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SUSTAINABLE SHADOW BANKING

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ABSTRACT

Commercial banks are subject to regulation that restricts their investments. When banks are concerned for their reputation, however, they could self-regulate and invest more efficiently. Hence, a shadow banking that arises to avoid regulation has the potential to improve welfare. Still, reputation concerns depend on future economic prospects and may suddenly disappear, generating a collapse of shadow banking and a return to traditional banking, with a decline in welfare. I discuss how a combination of traditional regulation and cross reputation subsidization may enhance shadow banking and make it more sustainable.

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1 Introduction

Banks' activities are usually regulated to prevent excessive risk-taking and to provide a safety net to investors and depositors. One of those regulations involves capital requirements, which are expressed as a capital adequacy ratio of safe assets that banks have to hold as a fraction of their loans. This type of regulation restricts banks' investments, potentially forcing them to give up superior and relatively safe opportunities that governments cannot identify ex-ante as such.

In the years leading to the 2007-09 financial crisis in the United States, banks increasingly devised instruments to get around capital requirements, moving away from *traditional banking* into so called *shadow banking* – intermediation usually associated with traditional banking, but that runs in the "shadow" of regulators. As documented by Poznar et al. (2012), "At the eve of the financial crisis, the volume of credit intermediated by the shadow banking system was close to $20 trillion, or nearly twice as large as the volume of credit intermediated by the traditional banking system at roughly $11 trillion. Today, the comparable figures are $16 and $13 trillion, respectively."

Acharya, Schnabl, and Suarez (2012), for instance, study asset backed commercial paper (ABCP) conduits, one of the most representative financial instruments used in shadow banking. These are special purpose vehicles (SPV) sponsored by commercial banks to purchase long term assets issuing short term commercial paper. Since SPV are off-balance sheet, they are not subject to capital requirements, becoming the most important mechanism used by banks to go around regulations. They also show that ABCP "grew from $ 650 billion in January 2004 to $ 1.3 trillion in July 2007. At that time, ABCP was the largest money market instrument in the United States. For comparison, the second largest instrument was Treasury Bills with about $940 billion outstanding."

This large increase came to a sudden halt on August 9, 2007, when BNP Paribas suspended withdrawals from three funds invested in mortgage backed securities. "The interest rate spread of overnight ABCP over the Federal Funds rate increased from 10 basis points to 150 basis points within one day of the BNP Paribas announcement. Subsequently, ...ABCP outstanding dropped from $1.3 trillion in July 2007 to $833 billion in December 2007." Yet, the surprising growth and posterior collapse of shadow banking is not unprecedent. In the absence of regulations during the late 19th century and early 20th century, banking experienced parallel events to the recent one. In particular, investors at some point became concerned about the credit quality and liquidation values of the collateral used to back financial assets, and coordinated on large bank runs.

To compensate investors for participating in shadow banking without the safety net that regulations provide, banks offered explicit guarantees to repay maturing ABCP at par. Acharya, Schnabl, and Suarez (2012) show that the banks that used ABCP more intensively before the recent crisis were also the banks that were more heavily constrained by regulation, hence arguing that these conduits were effectively used to avoid regulatory pressures and to reduce capital requirements.[1] These guarantees, however, were constructed to cover liquidity risks, not credit risks and excessive risk-taking, which are the main targets of capital requirements.

Why do investors agree on participating in shadow banking if they understand that banks are trying to avoid regulation that provides a safety net against excessive risk-taking? A potential answer is that indeed regulation and capital requirements are useless. However, if this were true, why would investors run from shadow to traditional banking when they become concerned about the quality of collateral?

I argue that *reputation concerns* lie at the heart of both the growth and the fragility of shadow banking. Shadow banking spurs as long as outside investors believe that capital requirements are not critical to guarantee the quality of banks' assets, since reputation concerns self-discipline banks' behavior. When bad news about the future arise, reputation concerns collapse because reputation becomes less valuable, and investors stop believing in the self-discipline of banks, moving their funds to a less efficient, but safer, traditional banking.

In the model, banks have capital and also borrow from outside investors. Banks can invest these funds in safe assets or risky assets. Safe assets pay a moderate return in case of success but a high probability of success. There are two types of risky assets, observable by banks but not by governments: Inferior risky assets pay a high return in case of success but have a low probability of success. Superior risky assets also pay a high return in case of success, but have the same high probability of success as

[1]Interestingly, Acharya and Schnabl (2010) noted that Spain and Portugal are the only european countries that impose the same regulatory capital requirement for both assets on balance sheet and assets on ABCP conduits. Consistently with the regulatory arbitrage motive, banks in these countries do not sponsor ABCP conduits.

safe assets. I assume a planner would like banks to invest in risky assets if the risky asset is superior or in safe assets if the risky asset is inferior. However, banks have incentives to always invest in risky assets, regardless of their type. This excessive risk-taking arises because outside investors end up facing most of the downside risk. Then, since the planner cannot identify between risky assets, it prefers investments only in safe assets than investments only in risky assets.

There are two ways to prevent excessive risk-taking. One is government regulation in the form of requirements to invest the bank capital in safe assets. The other is self-discipline sustained by reputation concerns. If the government cannot identify the type of risky asset, then capital requirements are useful in preventing banks from investing in inferior risky assets, but costly in preventing banks from investing in superior risky assets. Reputation concerns provide a more efficient disciplining device, preventing banks from investing in inferior risky assets without preventing them from investing in superior risky assets.

In this setting, if all banks are reputation-concerned, it is preferred to rely on self-regulation than in government regulation. However, the value of reputation depends on expected future economic conditions, and so the degree of reputation concerns depends on news about the future. When the future looks bright, with good business opportunities, building and maintaining reputation is valuable, inducing banks to invest optimally. However, when future prospects are poor, reputation is not that valuable, increasing the incentives of banks to take excessive risks. This trade-off between short term gains of always investing in risky projects and long terms costs in terms of reputation may change over time, rendering self-discipline fragile.

Even though banks always try to avoid restrictive regulation by issuing conduits with explicit guarantees, outside investors are not always willing to participate in shadow banking on terms that are convenient to banks. When the future looks bright, outside investors understand that self-regulation is at play and believe in the value of those guarantees, making shadow banking feasible. However, if there is sudden bad news about the future, investors understand that reputation concerns break down and become concerned about the quality of bank assets and the value of guarantees that are sustained by those assets, moving their funds to traditional banking.

Shadow banking only arises in the presence of reputation concerns, and its collapse is a mirror image of the collapse in reputation concerns, with the system returning to traditional banking, which provides a better safety net for investors. Then, the question is how to enhance shadow banking? How to make it less volatile?

I explore the effects of an alternative regulation that combines capital requirements and cross subsidization of banks, with taxes to banks with low reputation and subsidies to banks with high reputation, that balance the budget. This alternative regulation reduces even further the reputation concerns of firms with already low concerns, which is irrelevant for welfare since those banks cannot participate in shadow banking in the first place. In contrast it increases even further the reputation concerns of firms with already high concerns, making them more willing to participate in shadow banking and their self-discipline less sensitive to changes in future economic conditions. Hence, this alternative regulation has the potential to sustain a less fragile shadow banking.

Relation with the literature. Stein (2010) summarizes the economic forces behind securitization as the efficient enhancement of risk-sharing and the circumvention of capital and other regulatory requirements. Acharya, Schnabl, and Suarez (2012) show that regulatory arbitrage was critical in the recent phenomenal growth of shadow banking. In this paper I rationalize the rise and collapse of shadow banking by the rise and collapse of self-regulation driven by fragile reputation concerns as an alternative of government regulation.

This rationalization of shadow banking complements other explanations that focus on the risk-sharing properties of securitization. Gennaioli, Shleifer, and Vishny (2011) show that an increase in investors' wealth drives up securitization. This also introduces fragility because banks become interconnected and more exposed to systemic risk. In their model, securitization is also welfare improving and only subject to crises in the case when agents neglect those systemic risks. In contrast, in this paper securitization spurs when there are good economic conditions and can collapse in a rational expectations environment.

The paper also complements the view of Adrian and Shin (2009) and Shin (2009), who argue that securitization facilitates access to funds from investors, increasing credit supply. As balance sheets expand, however, new borrowers must be found and banks lower their lending standards. The reduction in asset quality leaves the system in a fragile position to face downturns. In this paper, the lower quality of assets arise from a collapse in self-regulation and not from more relaxed lending standards.

This paper also adds to the discussion of regulation in the new financial landscape. Gorton and Metrick (2010) structure their proposal to regulate shadow banking around the idea that securitization arises because it is bankruptcy remote. Ricks (2010) also proposes to extend the safety net of public insurance to shadow banking to reduce its fragility. However, as Adrian and Ashcraft (2012) extensively document, regulation has persistently failed in stabilizing shadow banking. This view of regulation may be misleading since banks can always find ways around regulation when self-regulation becomes feasible, and it is indeed efficient for them to do so. I discuss instead regulation that focus on "carrots" rather than "sticks" to discipline banks, with policy interventions that enhance the reputation discipline by cross-subsidizing banks, reducing the fragility of securitization and still maintaining its efficiency.[2]

My work also contributes more generally to the literature on herding behavior, which generates sudden collapses of reputation concerns. While the work pioneered by Scharfstein and Stein (1990) considers agents that mimic others and disregard private information, banks in my model cannot observe the actions of other banks and instead use private information about possible future economic conditions to coordinate behavior. The justification of herding when agents cannot observe the actions of others but instead a correlated signal about an aggregate variable is key in understanding how the collapse of the new, more complex, financial system was critically characterized by lack of information about other investors' positions.

Finally, even though this paper rationalizes the rise and collapse of shadow banking characterized by conduits with *explicit guarantees* and investors concerned about the quality of those guarantees, an important fraction of securities were not guaranteed at all. For those financial instruments, the investors' main concern is the incentives of sponsoring banks to cover securities in distress with balance-sheet assets, even without being legally bound to do it (that is, *implicit guarantees*). According to Acharya, Schnabl, and Suarez (2012), among all ABCP outstanding in 2007, 10% were barely guaranteed – extendible and SIV weak guarantees – in commercial banks, 50% in structured finance companies, and almost 75% in mortgage originators.

In Ordonez (2013), I show that conduits that do not have explicit guarantees can also be sustained by investors' beliefs that banks concerned for their reputation have in-

[2] Atkeson, Hellwig, and Ordonez (2012) also discuss the benefits of cross-subsidization in a general equilibrium environment with free entry of reputationally concerned firms.

centives to take securities in distress back to their balance-sheet. With these conduits, banks not only avoid regulation but also, given that there are no explicit guarantees, save on potential bankruptcy costs. Gorton and Souleles (2006) also argue that securitization arises as an implicit collusion between banks and investors to save on bankruptcy costs. However, in their paper there is no discussion on how the system sustains such collusion or how it can collapse.

In the next section I introduce a model that compares traditional and shadow banking, highlighting that shadow banking instruments, such as securitization, provide a more efficient, but fragile, alternative to traditional banking. I also discuss how firms choose between these two banking systems based on their reputation. In Section 3, I discuss a novel regulation to enhance and stabilize shadow banking. In Section 4, I illustrate the results and the dynamics with a numerical example. In Section 5, I make some concluding remarks.

2 Model

2.1 Description

Consider a two-period economy with a continuum of banks and lenders, and a government. There are two types of banks: *Good banks* (G) care about their future (low discount rate or high β), while *bad banks* (B) do not care about their future ($\beta = 0$).[3] Banks observe their own type. We define reputation of a bank ϕ as the probability that the bank is of type G.

In period 1, each bank has a unit of capital, which can be invested in one of two available illiquid assets: *"Safe assets"* pay y_s with probability p_s in period 2, and 0 otherwise, and *"risky assets"* pay $y_r > y_s$ in case of success. With probability α the risky asset is *superior* and succeeds with probability p_s. With probability $1 - \alpha$ the risky asset is *inferior* and succeed with probability $p_r < p_s$. Banks observe the type of risky assets, but lenders and governments do not.

The bank also has the ability to invest in an additional *"new asset"*, which also requires a unit of capital and pays x with probability p_x in period 2, and 0 otherwise. Firms

[3] This is a stylized way to introduce heterogeneity in quality. Bad banks, for example, may expect to perform poorly and leave the banking industry with a higher probability than good banks.

have to borrow the unit of capital at an endogenous rate R from infinitely many, short-lived, risk-neutral, and perfectly competitive lenders, whose outside option generates a risk free return normalized to 0. To make the model interesting, I make the following assumptions on asset payoffs.

Assumption 1 *Asset Payoffs*

1. $p_s y_r > p_s y_s > p_r y_r > 1$ *and* $p_x x > 1$ *(Superior risky assets pay in expectation more than safe assets. Inferior risky assets pay in expectation less than safe assets. All assets are efficient).*

2. $y_r > y_s > R$ *(Successful assets are enough to repay loans, where* R *is endogenous but expressed in terms of primitives).*

3. $p_s y_s > \alpha p_s y_r + (1-\alpha) p_r y_r$ *(It is ex-ante optimal to invest in safe assets).*

4. $p_s(y_r - R) > p_r(y_r - R) > p_s(y_s - R)$ *(Moral Hazard. Firms always prefer to invest in risky assets).*

Banks have two possible ways to finance the new asset: raising funds using *traditional banking* or *shadow banking*. For illustrative purposes, I focus attention on the most representative financing method for each banking type: *debt* and *securitization*, respectively. If banks raise debt (or collect demand deposits in the case of commercial banks, for example), they are subject to regulation and capital requirements that introduce restrictions on how firms invest their initial capital. In particular, we assume that firms are required to invest their unit of capital in safe assets.

In contrast, banks can raise funds securitizing the new asset, effectively selling it to a sponsored *special purpose vehicle* (SPV).[4] Since new assets are off-balance sheet, the investment of banks is not subject to any regulation or capital requirement, and thus can invest in either safe or risky assets without restrictions. To attract investors, banks can issue explicit guarantees to cover securities in distress with successful assets on

[4] An SPV is a legal entity which has been set up for a specific, limited, purpose by another entity, the sponsoring firm. The SPV is off-balance sheet of the sponsor if it meets the requirements set forth by Financial Accounting Standard 140. Critically, the SPV should be a separate and distinct legal entity from the sponsor, and an automaton in the sense that there are no substantive decisions for it to ever make, just simply rules that must be followed. SPVs are essentially robot firms that have no employees, make no substantive economic decisions, have no physical location, and cannot go bankrupt.

the balance sheet. However, not being subject to regulation, banks cannot guarantee to investors the safety of those assets and, as a consequence, the value of those guarantees.[5]

In essence, the decision between using traditional or shadow banking boils down to a decision between using a system where regulation determines the quality of bank assets or a system where banks choose the quality of bank assets. Banks *invest optimally* when buying risky assets only when they are superior. Without regulation, banks have incentives to invest only in risky assets, which we call *excessive risk-taking*. With *regulation* banks are constrained to invest only in safe assets. By assumption 1, optimal investments dominate in terms of expected output regulation, which at the time dominates excessive risk-taking.

Finally, banks obtain a positive continuation value $V(\phi, \theta)$ at the end of period 2, which is an exogenous function monotonically increasing both in reputation ϕ and in a unidimensional aggregate fundamental θ. The fundamental θ represents aggregate demand, economic conditions, housing prices, or in general any other variable that positively affects the expected prospects of banks after period 2. I assume this fundamental is drawn from a known normal distribution with mean μ and variance $\frac{1}{\gamma_\theta}$ (i.e., precision γ_θ).[6]

I also assume that, regardless of the financing choice, the continuation value from defaulting is zero. This can be interpreted in the repeated game as the bank being liquidated and unable to re-enter the industry by raising new funds from investors or depositors. This extreme assumption, which imposes a heavy punishment from defaulting, is just a normalization that simplifies the exposition.

To be concrete, the timing in each period is as follows,

- Period 1: All agents know the distribution $\theta \sim \mathcal{N}(\mu, \frac{1}{\gamma_\theta})$ of fundamentals. Banks observe the type of the risky asset. A bank of type $i \in \{B, G\}$ and reputation ϕ

[5] A companion paper analyzes why reputation concerns are critical for securitization that is not guaranteed, such as structured investment vehicles (SIV). In that case, the rationale for securitization is not only avoiding regulation but also costly bankruptcy procedures.

[6] For expositional reasons, I assume $V(\phi, \theta)$ is exogenous. It is easy to endogeneize the continuation value as a positive function of ϕ in a full fledged repeated game (since I will show that endogenous interest rates decrease with ϕ) and to show that continuation values are positive under limited liability. These extensions are cumbersome and unnecessary to illustrate the main points of the paper. For an application of how to endogeneize value functions in similar settings, see Ordonez (2012).

chooses whether to finance the new asset by issuing (regulated) debt or (unregulated) securities. If banks issue debt, they have to invest in safe assets. If banks issue securities, they choose whether to invest in a risky or safe asset.

- Period 2: Asset payoffs are realized and observed by all agents. If the bank does not repay the loan, it is liquidated and disappears, having a continuation value of 0. If the bank repays, it continues, its reputation is updated from ϕ to ϕ' according to Bayes' rule and it obtains a continuation value $V(\phi', \theta)$.

In what follows, I first characterize separately the payoffs from debt and from securitization for a bank of a given type $i \in \{B, G\}$ and reputation ϕ. Then, I characterize the optimal financing decision of banks with different types and reputations.

2.2 Debt

Since lenders are competitive and the risk-free rate is zero, interest rates R equalize the expected repayment with the size of the loan, normalized to 1. Define as $\hat{p}_D = p_x + (1 - p_x)p_s$ the probability of loan repayment, since p_x is the probability that the new asset succeeds and p_s is the probability that the safe asset succeeds. The face value of debt (in this case, also the interest rate) is the loan divided by the expected probability of repayment. Then,

$$R_D = \frac{1}{\hat{p}_D}, \tag{1}$$

Since the probability of repayment is determined by regulation from imposing investments only in safe assets, the interest rate R is independent of banks' type and, as a consequence, also independent of banks' reputation, ϕ. After repayment, reputation is not updated, determining the bank's continuation value, $V(\phi, \theta)$.

2.3 Securitization

In our setting securities are financial instruments constructed to avoid regulatory pressures to invest only in safe assets. By construction, however, bad banks only invest in risky assets if not regulated, then the expected probability a bad bank (B)

repays an issued security is

$$\begin{aligned}\widehat{p}_B &= p_x + (1-p_x)[\alpha p_s + (1-\alpha)p_r] \\ &= p_x + (1-p_x)[p_s - (1-\alpha)(p_s - p_r)] < \widehat{p}_D.\end{aligned}$$

Bad banks repay when the new asset is successful (with probability p_x), and when the new asset fails, the guarantee imposes repayment using the assets on the balance sheet. Since these are risky assets, their probability of success is p_s if the asset is superior (with probability α) and p_r if the asset is inferior (with probability $1-\alpha$).

Similarly, the expected probability a good bank (G) repays an issued security is

$$\begin{aligned}\widehat{p}_G(\widehat{\tau}) &= p_x + (1-p_x)[\alpha p_s + (1-\alpha)[p_s\widehat{\tau} + p_r(1-\widehat{\tau})]] \\ &= \widehat{p}_B + \widehat{\tau}(1-p_x)(1-\alpha)(p_s - p_r) \leq \widehat{p}_D,\end{aligned}$$

where the strategy $\tau \in [0,1]$ is the probability good banks invest optimally (invest in safe assets when risky assets are inferior) and $\widehat{\tau}$ is the lenders' beliefs about good banks' strategies. When $\widehat{\tau} = 1$, and lenders believe good banks invest optimally, then $\widehat{p}_G(\widehat{\tau} = 1) = \widehat{p}_D$.

The price of securities can then be expressed as an interest rate,

$$R_S(\phi|\widehat{\tau}) = \frac{1}{\phi\widehat{p}_G(\widehat{\tau}) + (1-\phi)\widehat{p}_B} = \frac{1}{\widehat{p}_B + \phi\widehat{\tau}(1-p_x)(1-\alpha)(p_s-p_r)} \geq R_D. \qquad (2)$$

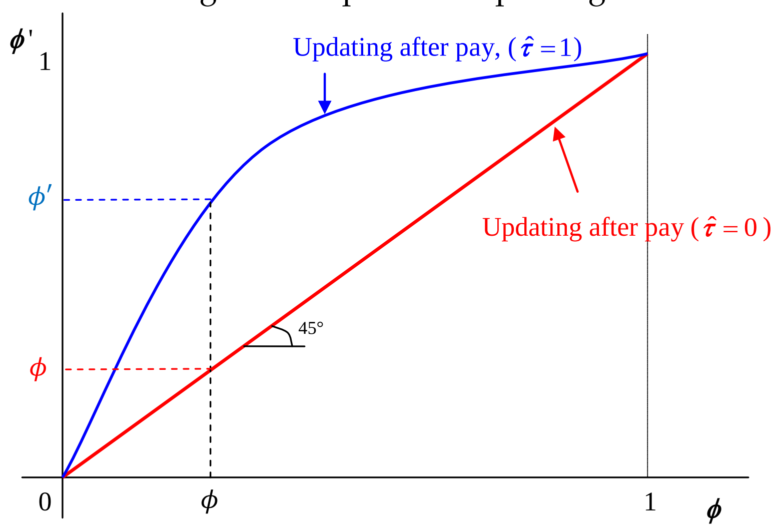
The only situation in which $R_S = R_D$ is when $\phi = 1$ and $\widehat{\tau} = 1$. In this extreme case it is believed the bank is good for sure and good banks always invest optimally.

Reputation updating also depends on beliefs, $\widehat{\tau}$. Using Bayes' rule,

$$\phi'(\phi|\widehat{\tau}) = \frac{\widehat{p}_G(\widehat{\tau})\phi}{\widehat{p}_G(\widehat{\tau})\phi + \widehat{p}_B(1-\phi)}.$$

As shown in Figure 1, $\phi'(\phi|\widehat{\tau})$ increases with $\widehat{\tau}$ for a given ϕ. Intuitively, if lenders believe that good banks invest optimally, then they expect that good banks are more likely to repay than bad banks, who only invest in risky assets. Given these beliefs, lenders will revise reputation up when they observe a bank repaying securities and covering guarantees. In contrast, if lenders expect that good banks never invest optimally, they expect that good banks repay with the same probability as bad banks, not revising reputation when observing repayment of a security.

Figure 1: Reputation Updating



Expected profits for good banks with reputation ϕ following strategy τ, conditional on lenders believing good banks with reputation ϕ follow strategy $\widehat{\tau}$ are

$$\begin{aligned} U_G^S(\phi,\tau|\widehat{\tau}) &= p_x x + \alpha p_s y_r + (1-\alpha)[\tau p_s y_s + (1-\tau)p_r y_r] \\ &\quad + \widehat{p}_G(\tau)\left[\beta V(\phi'(\phi|\widehat{\tau})) - R_S(\phi|\widehat{\tau})\right]. \end{aligned}$$

Good banks invest optimally ($\tau = 1$) given beliefs $\widehat{\tau}$, if

$$\Delta(\phi|\widehat{\tau}) = U_G^S(\phi,\tau=1|\widehat{\tau}) - U_G^S(\phi,\tau=0|\widehat{\tau}) > 0,$$

which can be rewritten as

$$\Delta(\phi|\widehat{\tau}) = (1-\alpha)(p_s y_s - p_r y_r) + (1-p_x)(1-\alpha)(p_s-p_r)[\beta V(\phi'|\widehat{\tau}) - R_S(\phi|\widehat{\tau})] > 0.$$

Definition 1 *A reputation equilibrium is one in which good banks invest optimally, and beliefs are consistent,* $\tau = \widehat{\tau} = 1$.

Defining the short term gains of investing in an inferior risky project as $\Psi \equiv \frac{p_r y_r - p_s y_s}{(1-p_x)(p_s-p_r)}$, the sufficient condition for a reputation equilibrium is

$$\beta V(\phi'|\widehat{\tau}=1) \geq \Psi + R_S(\phi|\widehat{\tau}=1). \tag{3}$$

In contrast, the condition for a non-reputation equilibrium, in which $\tau = \widehat{\tau} = 0$, is

$$\beta V(\phi'|\widehat{\tau}=0) \leq \Psi + R_S(\phi|\widehat{\tau}=0). \tag{4}$$

In what follows, I describe a potential multiplicity of equilibria and refine the set of equilibria using global games techniques. Then, using the unique equilibrium obtained from the refinement, I characterize the conditions under which different financing decisions are implemented.

2.3.1 Multiplicity with complete information

Since continuation values are monotonically increasing in posteriors ϕ', which are monotonically increasing in $\widehat{\tau}$, then $V(\phi|\widehat{\tau}=1,\theta) > V(\phi|\widehat{\tau}=0,\theta)$. Also, since $\widehat{p}_G(\widehat{\tau}=1) > \widehat{p}_G(\widehat{\tau}=0)$, then $R_S(\phi|\widehat{\tau}=1) < R_S(\phi|\widehat{\tau}=0)$. Combining these inequalities with equilibrium conditions (3) and (4), there are values of θ under which reputation and non-reputation equilibria coexist. Fundamentals are not only useful to characterize multiplicity in an environment with changing conditions, but are also key in selecting a unique equilibrium using global games techniques, by assuming that agents do not observe θ perfectly, but "almost" perfectly.

Good banks invest optimally when the expected gains from reputation are large enough. Since these gains increase with fundamentals θ, I focus on cutoff strategies,

$$\tau(\phi,\theta) = \begin{cases} 1 & if \quad \theta > \theta^*(\phi) \\ [0,1] & if \quad \theta = \theta^*(\phi) \\ 0 & if \quad \theta < \theta^*(\phi) \end{cases}$$

Given these strategies I redefine good banks' repayment probabilities as

$$\widehat{p}_G(\widehat{\theta}^*) = \widehat{p}_B + (1-\mathcal{N}(\widehat{\theta}^*))(1-p_x)(1-\alpha)(p_s-p_r),$$

where $\widehat{\theta}^*$ is the cutoff lenders believe good banks will follow and $\mathcal{N}(\widehat{\theta}^*)$ is the ex-ante expectation that $\theta < \theta^*(\phi)$ when the expectation of θ is μ. Then,

$$R_S(\phi|\widehat{\theta}^*) = \frac{1}{\widehat{p}_B + \phi(1-\mathcal{N}(\widehat{\theta}^*))(1-p_x)(1-\alpha)(p_s-p_r)} \tag{5}$$

If $\widehat{\theta}^* = -\infty$, then $\widehat{p}_G(\widehat{\theta}^* = -\infty) = \widehat{p}_B + (1-\alpha)(p_s - p_r)$ and $R_S(\phi|\widehat{\theta}^* = -\infty) = \frac{1}{\widehat{p}_B + \phi(1-\alpha)(p_s-p_r)}$. If good banks are believed to always invest optimally, interest rates are lower the higher the reputation of the sponsor. In contrast, if $\widehat{\theta}^* = \infty$ and $\widehat{p}_G(\widehat{\theta}^* = \infty) = \widehat{p}_B$, then $R_S(\phi|\widehat{\theta}^* = \infty) = \frac{1}{\widehat{p}_B}$. If good firms are believed to always invest in risky assets, then default probabilities are the same for good and bad banks, and banks pay the highest possible interest rates, independently of their reputation.

In this setting there are two possible sources of multiplicity. First, interest rates can possibly generate a finite number of equilibria. It is straightforward to select a unique equilibrium in this situation as in Stiglitz and Weiss (1981), assuming Bertrand competition in which lenders first offer a rate and then banks choose the best offer. Assume for example there are three possible interest rates in equilibrium and all lenders charge the highest rate. In this case there are incentives for a single lender to deviate, offering a lower rate consistent with a different equilibrium, attracting banks and still breaking even. Then, lenders that effectively provide loans are the optimistic ones. This refinement rationalizes as the unique equilibrium the one with the lowest rate.

The second source of multiplicity, reputation formation, is more difficult to deal with since it always generates a continuum of multiple equilibria. Can we still apply the selection mechanism proposed by Stiglitz and Weiss (1981)? Yes, but only if the lenders who update reputation are the same than those who provide loans. Only in this uninteresting case, in which a bank only obtains financing from a single lender all its life, and the perception of other market agents do not matter, is there not a meaningful complementarity problem from reputation formation.

However, if the lenders who set interest rates in the current period are different to the lenders who provide funds in following periods (or at least there is some chance lenders are not the same, which is a realistic assumption for depositors in commercial banks), interest rates cannot be used to select an equilibrium. Assume again all lenders charge a high rate and then good banks prefer to invest only in risky assets. A single lender does not have incentive to deviate and charge a lower interest rate (as opposed to the Bertrand intuition) because the bank taking its loan still would not be induced to repay, knowing that future lenders will likely not update its reputation. Hence, even when Bertrand competition can solve multiplicity generated by the first source, it cannot solve the multiplicity created by complementarity in reputation formation.

In what follows, I assume the first source of multiplicity is not an issue, so I can focus on the more interesting multiplicity created by reputation formation. First, I assume that, fixing a belief $\widehat{\tau}$ for all fundamentals θ, there is a unique cutoff θ^* at which banks are indifferent between investing optimally or not.

Assumption 2 *Single Crossing*

Assume fixed beliefs $\widehat{\tau}$ for all θ. There is a unique cutoff fundamental θ^*, consistent with beliefs $\widehat{\theta}^* = \theta^*$, at which banks are indifferent between investing optimally or not, such that

$$\beta V(\phi', \theta^* | \widehat{\tau}) = \Psi + R_S(\phi | \widehat{\theta}^* = \theta^*).$$

This assumption is fulfilled, for example, when the variance of fundamentals is low enough, such that the ex-ante probability of default $\mathcal{N}(\widehat{\theta}^*)$, and hence interest rates R_S, do not change abruptly with changes in beliefs about cutoffs $\widehat{\theta}^*$.

Now, I define a range of fundamentals for which, regardless of lenders' beliefs, a bank takes excessive risk and a range of fundamentals for which, regardless of lenders' beliefs, a banks invests optimally.

Assumption 3 *Dominance Regions*

There are fundamental levels $\underline{\theta}(\phi)$ under which $\beta V(\phi', \underline{\theta} | \widehat{\tau} = 1) < \Psi + R_S(\phi | \widehat{\theta}^* = \underline{\theta})$ and $\overline{\theta}(\phi)$ above which $\beta V(\phi', \overline{\theta} | \widehat{\tau} = 0) > \Psi + R_S(\phi | \widehat{\theta}^* = \overline{\theta})$.

For all fundamentals $\theta < \underline{\theta}$ banks take excessive risk, even if lenders believe $\widehat{\tau} = 1$ and reputation suffers a lot from taking risks. Intuitively, future prospects are so poor that reputation concerns are irrelevant. Similarly, for all fundamentals $\theta > \overline{\theta}$ banks invest optimally, even if lenders believe $\widehat{\tau} = 0$ and reputation does not improve from investing optimally. Here, future prospects are so good that firms are afraid of defaulting and getting a zero continuation value. Finally, $\underline{\theta}(\phi) < \overline{\theta}(\phi)$ for all ϕ, since $\beta V(\phi', \widehat{\theta}^*|\widehat{\tau} = 1) - R_S(\phi|\widehat{\theta}^*) > \beta V(\phi', \widehat{\theta}^*|\widehat{\tau} = 0) - R_S(\phi|\widehat{\theta}^*)$ for all ϕ and $\widehat{\theta}^*$.

For all $\widehat{\theta}^* \in [\underline{\theta}(\phi), \overline{\theta}(\phi)]$, reputation and non-reputation equilibria coexist. In this range, good banks invest optimally when lenders believe good banks will invest optimally and take excessive risk when lenders believe good banks will take excessive risk. This implies that a fundamental θ can be defined as an equilibrium cutoff if there exists a $\widehat{\tau}(\phi, \widehat{\theta}^*) \in [0, 1]$ such that

$$\beta V(\phi', \widehat{\theta}^*|\widehat{\tau}(\widehat{\theta}^*)) = \Psi + R_S(\phi|\widehat{\theta}^*).$$

This multiplicity is problematic for drawing conclusions about the effects of reputation in sustaining self-regulation in the shadow banking. In the next section, following Ordonez (2012), we relax the assumption of complete information about θ and select a unique equilibrium robust to small perturbations of information about θ.

2.3.2 Uniqueness with incomplete information

Assume now banks i and lenders j observe an informative signal of the fundamental, $s_i = \theta + \epsilon_i$ where $\epsilon_i \sim N(0, \frac{1}{\gamma_s})$. Cutoff strategies are then based on signals,

$$\tau(\phi, s_i) = \begin{cases} 1 & if \quad s_i > s^*(\phi) \\ [0,1] & if \quad s_i = s^*(\phi) \\ 0 & if \quad s_i < s^*(\phi) \end{cases}$$

The differential gains from investing optimally are now given by taking expectations about θ, conditional on the prior μ and the signal s_i

$$E_{\theta|s_i}\left[\Delta(\phi, \theta|\widehat{\tau}(s_i))\right] = (1-\alpha)\left[(p_s y_s - p_r y_r) + (1-p_x)(p_s - p_r)\left[\beta E_{\theta|s_i}\left[V(\phi', \theta|\widehat{\tau}(s_i))\right] - R(\phi|\widehat{s}^*)\right]\right],$$

where $\widehat{s}^*$ is the cutoff lenders believe firms follow. In this situation, lenders compute the interest rate to charge based on an ex-ante probability that fundamentals are smaller than $\widehat{s}^* = s^*$, such that default probability is $\mathcal{N}(s^*)$.

Proposition 1 *Unique Equilibrium.*

For $\gamma_s \to \infty$, there is a unique equilibrium in which every good bank with reputation ϕ invests optimally if and only if $s > s^*(\phi)$, where s^* solves

$$\beta E_{\theta|s^*}\left[V(\phi', \theta|\widehat{\tau}(s^*))\right] = \Psi + R(\phi|s^*), \tag{6}$$

where $\widehat{\tau}(s^*) = 1 - \Phi\left(\sqrt{\gamma}(s^* - \mu)\right)$ is the belief lenders use to update reputation when they think firms observe a signal s^*. Furthermore, $\gamma = \frac{\gamma_s \gamma_\theta^2}{(\gamma_\theta+\gamma_s)(\gamma_\theta+2\gamma_s)}$.

Proof Since $s^*(\phi)$ is the signal that makes a good bank with reputation ϕ indifferent between investing optimally or not, the condition that determines $s^*(\phi)$ is

$$\beta E_{\theta|s^*}\left[V(\phi', \theta|\widehat{\tau}(s^*))\right] = \Psi + R(\phi|s^*),$$

where $\widehat{\tau}(s_i) = 1 - Pr(E_j(\theta) < E_i(\theta)|s_i)$, this is the probability that lenders expect a fundamental θ which is smaller than the fundamental the bank expects conditional on the signal s_i that the bank observes. Since at the cutoff s^* banks are indifferent between investing optimally or not, $\widehat{\tau}(s^*)$ is also the probability that banks assign to lenders believing θ is such that the bank invests optimally, and hence the belief lenders use to update reputation at the cutoff s^*.

The updated belief of the bank about the fundamental, after observing a signal s_i is

$$E_i(\theta|s_i) = \frac{\gamma_\theta \mu + \gamma_s s_i}{\gamma_\theta + \gamma_s}.$$

The updated distribution of the fundamentals after the bank observes the signal s_i is

$$\theta|s_i \sim \mathcal{N}(E_i(\theta|s_i), \frac{1}{\gamma_\theta + \gamma_s}),$$

and the expected distribution of the signals that lenders observe, s_j, conditional on the signal the bank does observe, s_i, is

$$s_j|s_i \sim \mathcal{N}(E_i(\theta|s_i), \frac{1}{\gamma_\theta + \gamma_s} + \frac{1}{\gamma_s}). \tag{7}$$

Hence,

$$\begin{aligned} Pr\left(E_j(\theta) < E_i(\theta)|s_i\right) &= Pr\left(s_j < E_i(\theta) + \frac{\gamma_\theta}{\gamma_s}(E_i(\theta)-\mu)|s_i\right) \\ &= \Phi\left(\sqrt{\gamma}(s_i-\mu)\right), \end{aligned}$$

where $\gamma = \frac{\gamma_s\gamma_\theta^2}{(\gamma_\theta+\gamma_s)(\gamma_\theta+2\gamma_s)}$

As $\gamma_s \to \infty$, $\gamma \to 0$, then $\widehat{\tau}(s_i) = \frac{1}{2}$ for all s_i. Hence, in the limit the unique cutoff s^* is uniquely determined by $\beta E_{\theta|s^*}\left[V\left(\phi', \theta|\widehat{\tau}(s^*) = \frac{1}{2}\right)\right] = \Psi + R(\phi|s^*)$. Q.E.D.

Lenders update reputation beliefs based on their beliefs about the actions of banks, which depend on their signals. When lenders observe a signal s_j, they infer that the probability the bank observes a signal s_i below the cutoff $s^*(\phi)$, and decides to invest optimally, is

$$\widehat{\tau}(s_j) = 1 - Pr(s_i < s^*|s_j) = 1 - \Phi\left[\sqrt{\frac{\gamma_s(\gamma_\theta+\gamma_s)}{\gamma_\theta+2\gamma_s}}(s^* - \frac{\gamma_\theta\mu+\gamma_s s_j}{\gamma_\theta+\gamma_s})\right],$$

where Φ is just the standard normal distribution from equation (7). As $\gamma_s \to \infty$, $\widehat{\tau}(s_j) \to 0$ if $s_j < s^*(\phi)$ and $\widehat{\tau}(s_j) \to 1$ if $s_j > s^*(\phi)$. This implies that in the limit, whenever lenders observe a signal above $s^*(\phi)$, they believe almost certainly banks invest optimally and update reputation accordingly. Similarly, whenever investors observe a signal below s^*, they believe almost certainly banks take excessive risk and do not update reputation.

This refinement of equilibria uncovers the fragility of reputation. A bank with reputation ϕ invests optimally based on a cutoff $s^*(\phi)$ and their risk-taking strategies change dramatically around that cutoff. In the next section I study this extreme sensitivity of risk-taking, which makes reputation concerns, and then shadow banking, fragile.

2.3.3 Expected economic conditions and risk-taking

How does the deterioration of expected economic conditions, captured by a lower μ, affect risk-taking, total expected production, and the likelihood of default in the economy? In this section, I show that bad news about the future has the potential to reduce output, increase default rates of securities, and induce a flight of investors from shadow banking to traditional banking.

A reduction in economic prospects, μ, triggers two effects. The first effect is mechanical: A lower μ reduces the ex-ante probability that banks invest optimally for a given cutoff $s^*(\phi)$. The second effect is strategic: A lower μ leads to a higher cutoff $s^*(\phi)$, making banks less willing to invest optimally for a given θ. Since the first effect is obvious, the next proposition focuses on the second effect.

Proposition 2 *The cutoff $s^*(\phi)$ decreases monotonically with μ.*

Proof The proof applies for any ϕ, hence for notational simplicity I denote $s^*(\phi)$ just as s^*. Differentiating the condition (6) that pins down s^* with respect to μ,

$$\frac{\partial \beta\ E_{\theta|s^*}\left[V(\phi',\theta|\widehat{\tau}(s^*))\right]}{\partial s^*}\frac{ds^*}{d\mu}=\frac{\partial R(\phi|s^*)}{\partial s^*}\frac{ds^*}{d\mu}+\frac{\partial R(\phi|s^*)}{\partial \mu}.$$

Then,

$$\left(\frac{\partial \beta E_{\theta|s^*}\left[V(\phi',\theta|\widehat{\tau}(s^*))\right]}{\partial s^*}-\frac{\partial R(\phi|s^*)}{\partial s^*}\right)\frac{ds^*}{d\mu}=\frac{\partial R(\phi|s^*)}{\partial \mu}. \tag{8}$$

By assumptions 2 and 3, the term in parentheses is positive. Since $\frac{\partial \mathcal{N}(s^*)}{\partial \mu}<0$, then $\frac{\partial R(\phi|s^*)}{\partial \mu}<0$, and the left hand side is negative, which implies that $\frac{ds^*}{d\mu}<0$. Q.E.D.

Intuitively, a decline in μ increases $R(\phi|s^*)$ for a given s^* (by an increase in the cumulative distribution up to s^*). This requires a larger s^* to raise $E_{\theta|s^*}\left[V(\phi',\theta|\widehat{\tau}(s^*))\right]$ and fulfill equation (6). This direct effect increases s^*. Furthermore, an increase in s^* implies a further increase in $R(\phi|s^*)$, which reinforces the direct effect generated by a lower μ. There is also a second effect that comes from reducing beliefs $\widehat{\tau}(s_i)$ and reputation updating at each s_i, (since $\widehat{\tau}(s_i)=1-\Phi\left(\sqrt{\gamma}(s_i-\mu)\right)$, weakly reducing $E_{\theta|s_i}\left[V(\phi',\theta|\widehat{\tau}(s_i))\right]$, for every signal s_i. Hence, a further increase in s^* is necessary to compensate for this reduction and still fulfill equation (6).

At this point we can distinguish between informative and uninformative news about changes in expected economic conditions. Figure 2 shows the effects of uninformative bad news (lower expected fundamental μ without a real change in the distribution of fundamentals). This wave of pessimism induces less production and more default by changing banks' strategic risk-taking behavior. In contrast, Figure 3 shows the effects of informative bad news (a real reduction of μ), which decreases output and increases default both mechanically (larger ex-ante probability of risk-taking) and strategically.

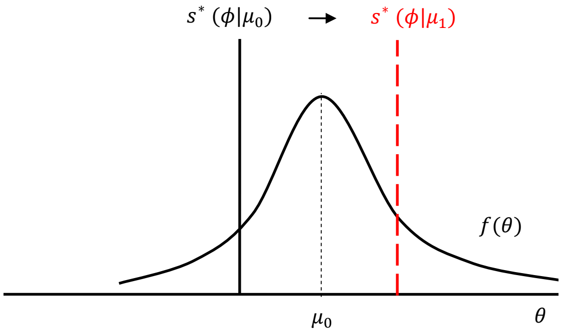


Figure 2: Uninformative Bad News

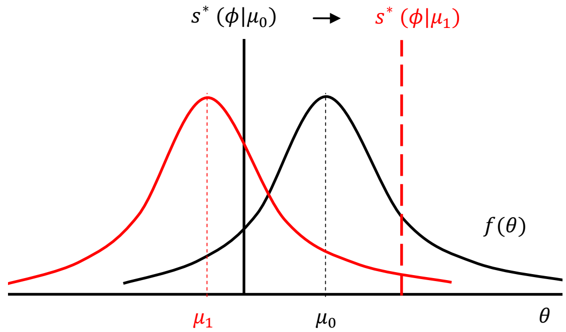


Figure 3: Informative Bad News

2.4 Financing through Traditional or Shadow Banking?

Now I study which banks raise funds issuing debt (traditional banking) and which banks raise funds issuing securities with guarantees (shadow banking). When reputation incentives are strong, lenders' confidence about self-regulation prevails and securitization provides a feasible way to avoid restrictive regulation. The next proposition, proved in the Appendix, summarizes the result.

Proposition 3 *Optimal Financing Decisions*

Assume $\gamma_s \to \infty$. If $\mu \in \mathbb{R}$, there is a unique cutoff $\mu^*(\phi)$ such that firms with reputation ϕ issue securities when $\mu \geq \mu^*(\phi)$ and issue debt when $\mu < \mu^*(\phi)$. If the following condition is satisfied, then $\mu^*(\phi) = \infty$.

$$p_s\alpha(y_r - y_s) + \beta\hat{p}_D E_{\theta|\mu=\infty}[V(\phi', \theta) - V(\phi, \theta)] \geq \frac{(1-\phi)(1-p_x)(1-\alpha)(p_s - p_r)}{\hat{p}_B + \phi(1-p_x)(1-\alpha)(p_s - p_r)} \quad (9)$$

An important corollary of the previous proposition, when the range of possible μ is restricted is the following:

Corollary 1 *Assume $\mu \in [\underline{\mu}, \overline{\mu}]$. If $\underline{\mu} > \mu^*(\phi)$, banks with reputation ϕ always issue securities and raise funds with shadow banking. If $\overline{\mu} < \mu^*(\phi)$, banks with reputation ϕ always issue debt and raise funds with traditional banking.*

Figure 4 illustrates the main properties of expected profits when banks issue debt and when they issue securities. I also show the threshold $\mu^*(\phi)$ that defines the regions under which debt and securities are preferred. Intuitively, when good banks are optimistic about future conditions (this is, $\mu > \mu^*(\phi)$), they value reputation and invest safely enough to credibly guarantee securities as if they were regulated. This system, however, has a chance of collapse in case fundamentals reveal to be weaker than expected, since good banks would rather take excessive risks.

At the other extreme, when good banks are pessimistic about future conditions (this is, $\mu < \mu^*(\phi)$), they do not value reputation and do not have incentives to invest optimally. Lenders are aware of this lack of banks' incentives and understand that the quality of banks' assets that sustain guarantees is not as if banks were regulated. Then lenders require higher rates for their funds in compensation for taking higher risks in shadow banking, which make banks better off by raising funds through traditional banking.

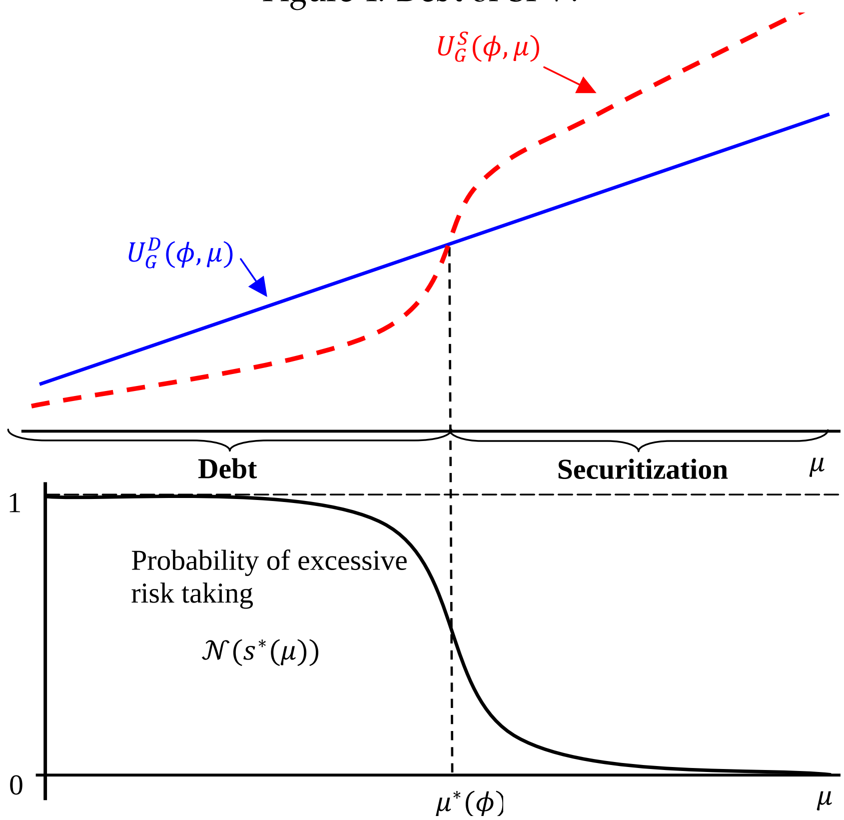
The previous analysis characterizes the decisions of good banks, but bad banks always pool with good banks and take the same financing choices. If good banks raise funds with securities, bad banks also issue securities, which give them the possibility of investing only in risky assets at an interest rate subsidized by the presence of good banks. If good banks raise funds with debt, bad banks also issue debt, otherwise their reputation gets lost immediately and either they have to finance with debt anyways, or if financing with securities they have to borrow facing the highest possible interest rate $\frac{1}{\hat{p}_B}$, receiving the lowest possible reputation $\phi' = 0$ forever in the future.

In the next proposition, I consider how $\mu^*(\phi)$ varies for different reputation levels $\phi \in [0, 1]$. This comparison is important to understand how the fragility of the financial system is endogenous to the distribution of reputation levels in the economy. The proof is in the Appendix.

Proposition 4 *Thresholds $\mu^*(\phi)$ decrease with reputation ϕ.*

Intuitively, for a given expectation of future conditions μ, banks with good reputations have larger reputation concerns, and their guarantees to cover securities in distress with high quality assets are more credible to lenders. Then lenders charge a lower rate for securities and high reputation banks are better off raising funds with shadow banking and avoid restrictive regulations. The next proposition, which arises from combining Propositions 3 and 4 for a given μ, summarizes this result.

Figure 4: Debt or SPV?



Proposition 5 *Given expected future economic conditions, μ, there is a $\phi^*(\mu)$ such that all banks with reputation $\phi > \phi^*(\mu)$ issue securities and participate in shadow banking while all banks with reputation $\phi < \phi^*(\mu)$ issue debt and participate in traditional banking.*

3 Regulation that Enhances Reputation Forces

Capital requirements are beneficial because they provide firewalls against excessive risk-taking, but are costly because they can choke off potential good investment opportunities. Securitization is an option for banks to avoid restrictive regulation, spawning a shadow banking sector that is preferred but also fragile.

I now discuss alternative regulatory tools, that I call *novel regulation*, which complement the use of capital requirements, to which I refer as *standard regulation*. Specifically, I show that a budget balanced scheme of taxes and subsidies that cross-subsidize firms with different reputation levels can enhance the disciplining effects of reputation concerns among banks that self-select into shadow banking, increasing expected production, and at the same time, making the financial system less sensitive to news about future economic conditions.

Assume the economy does not have aggregate shocks (there is a unique possible μ). I relax this assumption when illustrating my results using simulations in the next section. First, assume that the government can impose taxes and subsidies conditional on θ for each ϕ, such that $\widehat{V}(\phi) = V(\phi, \theta)T(\phi, \theta)$ is fixed. In this case, the results so far can be recomputed considering $\widehat{V}(\phi)$, independent of θ. This potential taxation is compelling but difficult to sustain. Financial decisions and crises are intimately related to news about expected economic conditions, so it is usually not plausible to eliminate financial cycles by eliminating economic cycles and news about the future directly. This raises a more challenging question: Is it possible to reduce fragility if it is not possible to attack the source of fragility directly?

Another, ideal but unfeasible solution, is to just give a high subsidy to all banks, regardless of their reputation ϕ, conditional on their repayment of the loans, such that $\widehat{V}(\phi) = V(\phi, \theta)T$ with $T > 1$. This naturally increases the cost of default for all banks and then allows for more self-regulation. This solution has the same effects as an exogenous increase of μ, but how does one finance these widely available subsidies?

In order to at least partially finance this alternative policy, a government needs to transfer resources across reputation levels, subsidizing banks of relatively high reputation (this is $T(\phi) > 1$ for $\phi > \bar{\phi}$) and taxing banks of relatively high reputation (this is $T(\phi) < 1$ for $\phi > \bar{\phi}$). I assume, then, a subsidy scheme independent on θ and monotonically increasing in reputation, with a level of reputation $\bar{\phi}$ for which $T(\bar{\phi}) = 1$ and not tax or subsidy is applied.

This *novel regulation* both increases the incentives for banks with low reputation to participate in a regulated traditional banking, and increases the incentives for banks with high reputation to participate in shadow banking. Furthermore, the incentives for banks participating in shadow banking to invest optimally are larger and less sensitive to news about future economic prospects, inducing a more stable financial system and overall higher production. The next proposition, proved in the Appendix, summarizes this result.

Proposition 6 *Define $\phi^*(\mu)$ as the reputation that make good banks indifferent between shadow and traditional banking in the absence of cross subsidization and $\phi^{**}(\mu)$ the reputation that make good banks indifferent in the presence of cross subsidization. There is a subsidy scheme increasing in reputation, $\frac{\partial T(\phi)}{\partial \phi} > 0$ such that $T(\hat{\phi}) = 1$, where $\phi^*(\mu) < \hat{\phi} < \phi^{*\prime}(\mu)$ and $\phi^*(\mu) = \phi^{**}(\mu)$.*

Furthermore, the expected gains from assets invested by banks with reputation $\phi < \phi^*(\mu)$ remain unchanged, while expected gains from assets invested by banks with reputation $\phi > \phi^*(\mu)$ increase, since their ex-ante probability of excessive risk-taking ($\mathcal{N}(s^*(\phi, \mu))$) decline.

Intuitively, a cross-subsidization scheme just affects behavior of those firms that use securitization in equilibrium (those with relatively high reputation), and not firms that use debt in equilibrium, and are then regulated. Hence, this novel intervention hinges on subsidizing shadow banking and making it sustainable using funds from firms that already use a stable, standard, regulated banking system. In a sense good banks cannot effectively enjoy their capacity to self-regulate because lenders confuse them with bad banks. Since bad banks on average have lower reputation levels than good banks, taxing low reputation is a way for bad banks to compensate the externality they impose over good banks.

Naturally, whether the cross-subsidization can completely finance itself depends on the distribution of reputation among banks and on the value functions for different reputation levels. In particular, cross-subsidization is sustainable without external funds for the government at each expected future condition θ if

$$\int_0^1 T(\phi)V(\phi,\theta)d\phi = \int_0^1 V(\phi,\theta)d\phi.$$

where $d\phi$ is the distribution of reputation, conditional on a realized fundamental θ.

4 Simulations

In this section I illustrate the results from the model using a numerical example. I assume that continuation values are linearly increasing in ϕ and θ. In this case, even when payoffs are linear, reputation formation convexifies the schedule of cutoffs that determine the financing choices, inducing sudden and dramatic increases in risk-taking and collapses in shadow banking, even without obvious declines in expected economic conditions. Furthermore, shadow banking can collapse even in the absence of real fundamental changes; just in response to small and uninformative bad news.

I assume the following parameters: The probability of success is $p_s = 0.5$ for safe and superior risky assets, $p_r = 0.1$ for inferior risky assets, and $p_x = 0.2$ for new assets. Payoffs in case of success are $y_s = 3$ for safe assets, $y_r = 10$ for risky assets and $y_x = 7$ for new assets. A risky asset is superior with probability $\alpha = 0.1$, discounting is $\beta = 0.99$, the variance of fundamentals is $\gamma_\theta = 2$, signals about fundamentals are very precise $\gamma_s \to \infty$, and $V(\phi, \theta) = k\phi\theta$ with $k = 0.5$. These parameters fulfill Assumption 1. Finally, I assume a uniform distribution of reputation levels in the market.[7]

4.1 Static Results

Figure 5 shows the expected profits from financing using debt and securitization for a good bank with reputation $\phi = 0.5$. The bank chooses to finance with securities and avoid regulation for all μ greater than $\mu^* = 3.65$. Figure 6 shows the interest rates for debt and securities. Rates for debt, R_D, do not depend on expected fundamentals or future prospects because the probability of default is independent of μ. In contrast, rates for securities R_S critically depend on expected future prospects, suddenly increasing from 2.2 to 3.2 as μ declines from 6 to 1. Figure 7 illustrates the ex-ante probability that good banks take excessive risks when raising funds with shadow banking, highlighting the source of interaction between the rate of securities R_S and expected future prospects μ in Figure 6.

Finally, while Figure 5 shows thresholds $\mu^*(\phi)$ only for banks with reputation $\phi = 0.5$, Figure 8 shows those thresholds for all reputation levels. The schedule of thresholds is convex in expected fundamentals, even though continuation values are linear in fundamentals. As is clear in Figure 1, learning is stronger for intermediate reputation levels and weaker for extreme reputation levels. This is a more general property once continuation values are determined endogenously, as shown in Ordonez (2012).

[7] This is a conservative assumption since bad banks default and exit more often, which means the distribution of reputation is skewed towards higher reputation levels, hence creating even more clustering in financing and risk-taking decisions than I illustrate here.

Figure 5: Value Functions for $\phi = 0.5$

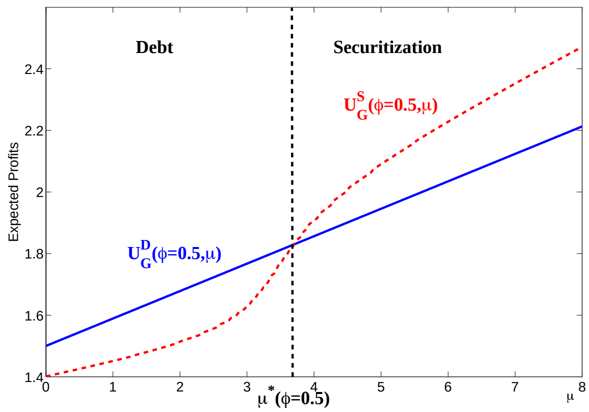


Figure 6: Interest Rates for $\phi = 0.5$

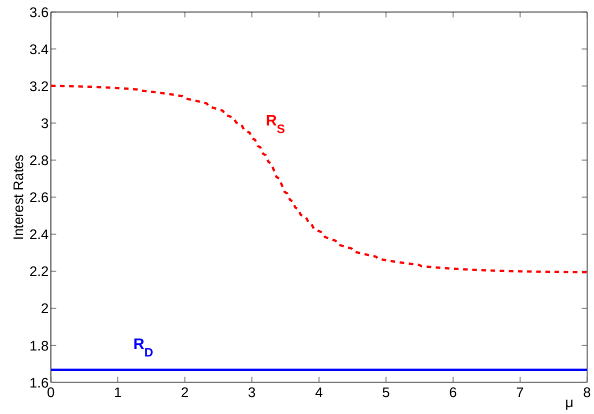


Figure 7: Excessive Risks for $\phi = 0.5$

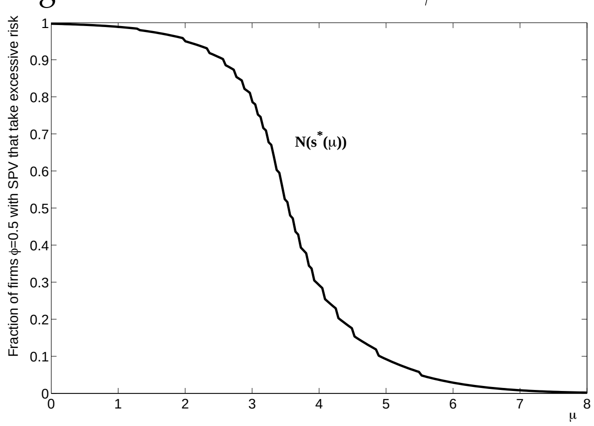
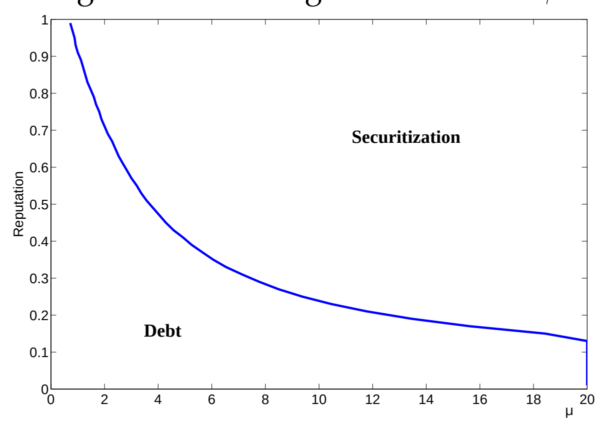


Figure 8: Financing Choices for all ϕ



4.2 Dynamic Results

Now I simulate 100 periods of this economy to illustrate the dynamics of shadow banking and its impact on total production and default. An important dynamic in the economy is how agents learn about expected economic conditions. The previous static results show that poor current economic conditions lead to more expectations of risk taking, less securitization, and more constrained shadow banking. In this section I show that poor current economic conditions also lead agents to infer conditions will be poor in the future as well. This implies that times with high default are followed by a collapse in securitization and shadow banking. I also illustrate the effects of the *novel regulation* on production and default.

Assume highly persistent normal times and uncommon recessionary times. These states are characterized by two possible distributions, with means $\mu_N = 3$ and $\mu_R =$

-1, which follow a Markov process with persistence parameters $\lambda_N = 0.98$ and $\lambda_R = 0.70$.

Agents observe the realized θ_t at the end of each period and uses it to estimate the current distribution (μ_t) and the expected distribution next period ($E(\mu_{t+1})$). The probability that the economy faces a recession, conditional on θ_t, is

$$Pr(\mu_t = \mu_R|\theta_t) = \widehat{\mu}'_t = \frac{f(\theta_t|\mu_R)\widehat{\mu}_t}{f(\theta_t|\mu_R)\widehat{\mu}_t + f(\theta_t|\mu_N)(1-\widehat{\mu}_t)},$$

where $f(\theta_t|\mu_R)$ is the density of θ_t in recessions, when the mean is μ_R and the precision is γ_θ, and $\widehat{\mu}_t$ is the prior probability that $\mu_t = \mu_R$. Finally, the posterior $\widehat{\mu}'_t$ is used to estimate the probability that $\mu_{t+1} = \mu_R$ from the Markov process,

$$Pr(\mu_{t+1} = \mu_R|\widehat{\mu}'_t) = \widehat{\mu}_{t+1} = \lambda_R\widehat{\mu}'_t + (1-\lambda_R)(1-\widehat{\mu}'_t).$$

This probability is used to estimate the expected distribution that generates the fundamental θ next period

$$\widehat{\mu}_{t+1}\mathcal{N}(\mu_R, \frac{1}{\gamma_\theta}) + (1-\widehat{\mu}_{t+1})\mathcal{N}(\mu_N, \frac{1}{\gamma_\theta}) = \mathcal{N}(\bar{\mu}_{t+1}, \sigma_{t+1}),$$

where $\bar{\mu}_{t+1} = \widehat{\mu}_{t+1}\mu_R + (1-\widehat{\mu}_{t+1})\mu_N$ and $\sigma_{t+1} = \left[\widehat{\mu}^2_{t+1} + (1-\widehat{\mu}_{t+1})^2\right]\frac{1}{\gamma_\theta}$.

Figure 9 shows 100 simulated fundamentals θ_t from simulated distributions of fundamentals μ_t, and expected distribution of fundamentals $\bar{\mu}_t$ at each period t, following the previously described learning process about economic conditions.

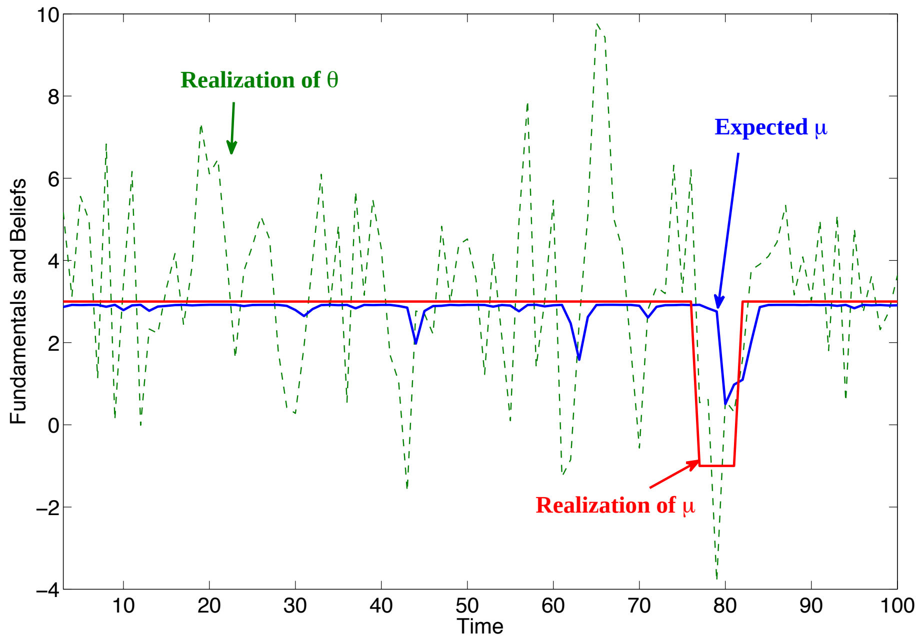
In the next figures I compare thresholds, the scope of shadow banking, and total production with and without the discussed *novel regulation*.

I assume a subsidy schedule of the form $T(\phi) = a\phi'^b$, such that $\widehat{V}(\phi', \theta) = a\phi'^b V(\phi', \theta)$. Given the linearity of value functions and the uniform distribution of reputation, this scheme is completely self-sustainable if

$$\int_0^1 ak\theta\phi^{b+1}d\phi = \int_0^1 k\theta\phi d\phi,$$

which happens when $a = 1 + \frac{b}{2}$. Specifically, in what follows I compare the situation without the novel regulation ($b = 0$) with a case of novel regulation in which $b = 2$,

Figure 9: Real and estimated μ



and then $a = 2$. In this case $T(\phi) = 2\phi^2$ and then $T(\phi) = 1$ for $\phi = 0.71$.

Figure 10 shows the expected profits of a bank with reputation $\phi = 0.5$ with and without taxation to implement the *novel regulation*. The functions without this alternative regulation are the same as in Figure 5, and depicted lightly. In contrast to the absence of cross subsidization, in which banks with reputation $\phi = 0.5$ securitize if $\mu > 3.65$, when there is cross subsidization banks with reputation $\phi = 0.5$ securitize if $\mu > 5$. Intuitively, as discussed in the previous section, the novel regulation increases expected future values for all reputation levels above $\phi = 0.71$. This implies that all good banks with reputation $\phi < 0.71$ have less incentives to invest optimally if raising funds in the shadow banking.

Figure 11 shows the thresholds for all reputation levels with and without the novel regulation. High reputation levels are more likely to securitize with cross-subsidization, while lower reputation levels are more likely to raise debt and be subject to standard regulation. Since the schedule of thresholds is less sensitive to changes in μ, the economy is less subject to shocks to future economic conditions.

Note that I choose the subsidy scheme to maintain $\phi^*(\mu = 3) = \phi^{**}(\mu = 3) = 0.6$. To see why, take a bank with current reputation $\phi = 0.6$. If reputation is not updated then $\phi' = 0.6$ and $T(\phi' = 0.6) = 2(0.6)^2 = 0.72$, which implies the bank has to pay a fraction 28% of its value function at the end of the period. In the case reputation is updated because banks invest optimally and repay, then $\phi' = 0.76$ and $T(\phi' = 0.76) = 2(0.76)^2 = 1.16$, which implies the bank receives a subsidy of 16% of its value function at the end of the period. These two effects exactly compensate each other such that banks with reputation $\phi = 0.6$ are still indifferent between participating in traditional and shadow banking.

Figure 10: Financing Regions

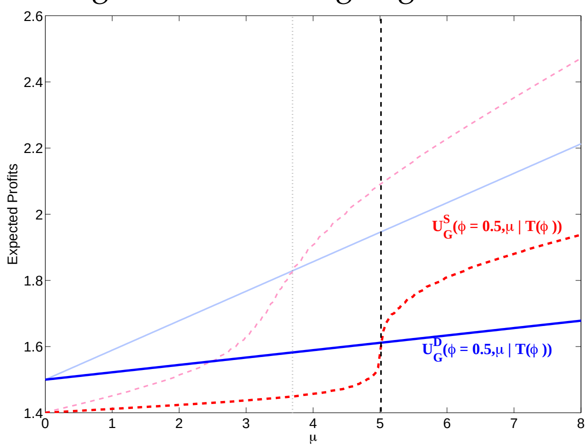


Figure 11: Confidence Thresholds

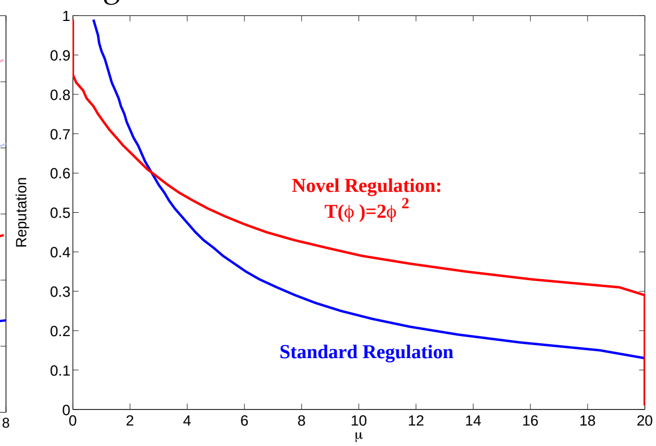


Figure 12 shows the fraction of firms in the economy that securitize every period. Most of the time, since $\mu = 3$ the level of securitization is the same with or without the novel regulation. As is clear in Figure 11, when $\mu = 3$ both with and without novel regulation, all firms with reputation above $\phi = 0.6$ securitize. Given the uniform reputational distribution this implies that 40% of firms choose to securitize.

When there is novel regulation, however, there is a smaller decline in securitization when the expected μ declines. In essence, with cross subsidization, high reputation banks have more incentives to invest optimally, which sustains shadow banking in the presence of adverse shocks to expected future conditions.

Figure 13 shows expected production in the economy with and without the novel regulation. With cross-subsidization there are more incentives to invest optimally for banks with high reputation, which are those who select into shadow banking. Since expected profits for the banks that do not securitize are subject to standard regulation and generate the same expected profits, total production does not suffer as it does without the novel regulation. This implies that the right combination between the novel and the standard regulation has the potential to increase expected production in all states of the world.

Interestingly, the only time the economy enters into a recession (μ_R) during the 100 periods of the simulation is in periods 80-82. However, there are negative shocks to production also in periods 45 and 61, not because of a recession but just because bad news about the economy. These irrelevant shocks make individuals revise the probability of a recession upward, reducing reputation concerns and inefficiently discouraging shadow banking.

Figure 12: Securitization

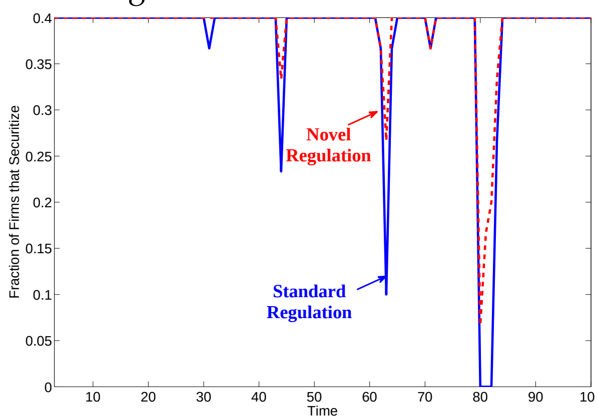
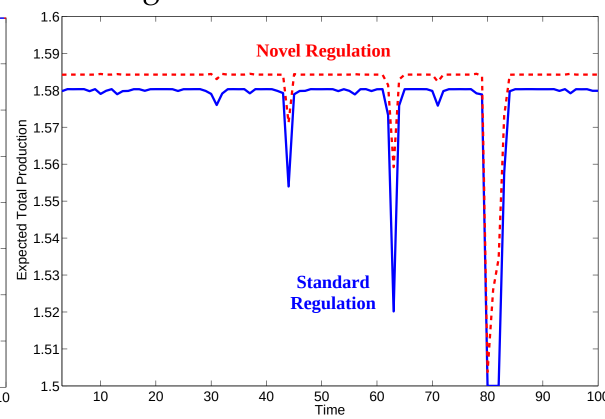


Figure 13: Total Production



To put these results in context, it is important to highlight that production when all banks invest optimally is 1.85, production when all banks take excessive risk is 1.4 and production when all banks raise debt and then are subject to standard regulation and capital requirements that make them invest only in safe assets is 1.5. This shows the benefits of standard regulation in the absence of reputation concerns, which is raising production from 1.4 to 1.5. This also shows the benefits and fragility of shadow banking in the presence of reputation concerns, raising production from 1.5 to 1.58 in normal times, but causing sudden reductions under bad news. Finally, this exercise also shows the benefits of the novel regulation in increasing production from 1.58 to 1.585 in normal times and buffering the losses in case of bad news.

5 Conclusions

This paper provides a new view of shadow banking, not as an inherently dangerous system due to their lack of regulatory firewalls, but as a positive signal that self-regulation is at work in the financial market and that agents can get rid of restrictive government regulations. Still, since self-regulation is provided by the market through reputation concerns, it is fragile because the value of reputation depends on news about future economic prospects. In essence, I argue that securitization not only allows for better risk-sharing, but also allows banks to avoid excessively restrictive regulation. These gains, however, should be evaluated against the fragility of the system.

The natural question is how to enhance the benefits of shadow banking and at the same time reduce its costs. I show that banks with low reputation and lack of discipline self-select into the use of traditional banking and those with high reputations self-select into shadow banking. I discuss an alternative regulation that combines traditional capital requirements with cross-subsidizations. With this alternative regulation, banks that do not securitize are still restrained by regulation and banks that securitize are less sensitive to news about economic conditions, making shadow banking more stable.

The insight that shadow banking arises endogenously when self-regulation becomes feasible is also critical to evaluate the frequent proposals for more stringent government regulations. Indeed, trying to regulate more extensively traditional banking and eliminate shadow banking can generate undesirable consequences, attracting the creation of a potential "new shadow banking system" with banks less concerned for their reputation and then more fragile in their risk-taking behavior.

This paper can be extended in several directions: First, reputation gains can be determined endogenously, as in Ordonez (2012); second, the forces in this paper can be accommodated to study other financial institutions and instruments, such as repo, money markets, investment banks, etc; third, the model can be used to study confidence relations when transactions include collateral of unknown quality, the price of which also depends on aggregate economic conditions.

All these extensions would make the model richer and more realistic, but would not change the main insight: Reputation introduces discipline that restricts risk without compromising output, as is the case with capital requirements. In this sense, reputation concerns allow for the rise of shadow banking as a superior, but more fragile, alternative to traditional banking. Whether it is desirable to have a system based on self-regulation depends on the trade-off between these benefits and costs. Hence, the challenge for regulation is not to eliminate shadow banking, but to make it sustainable and more stable.

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A Appendix

A.1 Proof of Proposition 3

Value functions from issuing debt and securities depend on ϕ and μ. If there is almost perfect information ($\gamma_s \to \infty$), these value functions are arbitrarily closely approximated by

$$U_G^D(\phi,\mu) = p_x x + p_s y_s + \hat{p}_D \left[\beta E_{\theta|\mu} V(\phi,\theta) - R_D\right] \tag{10}$$

and

$$\begin{aligned} U_G^S(\phi,\mu) \quad = \quad & p_x x + \alpha p_s y_r + (1-\alpha)\left[\mathcal{N}(s^*(\phi,\mu)) p_r y_r + (1-\mathcal{N}(s^*(\phi,\mu))) p_s y_s\right] \\ & + \mathcal{N}(s^*(\phi,\mu)) \hat{p}_G(\widehat{\tau}=0)\left[\beta E_{\theta|\mu,\theta<s^*} V(\phi,\theta) - R_S(\phi|s^*(\phi,\mu))\right] \\ & + (1-\mathcal{N}(s^*(\phi,\mu))) \hat{p}_G(\widehat{\tau}=1)\left[\beta E_{\theta|\mu,\theta>s^*} V(\phi',\theta) - R_S(\phi|s^*(\phi,\mu))\right] \end{aligned} \tag{11}$$

respectively, where $\hat{p}_G(\widehat{\tau}=0) = \hat{p}_B$, $\hat{p}_G(\widehat{\tau}=1) = \hat{p}_D$ and ϕ' is the updated reputation computed with $\widehat{\tau}=1$.

When μ is sufficiently low, such that $\mathcal{N}(s^*(\phi,\mu)) \to 1$, then it is always optimal for good banks to issue debt and be subject to regulation (this is, $U_G^D(\phi,\mu) > U_G^S(\phi,\mu)$ for all ϕ). This result is straightforward from replacing $\mathcal{N}(s^*(\phi,\mu)) \to 1$ into equation (11), since by assumption $p_s y_s > \alpha p_s y_r + (1-\alpha) p_r y_r$ and $\hat{p}_D > \hat{p}_B$. This implies there is always a range of μ low enough such that firms take excessive risk almost with certainty (this is $\mathcal{N}(s^*(\phi,\underline{\mu})) \to 1$), and banks participate in traditional banking.

When μ is sufficiently high such that $\mathcal{N}(s^*(\phi,\mu)) \to 0$ then it is optimal for good banks to issue securities and avoid regulation only if $U_G^D(\phi,\mu) < U_G^S(\phi,\mu)$. From replacing $\mathcal{N}(s^*(\phi,\mu)) \to 0$ into equation (11), this happens only under condition (9) evaluated at μ. This implies that, if μ is such that good banks invest optimally almost with certainty (this is $\mathcal{N}(s^*(\phi,\overline{\mu})) \to 0$), then banks raise securities only if condition (9) evaluated at μ is fulfilled. If not, then banks raise debt.

Assuming condition (9) is fulfilled for some range of μ, there are values of μ low enough such that $U_G^D(\phi,\mu) > U_G^S(\phi,\mu)$ and values of μ high enough such that $U_G^D(\phi,\mu) < U_G^S(\phi,\mu)$. Now, I show that there is a unique threshold μ^* at which $U_G^D(\phi,\mu^*) = U_G^S(\phi,\mu^*)$.

Taking derivatives of the banks' expected profits with respect to μ,

$$\frac{\partial U_G^D(\phi,\mu)}{\partial \mu} = \beta \hat{p}_D \frac{\partial E_{\theta|\mu} V(\phi.\theta)}{\partial \mu} > 0 \tag{12}$$

while

$$\begin{aligned}
\frac{\partial U_G^S(\phi,\mu)}{\partial \mu} = \; & \mathcal{N}(s^*(\phi,\mu))\beta\hat{p}_B \frac{\partial E_{\theta|\mu,\theta<s^*} V(\phi,\theta)}{\partial \mu} + (1-\mathcal{N}(s^*(\phi,\mu)))\beta\hat{p}_D \frac{\partial E_{\theta|\mu,\theta>s^*} V(\phi',\theta)}{\partial \mu} \\
& + \frac{\partial \mathcal{N}(s^*(\phi,\mu))}{\partial \mu}\left[(1-\alpha)(p_r y_r - p_s y_s)\right] \\
& + \frac{\partial \mathcal{N}(s^*(\phi,\mu))}{\partial \mu}\beta\hat{p}_B\left[E_{\theta|\mu,\theta<s^*} V(\phi,\theta) - R_S(\phi|s^*(\phi,\mu))\right] \\
& - \frac{\partial \mathcal{N}(s^*(\phi,\mu))}{\partial \mu}\beta\hat{p}_D\left[E_{\theta|\mu,\theta>s^*} V(\phi',\theta) - R_S(\phi|s^*(\phi,\mu))\right] \\
& - \left[\mathcal{N}(s^*(\phi,\mu))\beta\hat{p}_B + (1-\mathcal{N}(s^*(\phi,\mu)))\beta\hat{p}_D\right] \frac{\partial R_S(\phi|s^*(\phi,\mu))}{\partial \mathcal{N}(s^*(\phi,\mu))} \frac{\partial \mathcal{N}(s^*(\phi,\mu))}{\partial \mu}
\end{aligned} \tag{13}$$

Adding and subtracting the following expression

$$\beta\hat{p}_D \frac{\partial E_{\theta|\mu} V(\phi.\theta)}{\partial \mu} \equiv \beta\hat{p}_D \left[\mathcal{N}(s^*)\frac{\partial E_{\theta|\mu,\theta<s^*} V(\phi.\theta)}{\partial \mu} + (1-\mathcal{N}(s^*))\frac{\partial E_{\theta|\mu,\theta>s^*} V(\phi.\theta)}{\partial \mu}\right]$$

to the first term of equation (13), then that first term can be rewritten as

$$\begin{aligned}
& \beta\hat{p}_D \frac{\partial E_{\theta|\mu} V(\phi.\theta)}{\partial \mu} - \beta\mathcal{N}(s^*(\phi,\mu))(\hat{p}_D - \hat{p}_B)\frac{\partial E_{\theta|\mu,\theta<s^*} V(\phi.\theta)}{\partial \mu} \\
& + \beta(1-\mathcal{N}(s^*(\phi,\mu)))\hat{p}_D \frac{\partial E_{\theta|\mu,\theta>s^*}[V(\phi',\theta) - V(\phi,\theta)]}{\partial \mu} > 0
\end{aligned}$$

From Proposition 2, $\frac{\partial \mathcal{N}(s^*(\phi,\mu))}{\partial \mu} < 0$. Then, the second term and the sum of the third and fourth terms of equation (13) are positive too. Finally, the last term is also positive because $\frac{\partial R_S(\phi|s^*(\phi,\mu))}{\partial \mathcal{N}(s^*(\phi,\mu))} > 0$. Hence, $\frac{\partial U_G^S(\phi,\mu)}{\partial \mu} > 0$

Furthermore, when $\mathcal{N}(s^*(\phi,\mu)) \to 1$,

$$\frac{\partial U_G^S(\phi,\mu)}{\partial \mu} \approx \beta\hat{p}_B \frac{\partial E_{\theta|\mu} V(\phi.\theta)}{\partial \mu} < \frac{\partial U_G^D(\phi,\mu)}{\partial \mu} \tag{14}$$

and when $\mathcal{N}(s^*(\phi,\mu)) \to 0$,

$$\frac{\partial U_G^S(\phi,\mu)}{\partial \mu} \approx \beta \hat{p}_D \frac{\partial E_{\theta|\mu} V(\phi'.\theta)}{\partial \mu} > \frac{\partial U_G^D(\phi,\mu)}{\partial \mu} \tag{15}$$

In words, expected profits from raising funds, both in traditional and shadow banking, increase with μ. Furthermore, when μ is relatively low, expected profits with securities increase at a lower rate than expected profits with debt. In contrast, when μ are relatively high, expected profits with securities increase at a faster rate than expected profits with debt.

Given the symmetry of the normal distribution, since $\frac{\partial \mathcal{N}(s^*(\phi,\mu))}{\partial \mu} < 0$ from Proposition 2 and the fact that the second, third, and fourth terms of equation (13) are positive, it is straightforward to see that $\frac{\partial U_G^S(\phi,\mu)}{\partial \mu}$ is increasing for $\mathcal{N}(s^*(\phi,\mu)) > 0.5$ and that $\frac{\partial U_G^S(\phi,\mu)}{\partial \mu}$ is decreasing for $\mathcal{N}(s^*(\phi,\mu)) < 0.5$ (normal densities are decreasing for $\mathcal{N}(s^*(\phi,\mu)) > 0.5$ and increasing for $\mathcal{N}(s^*(\phi,\mu)) < 0.5$). This last statement implies that the lower bound for $\frac{\partial U_G^S(\phi,\mu)}{\partial \mu}$ when $\mathcal{N}(s^*(\phi,\mu)) < 0.5$ is the expression (15). Then, if condition (9) holds, the expected profits with securities cross expected profits with debt from below only once, and there is only a cutoff $\mu^*(\phi)$ for which $U_G^S(\phi,\mu^*) = U_G^D(\phi,\mu^*)$.

A.2 Proof of Proposition 4

Taking derivatives of banks' expected profits with respect to ϕ,

$$\frac{\partial U_G^D(\phi,\mu)}{\partial \phi} = \beta \hat{p}_D \frac{\partial E_{\theta|\mu} V(\phi.\theta)}{\partial \phi}, \tag{16}$$

which is positive by construction of value functions increasing with ϕ.

$$\begin{aligned}
\frac{\partial U_G^S(\phi,\mu)}{\partial \phi} = {} & \mathcal{N}(s^*(\phi,\mu))\beta \hat{p}_B \frac{\partial E_{\theta|\mu,\theta<s^*} V(\phi,\theta)}{\partial \phi} + (1-\mathcal{N}(s^*(\phi,\mu)))\beta \hat{p}_D \frac{\partial E_{\theta|\mu,\theta>s^*} V(\phi',\theta)}{\partial \phi'} \frac{\partial \phi'}{\partial \phi} \\
& + \mathcal{N}(s^*(\phi,\mu))\beta \hat{p}_B \frac{\partial E_{\theta|\mu,\theta<s^*} V(\phi,\theta)}{\partial s^*} \frac{\partial s^*}{\partial \phi} + (1-\mathcal{N}(s^*(\phi,\mu)))\beta \hat{p}_D \frac{\partial E_{\theta|\mu,\theta>s^*} V(\phi',\theta)}{\partial s^*} \frac{\partial s^*}{\partial \phi'} \frac{\partial \phi'}{\partial \phi} \\
& + \frac{\partial \mathcal{N}(s^*(\phi,\mu))}{\partial s^*} \frac{\partial s^*}{\partial \phi} \left[(1-\alpha)(p_r y_r - p_s y_s)\right] \\
& + \frac{\partial \mathcal{N}(s^*(\phi,\mu))}{\partial s^*} \frac{\partial s^*}{\partial \phi} \beta \hat{p}_B \left[E_{\theta|\mu,\theta<s^*} V(\phi,\theta) - R_S(\phi|s^*(\phi,\mu)\right] \\
& - \frac{\partial \mathcal{N}(s^*(\phi,\mu))}{\partial s^*} \frac{\partial s^*}{\partial \phi} \beta \hat{p}_D \left[E_{\theta|\mu,\theta>s^*} V(\phi',\theta) - R_S(\phi|s^*(\phi,\mu)\right] \\
& - \left[\mathcal{N}(s^*(\phi,\mu))\beta \hat{p}_B + (1-\mathcal{N}(s^*(\phi,\mu)))\beta \hat{p}_D\right] \frac{\partial R_S(\phi|s^*(\phi,\mu))}{\partial \mathcal{N}(s^*(\phi,\mu))} \frac{\partial \mathcal{N}(s^*(\phi,\mu))}{\partial s^*} \frac{\partial s^*}{\partial \phi}
\end{aligned} \tag{17}$$

Differentiating the condition that pins down s^* with respect to ϕ,

$$\frac{d\beta\ E_{\theta|s^*}\left[V(\phi',\theta|\widehat{\tau}(s^*))\right]}{d\phi} = \frac{d[\Psi + R_S(\phi|s^*)]}{d\phi}.$$

Developing the total derivative

$$\frac{\partial\beta\ E_{\theta|s^*}\left[V(\phi',\theta|\widehat{\tau}(s^*))\right]}{\partial s^*}\frac{ds^*}{d\phi} + \frac{\partial\beta\ E_{\theta|s^*}\left[V(\phi',\theta|\widehat{\tau}(s^*))\right]}{\partial\phi'}\frac{\partial\phi'}{\partial\phi} = \frac{\partial R(\phi|s^*)}{\partial s^*}\frac{ds^*}{d\phi} + \frac{\partial R_S(\phi|s^*)}{\partial\phi}$$

$$\left[\frac{\partial\beta\ E_{\theta|s^*}\left[V(\phi',\theta|\widehat{\tau}(s^*))\right]}{\partial s^*} - \frac{\partial R(\phi|s^*)}{\partial s^*}\right]\frac{ds^*}{d\phi} = \frac{\partial R_S(\phi|s^*)}{\partial\phi} - \frac{\partial\beta\ E_{\theta|s^*}\left[V(\phi',\theta|\widehat{\tau}(s^*))\right]}{\partial\phi'}\frac{\partial\phi'}{\partial\phi}.$$

By assumptions 2 and 3, the term in brackets is positive. In contrast, the right hand side is negative because

$$\frac{\partial R_S}{\partial\phi} = -\frac{(1-p_x)(1-\alpha)(p_s-p_r)}{(\hat{p}_B + \phi(1-\mathcal{N}(s^*))(1-p_x)(1-\alpha)(p_s-p_r))^2}(1-\mathcal{N}(s^*)) < 0,$$

and $\frac{\partial\beta\ E_{\theta|s^*}[V(\phi',\theta|\widehat{\tau}(s^*))]}{\partial\phi'}\frac{\partial\phi'}{\partial\phi} > 0$, again by construction of value functions and Bayesian updating. This implies that

$$\frac{ds^*}{d\phi} < 0,$$

The first and second terms of equation (17) are positive by construction of the value functions, the sum of the third and fourth terms is positive (since $\frac{\partial\mathcal{N}(s^*(\phi,\mu))}{\partial s^*} > 0$), and the last term is also positive (since $\frac{\partial R_S(\phi|s^*(\phi,\mu))}{\partial\mathcal{N}(s^*(\phi,\mu))} > 0$). This implies that $\frac{\partial U_G^S(\phi,\mu)}{\partial\phi} > 0$.

Since both $U_G^S(\phi,\mu)$ and $U_G^D(\phi,\mu)$ increase with ϕ for each μ, the threshold $\mu^*(\phi)$ declines with ϕ if $\frac{\partial U_G^S(\phi,\mu^*(\phi))}{\partial\phi} \geq \frac{\partial U_G^D(\phi,\mu^*(\phi))}{\partial\phi}$. Since the threshold $\mu^*(\phi)$ is given by the value μ at which equations (10) and (11) are equal, by evaluating equations (16) and (17) at μ^* it is clear that this condition is fulfilled.

A.3 Proof of Proposition 6

First I prove the impact of subsidies on the incentives to invest optimally in shadow banking, summarized by s^*.

Imposing $E_{\theta|s^*}\left[V(\phi',\theta|\widehat{\tau}(s^*))T(\phi')\right]$ in condition (6) that pins down s^*, and differentiating with respect to $T(\phi')$,

$$\frac{\partial\beta\ E_{\theta|s^*}\left[V(\phi',\theta|\widehat{\tau}(s^*))T(\phi')\right]}{\partial T(\phi')} + \frac{\partial\beta\ E_{\theta|s^*}\left[V(\phi',\theta|\widehat{\tau}(s^*))T(\phi')\right]}{\partial s^*}\frac{ds^*}{dT(\phi')} = \frac{\partial R(\phi|s^*)}{\partial s^*}\frac{ds^*}{dT(\phi')}.$$

Then,

$$\left(\frac{\partial \beta E_{\theta|s^*}\left[V(\phi',\theta|\widehat{\tau}(s^*))T(\phi')\right]}{\partial s^*} - \frac{\partial R(\phi|s^*)}{\partial s^*}\right)\frac{ds^*}{dT(\phi')} = -\beta\ E_{\theta|s^*}\left[V(\phi',\theta|\widehat{\tau}(s^*))\right]. \quad (18)$$

The right hand side is negative and, by assumptions 2 and 3, the term in brackets is positive, which implies that $\frac{ds^*}{dT(\phi')} < 0$. In words, the ex-ante probability of risk-taking declines for all reputations ϕ for which the update ϕ' is subsidized with $T(\phi') > 1$. In contrast, the ex-ante probability of risk-taking increases for all reputations ϕ for which the update ϕ' is taxed with $T(\phi') < 1$.

This result is important to prove the first part of the proposition. Assume $T(\phi^*) = 1$ such that $T(\phi^{*\prime}) > 1$. This implies that, in the presence of cross-subsidization, good banks with reputation ϕ^* strictly prefer to raise funds in the shadow banking. This is clear from comparing equations (10) and (11). Equation (10) remains constant while equation (11) increases for two reasons. First, fixing s^*, the value of reputation updating is larger because $E_{\theta|\mu,\theta>s^*}V(\phi^{*\prime},\theta)T(\phi^{*\prime}) > E_{\theta|\mu,\theta>s^*}V(\phi^{*\prime},\theta)$. Second, as shown above, s^* declines, which reduces R_S and further increases the gains from shadow banking in equation (11).

Combining this result with proposition 4, when $T(\phi^*) = 1$, then $\phi^* > \phi^{**}$. By imposing $T(\phi) < 1$, equation (10) declines while equation (11) does not increase so much as in the previous case. This implies there is always a $\phi^*(\mu) < \hat{\phi} < \phi^{*\prime}(\mu)$ such that $T(\hat{\phi}) = 1$ and $\phi^*(\mu) = \phi^{**}(\mu)$.

If the government imposes such a scheme, the banks that participate in traditional and shadow banking do not change. The banks with reputation $\phi < \phi^*$ participate in traditional banking and since they are subject to regulation, the keep investing only in safe assets. In contrast, the good banks with reputation $\phi > \phi^*$ participate in shadow banking, but because subsidies decrease $s^*(\phi)$, they invest optimally with a higher probability and shadow banking is less fragile.