 (-0.174)	0.051 (-0.150)
GAIN2	-0.099 (0.054)	0.374 (-0.395)
BELIEFS1	0.814 (0.418)	
BELIEFS2		0.637 (0.201)

Measures of the recovery (GAIN) should go up, and so should the standard deviation of the cross section of returns after the shock if information has been produced. Over the period 1822-1913, this is true with R-BELIEFS2 and both measures of GAIN, but it is not true for R-BELIEFS1. Over the period 1839-1913, this is only found for the GAIN2 and R-BELIEFS1 combination.

The standard deviation of the cross section of returns should go down prior to the shock (BELIEFS), corresponding to the credit boom. After the shock hits, beliefs are revised; the cross section of stock returns goes up (R-BELIEFS). The negative correlation between BELIEFS and R-BELIEFS is sometimes present over 1822-1913, but not over the period 1839-1913.

The evidence for hypothesis (4) is mixed at best. The test of this hypothesis has two problems. First, as mentioned above, there is disagreement about the dating of the troughs. Second, according to our theory information is produced in some events and not others. But, these can't be distinguished. One possibility is to only look at downturns that had panics, assuming that these events correspond to information being produced. But, then a decision must be made about which events were panics. This is the subject of more research.

In general, the evidence is mixed. It is stronger for predictions that concern the pre-crisis period, that is, hypothesis (3) that the upswing in production is accompanied by a decline in the standard deviation of the cross section of beliefs. Evidence on what happens at or after the peak is much more mixed. There are many measurement problems, including the uncertainty about the timing of the trough dates, the fact that annual data is probably not the best given that the panic date may be the date at which information starts to be produced. Also, since information production is not observable, we are potentially mixing the two events. Further research is needed.

9 Conclusions

In this paper we discuss the positive and negative effects of information-insensitive debt. At the one hand, information-insensitive debt generates a credit boom because firms with bad collateral are able to borrow when information is not produced. This effect has been also highlighted in different contexts by Hirshleifer (1971) and Dang, Gorton, and Holmström (2011). On the other hand, the longer an economy is issuing information-insensitive debt and the longer the credit boom, the larger the system fragility, such that a negative aggregate shock to collateral of a given size is more likely to create a large systemic reduction in output and consumption. Furthermore, if the crisis triggers information production, the economy recovers faster in the absence of collateral policies, but slower in their presence.

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Table 1: Pre-Federal Reserve Business Cycles and Panics

NBER Chronology		Davis Chronology		Bank Panics	
Peak	Trough	Peak	Trough	Major	Minor
Pre-Civil War Business Cycles					
1796	1799	1796	1798	1796	
1802	1804	1802	1803		
1807	1810	1807	1808		
1811	1812	1811	1812		
1815	1821	1815	1816	1819	
1822	1823	1822	1823		
1825	1826				Jan. 1825
1828	1829	1828	1829		
1833	1834	1833	1834	Nov. 1833	
1836	1838	1836	1837	Oct. 1839	
1839	1843	1839	1840	Oct. 1857	
1845	1846				
1847	1848				
1853	1855				Sept. 1854
1856	1858	1856	1858	Aug. 1857	
Civil War Cycles					
1860	1861	1860	1861		Dec. 1861
1864	1867	1864	1865		
Post-Civil War Pre-Federal Reserve Cycles					
1869	1870				
1873	1878	1873	1875	Sept. 1873	
1882	1885	1883	1885	May 1884	
1887	1888				
1890	1891				1890
1892	1894	1892	1894	May 1893	
1895	1896	1895	1896		
1899	1900				
1903	1904	1903	1904		
1907	1908	1907	1908	Oct. 1907	
1910	1911	1910	1911		
1913	1914	1913	1914	July 1914	

Sources: NBER; Davis (2004); Gorton (1988); Jalil (2009).

Table 2: Variables

Variable	Definition	Comments
LOSS1	Cumulative industrial production loss from peak to the date where the part peak is achieved.	Output loss as a result of the negative shock: peak to year when previous level is achieved again.
LOSS2	Cumulative industrial production loss from peak to trough.	Output loss as a result of the negative shock: peak to next trough.
BOOM1	Years from trough to peak.	Measure of upswing prior to the negative shock, as credit is growing.
BOOM2	Cumulative industrial production change from prior trough to peak.	Measure of upswing prior to the negative shock, as credit is growing.
GAIN1	Cumulative industrial production gain from trough to next peak.	Measure of recovery growth after negative shock.
GAIN2	Cumulative industrial production gain from trough to two years after trough.	Another measure of recovery.
BELIEFS1	Standard deviation of the cross section of stock returns, NOT price weighted, from prior trough to peak.	Measure of the agents' beliefs during the upswing prior to the negative shock, as credit is growing.
BELIEFS2	Standard deviation of the cross section of stock returns, price weighted, from prior trough to peak.	Another such measure.
R-BELIEFS1	Standard deviation of the cross section of stock returns, NOT price weighted, from the year before the peak through peak.	Measure of the agents' beliefs after the negative shock, during which time information may be being produced.
R-BELIEFS2	Standard deviation of the cross section of stock returns, price weighted, from the year before the peak through peak.	Another such measure.