

# Disclosures, Rollover Risk, and Debt Runs

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## Abstract

Financial institutions (“banks”) issuing short-term debt collateralized by long-term assets are exposed to rollover risk: creditors may decide to run, forcing an inefficient liquidation of the assets. This paper investigates the impact of asset opacity and disclosure policy on short-term spreads dynamics, run probability and efficiency. When the initial quality of collateral is high, opacity reduces spreads and run likelihood: debt is money-like. This, however, only holds in the short run. At longer horizons, the lack of information raises concerns about the actual collateral value. Precisely because of opacity, the bank has difficulties to credibly address these concerns and runs become very likely. These runs are particularly inefficient as they often lead to liquidate good assets. All these effects are amplified when disclosure is voluntary rather than mandatory, i.e. when the bank has superior information and does not reveal bad news: the short-term protection is stronger but runs occur more often at longer horizons. The model concludes that opacity (i) only reduces run probability when the run probability under full information is low already, (ii) always decreases efficiency, (iii) is more inefficient when combined with voluntary disclosure. Another output of the model is to show how non-panic debt runs can occur suddenly, i.e. without news disclosure and as short-term spreads are very low. Contrary to panic runs, the trigger time of these runs is a function of the fundamentals.

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# 1 Introduction

DEBT RUNS ARE PROMINENT features of financial crises. The most recent one was no exception: during the years 2007-2008, the asset-backed commercial paper (ABCP) market, the repo market, money market mutual funds and banks such as Northern Rock and Bear Stearns were subject to runs<sup>1</sup>. It is therefore not surprising that policy makers and academics have tried to understand in depth the determinants of debt runs and the nature of their interplay with crises. A first view is that runs are panic events which *cause* crises. In Diamond and Dybvig (1983), uncoordinated creditors with pessimistic expectations about other creditors' lending decisions trigger inefficient liquidation of a long-term project. A second view is that runs are fundamental-driven, i.e. *are caused* by a deterioration of economic fundamentals, together with a combination of factors, including important maturity mismatch, high leverage and liquidation costs. He and Xiong (2012) and Schroth, Suarez and Taylor (2014) propose dynamic structural models to quantify the importance of each of these factors, with a focus on the 2007 run on ABCP. Acharya, Gale and Yorulmazer (2011) show that high rollover frequency and a short-term orientation of creditors can cause runs - or *market freezes* in their terminology - to occur for debt levels much below the fundamental value of the asset backing up the debt.

These models assume full information. However, there is a widespread perception that many institutions concerned by the 2007-2008 crisis were managing opaque assets.<sup>2</sup> Thus, it is natural to ask how opacity impacts run likelihood and efficiency.<sup>3</sup> To answer this question, I extend the two-states market freezes model of Acharya et al. (2011) by allowing the bank's assets to be opaque.

Recent advances (Dang, Gorton and Holmström (2012, 2013) , Gorton and Ordoñez (2014) and Dang, Gorton, Holmström and Ordoñez (2014)) are closely related to the present work.

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<sup>1</sup>See Schroth, Suarez and Taylor (2014) and the references therein for empirical studies about these events. Notably, Gorton and Metrick (2012) document the run on the repo market, and Covitz, Liang and Suarez (2013) investigate the run on the ABCP market.

<sup>2</sup>For instance, Gorton (2008), quoted by Alvarez and Barlevy (2014) explains that "The ongoing panic of 2007 is due to a loss of information about the location and size of risks of loss due to default on a number of interlinked securities, special purpose vehicles, and derivatives, all related to subprime mortgages [...] it was not possible to know where the risk resided and without this information market participants rationally worried about the solvency of their trading counterparties. This led to a general freeze of intra-bank markets, [...]"

<sup>3</sup>Of course, the idea of linking opacity and disclosures to financial fragility is far from novel: recent models of banking under opacity include Parlatore (2013) , Gao and Jiang (2014) , Alvarez and Barlevy (2014), Bouvard, Chaigneau and de Motta (2014), Monnet and Quintin (2014) , de Faria e Castro, Martinez, and Philippon (2014) . Bushman (2015) provides a survey of the literature.

These papers introduce the notion of *information sensitivity*. A security is information insensitive when agents have no incentive to acquire costly signals about its payoff. Because of their capped payoff, debt contracts are natural candidates for information insensitivity, and more so if collateral is opaque. If, in addition, the expected value of collateral is high enough, debt is risk free and of constant value: it can be used as money. Therefore bank should be "secret keepers" (Dang, Gorton, Holmström and Ordoñez (2014)). Deterring information acquisition with opaque collateral also ensures that information is always symmetrical. This prevents market freezes due to adverse selection issues (Dang, Gorton and Holmström (2012)). Gorton and Ordoñez (2014) provide important insights to understand the link between collateral opacity and credit market freezes. Opacity prevents investors from screening firms with low-quality collateral. In their model, all firms have profitable investment opportunities and should therefore be financed at the first-best. When collateral is opaque and has high enough expected value, investors can finance firms regardless of their collateral quality, achieving the first-best.

In this paper, I highlight two mechanisms that may help put this view into perspective. First, if collateral is opaque, firms or banks using it to back up their borrowing may be subject to moral hazard. Absent any verification opportunity for outsiders, a bank could have no incentive to monitor adequately its projects or could disclose wrong information about their quality. Rational investors anticipate the strategic nature of disclosure: for instance, they know that a bank observing its asset in the worst state of the world will always pretend it has no information instead of revealing it. Voluntary disclosure reignites adverse selection concerns that opacity is supposed to suppress. Second, when the perceived quality of collateral is not high enough, banks are liquidated. If verification is too costly, this liquidation occurs regardless of the actual quality of the asset. This introduces an inefficiency: if the deadweight loss associated with the liquidation of a sound bank is higher, it is better to have transparent collateral and to liquidate only banks doing poorly.

The main contributions of my model are the following. First, there is a trade off between short-term protection and longer-term exposure: opacity indeed reduces spreads and run likelihood after a good signal, making debt very safe. As time goes by, uncertainty about the asset quality reappears and runs become likely. These runs, moreover, can hit bad as well as good banks, an additional source of inefficiency. Interestingly, the short-term safety of debt is only possible because of the option to run and liquidate in the future. The intuition is that absent insurance by a third party, there is no "miracle" way to transform a risky project into safe debt. The only way to have a risk-free payoff at any point in time is to

liquidate. But liquidation is costly. Hence, having safe debt in the short-term necessarily implies inefficient liquidations in the future. Also, these effects are stronger when disclosure is voluntary. Second, the model suggests that short-term spreads have an opacity component. This component is negative in "normal times" and positive in "crisis". Third, opacity decreases run probability only when it is already small under full information, but always decreases efficiency, notably because it makes runs happen on good banks. Finally, I show how non-panic runs can arise even when short-term spreads are very low and absent news disclosure.

## 2 The Model

The model features a financial institution ("bank") and outside lenders. Time is discrete:  $t = 0, 1, 2, \dots$

**Bank - Asset side.** *The asset process.* At time  $t$ , the bank's asset is in state  $y_t$ .  $y_t$  can take two values:  $y^G$  (good state)  $>$   $y^B$  (bad state). The asset is initially in the good state:  $y_0 = y^G$ .  $(y_t)$  is a Markov chain with transition matrix

$$\Lambda = \begin{pmatrix} \lambda_{11} & 1 - \lambda_{11} \\ \lambda_{21} & 1 - \lambda_{21} \end{pmatrix}.$$

$\lambda_{11}$  is the probability to stay in the good state, while  $\lambda_{21}$  can be interpreted as a recovery probability, from the bad to the good state.

*Maturity.* Maturity is a random time  $\tau_\varphi$ : at the beginning of each period  $t \geq 1$ , the asset matures with probability  $\varphi$ , independent of everything in the past. Note that the expected maturity is

$$\begin{aligned} \mathbb{E}[\tau_\varphi] &= \sum_{t \geq 1} t \mathbb{P}(\tau_\varphi = t) \\ &= \sum_{t \geq 1} t \varphi (1 - \varphi)^{t-1} \\ &= \frac{1}{\varphi}. \end{aligned}$$

*Payoff.* The asset only delivers cash flows at maturity, paying  $y_{\tau_\varphi}$ . I assume that  $\lambda_{11} > \frac{1}{2}$ ,  $\lambda_{12} < \frac{1}{2}$ . Then

$$\mathbb{E}[y_{\tau_\varphi} | y_t = y^G, t < \tau_\varphi] > \mathbb{E}[y_{\tau_\varphi} | y_t = y^B, t < \tau_\varphi].$$

In words, being in the good state before maturity indeed signals a high expected payoff at maturity.

**Bank - Liability side.** The initial capital structure of the bank is taken as given. There is a stock of short-term (one-period) debt  $D_0$  to be rolled over. The rest is financed by equity. Debt can stop being rolled over in two cases:

- *Strategic default.* The bank can decide to default on the debt, in which case its asset is liquidated. Since the proceeds of liquidation must be used to repay debtors and shareholders of the bank maximize the expected residual claim, strategic default is never optimal (see the Appendix).
- *Impossibility to rollover.* If debt is too high, there is no promised face value to compensate lenders for the high risk of default. No new lender accepts to roll over the debt, forcing the bank into liquidation.

I call  $\tau_l$  the liquidation time. If maturity is reached before liquidation,  $\tau_l = \infty$ .

**Outside lenders.** I do not focus on coordination issues so that I assume a single lender at each period (which could also be interpreted as a group of small, but coordinated creditors). Given an amount of debt to roll over, the bank offers a contract with a promised repayment, the face value. Lenders are risk-neutral and competitive (one agent effectively lends, but many of them are competing ex ante to obtain the contract). All lenders are short-term: once an outsider has lent money over one period, he leaves forever. The risk-free rate is normalized to zero. Therefore at each period a lender makes zero profit on average. When no face value satisfies the zero profit condition, liquidation occurs.

**Opacity and disclosure policies.** A security is *opaque* if it is time-consuming, costly or even impossible to gather all its payoff-relevant information available today. Hence, opacity does not refer to the uncertainty implied by future random shocks. It refers to uncertainty about today's state of the world. This state is already realized but in effect not observable. This can be because of insufficient monitoring, endogenous disclosure decisions or rational inattention to a complex contract, for instance.

The bank observes the value of  $y_t$  with probability  $p$ , at each time independently of everything in the past. In my model, opacity is characterized by the parameter  $p$ .  $p = 1$  is the full information case,  $p = 0$  the full opacity case. Outsiders can not make any direct observation and rely on the bank's disclosure policy.

I shall compare two disclosure regimes: *voluntary* and *mandatory*. A voluntary disclosure policy is subject to the following conditions (see, e.g. Dye (1985)):

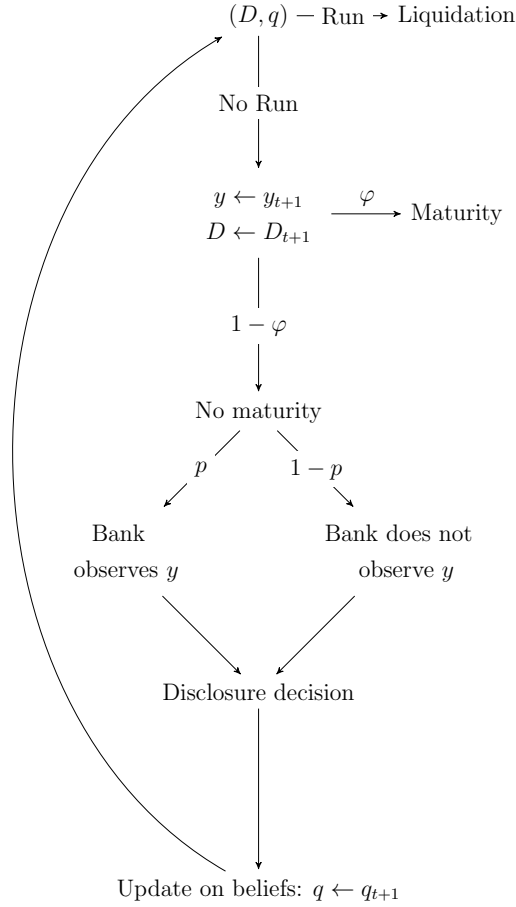
- any published news must be accompanied with evidence. It is therefore impossible for the bank to announce it observed state  $y^G$  while this is not the case.
- it is possible to conceal an observation. Thus, the bank can say it received no signal while it observed state  $y^B$ .

More specifically, when disclosure is voluntary, I focus on the *sanitization strategy*, borrowing the terminology of Shin (2003) , where the bank makes a disclosure if and only if it observes the good state.

Under mandatory disclosure, information is symmetric: the bank must truthfully reveal any information it has.

**Liquidation.** In case of liquidation, the value  $\alpha V$  is recovered, where  $V$  is the fundamental value of the asset computed with the bank's information. Here I make the assumption that during the liquidation procedure all insiders' information is revealed.  $1 - \alpha$  is a measure of illiquidity: for instance, the bank may be the first-best user of the asset, so that transferring the control rights over the asset to another party reduces its value (see Shleifer and Vishny (1992)). Because of the deadweight cost  $(1 - \alpha)V$ , liquidation is never efficient from a welfare point of view in this model. Note however that the inefficiency is large for sound banks ( $V$  high) and small for struggling banks ( $V$  low).

**Summary of the model.** Lenders know the disclosure regime and update their belief after each disclosure (or non-disclosure) about the value of the asset, or equivalently, about the probability to be in the good state. This probability is denoted  $q$  and will be used as a state variable in solving the model, together with the level of debt  $D$ . More details are provided in the next Section. For now, we only need to recognize that debt will be rolled over for "high"  $q$  and "low"  $D$ . Initially,  $q = 1$  and  $D = D_0$ , and the model can be summarized as follows:



<u>Variable</u>	<u>Definition</u>	<u>Baseline Value</u>
$y^G$	Good state	100
$y^B$	Bad state	70
$D_0$	Initial debt	70.1
$p$	Opacity of the asset: prob. of bank observing $y_t$	0.5
$\lambda_{11}$	Prob. of staying in the good state: $y^G \rightarrow y^G$	0.98
$\lambda_{21}$	Prob. of recovery: $y^B \rightarrow y^G$	0.02
$\varphi$	Intensity of maturity $\tau_\varphi$	0.15
$\alpha$	Liquidity of the asset	0.8

## 3 Model Solution

### 3.1 Voluntary Disclosure

I first assume that it is common knowledge that the bank follows a sanitization strategy and derive the debt capacity and the bond yield as a function of the state variables.

#### 3.1.1 State Variables

The bank offers face values, and outsiders play second and either accept or reject. Hence, what matters is the outsiders' expectations about the asset. Since there are only two states, the probability to be in state  $y^G$ , under the outsiders' information, can be picked as a state variable of the problem. Denote it  $q$ , initially we have  $q = 1$ , and immediately after any disclosure  $q = 1$  as well - recall that disclosure only occurs when the bank observes  $y^G$ . Now assume no disclosure at  $t = 1$ . Either the state was bad and observed (probability  $p(1 - \lambda_{11})$ ) or the state was not observed (probability  $1 - p$ ). So non-disclosure happens with probability  $1 - p + p(1 - \lambda_{11})$ . And non-disclosure in the good state happens with probability  $(1 - p)\lambda_{11}$ . Hence, the probability to be in state  $y^G$  after one non-disclosure period is

$$q_1 = \frac{(1 - p)\lambda_{11}}{1 - p + p(1 - \lambda_{11})}.$$

And the probability to be in state 1 at  $t = 2$  is

$$\gamma_1 = q_1\lambda_{11} + (1 - q_1)\lambda_{21}.$$

Denote  $\tau$  the time elapsed since the last disclosure. Let

$$q_k(t) = \mathbb{P}(y_t = y^G | \tau = k, \tau_\varphi > t)$$

be the value of the state variable  $q$  after  $k$  periods of non-disclosure and

$$\gamma_k(t) = \mathbb{P}(y_{t+1} = y^G | \tau = k, \tau_\varphi > t)$$

be the probability to be in state 1 tomorrow after  $k$  periods of non-disclosure. These quantities only depend on  $t$  to the extent that  $t$  must be smaller than the maturity time. So I drop the dependency in  $t$ . Also for notational simplicity, the subscript  $k$  will be denoted  $\tau$ .



Using Bayesian updating, as in the case  $k = 1$  detailed above, we obtain recursively:

$$\begin{aligned} q_{\tau+1} &= \frac{(1-p)\gamma_\tau}{1-p+p(1-\gamma_\tau)}, \\ \gamma_\tau &= q_\tau\lambda_{11} + (1-q_\tau)\lambda_{21}. \end{aligned}$$

To each  $\tau$  corresponds one  $q_\tau$ . In the model solution, I select  $\tau$  as the state variable. To sum up, the situation before maturity is characterized by the time elapsed since the last disclosure and the level of debt.

Figure 1 provides a graphical representation of  $(q_\tau)$ . Note that  $q_\tau$  decreases to a limit weight  $q_V^*$ , which has an important economic meaning: see discussion in Section 3.2.2.

### 3.1.2 Fundamental Value

Let  $V(q)$  be the fundamental value of the asset when the probability to be in state  $y^G$  is  $q$ . Let  $\mathbf{y} = (y^G \ y^B)$  be the vector of states, and  $\mathbf{q} = (q \ 1-q)^T$  be the vector of weights on the two states. By assumption the asset has not matured at time  $t = 0$ , and the probability of the maturity being  $\tau_\varphi = t + 1$  for  $t \geq 0$  is  $(1-\varphi)^t\varphi$ . At time  $t + 1$ , the weights on the 2 states are given by the vector  $\Lambda^{t+1}\mathbf{q}$ , so the expected asset value conditional on  $t + 1 = \tau_\varphi$  is  $\mathbf{y}\Lambda^{t+1}\mathbf{q}$ . Therefore

$$\begin{aligned} V(q) &= \sum_{t \geq 0} \mathbb{E}[y_t | \tau_\varphi = t + 1] \mathbb{P}(t + 1 = \tau_\varphi) \\ &= \sum_{t \geq 0} (1-\varphi)^t \varphi \mathbf{y} \Lambda^{t+1} \mathbf{q} \\ &= \varphi \mathbf{y} \Lambda (\text{Id}_2 - (1-\varphi)\Lambda)^{-1} \mathbf{q}. \end{aligned}$$

Note that  $V$  is affine in  $q$ :

$$V(q) = qV(1) + (1-q)V(0).$$

$V$  can also be expressed as a function of  $\tau$ , the time since last disclosure:

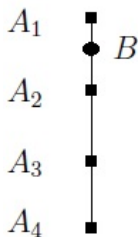
$$V_\tau \equiv V(q_\tau).$$

### 3.1.3 Debt Capacity

**Definition.** The *debt capacity* is the maximal amount of debt financing that can be obtained by pledging the assets under management as collateral. As in Acharya et al. (2011) the set of contracts is restricted to one-period bonds to be rolled over. By definition, if debt

becomes higher than debt capacity during the lifespan of the asset, it is no longer possible to find short-term investors to refinance the current amount of debt. In my model, no cash flows are available before maturity, so that no refinancing implies liquidation: a run occurs. Therefore, debt capacity can equivalently be thought of as a *run threshold*.

**Computation.** The method used to compute debt capacities is of the same kind as in Acharya et al. (2011) (see, e.g., their 2-states example), with two important differences. First, they have a finite deterministic horizon instead of a random maturity, so that in my model, there is no explicit terminal condition. Second, the state of the asset is perfectly observable in their model, while I must account for opacity and thus introduce a new state variable. Debt capacity is now a function of  $\tau$ , the time since last disclosure. The method



is illustrated by the following example. Assume that the cash flows available tomorrow with positive probability are  $A_1$ ,  $A_2$ ,  $A_3$  and  $A_4$ . Since the asset does not pay off anything before maturity, these cash flows are either maturity payoffs (in case the asset matures tomorrow) or short-term debt funding. By definition of debt capacity, any amount equal or below the debt capacity in tomorrow's state will be available. So the  $A_i$  can correspond to debt capacities in all the possible states of the world tomorrow. Debt capacity today is at least  $\max(m(A_1), m(A_2), m(A_3), m(A_4))$  where  $m(x)$  denotes the fair pricing of a bond with face value  $x$ . Indeed, by promising  $A_i$  tomorrow, the bank obtains today an amount of funds equal to  $m(A_i)$ . The key observation is that it is not necessary to consider other promises  $B$  than the  $A_i$ . Indeed,  $B > A_1$  implies immediate liquidation and  $B < A_4$  allows to raise  $m(B) = B < A_4 = m(A_4)$ . Finally, if  $A_{i+1} < B < A_i$ , the bank can obtain more by increasing the promise up to  $A_i$ . Indeed, the bond pays off the same if state  $A_j$  with  $j > i$  is realized (namely  $\alpha A_j$ ), and more if state  $A_j$  with  $j \leq i$  is realized. Hence for  $A_{i+1} < B < A_i$ ,  $m(B) < m(A_i)$ . Note that in general  $m(A_{i+1}) < m(A_i)$  *does not hold* because of the liquidation parameter  $\alpha < 1$ .

*Conclusion:* if the possible cash flows tomorrow are  $A_1, \dots, A_n$  and  $m$  is the fair pricing function in the current state, debt capacity today is equal to  $\max(m(A_1), \dots, m(A_n))$ .

See Figure 3 for the graphical representation of  $m$ .

Back to my model, the states of the world for tomorrow (from the point of view of outsiders) are always 4 before maturity.

- State  $a$ : the asset has just matured, in the good state.
- State  $b$ : the asset has just matured, in the bad state.
- State  $c$ : the asset has not matured, and a disclosure was made ( $\tau = 0$ ).
- State  $d$ : the asset has not matured, no disclosure was made ( $\tau \rightarrow \tau + 1$ ).

Let  $C(\tau)$  denote the debt capacity in state  $\tau$ . Following the method described above,

$$C(\tau) = \max(m(C(0)), m(C(\tau + 1)), m(y^G), m(y^B)). \quad (1)$$

In this model, going from state  $\tau$  to state  $\tau + 1$  can only be bad news. Indeed, the probability to be in state  $y^G$  decreases, and the asset has not matured yet. Therefore I impose  $C(\tau + 1) \leq C(\tau)$ , which rules out Ponzi schemes. Given  $m(x) \leq x$ , for  $\tau > 0$ , Equation (1) reduces to:

$$C(\tau) = \max(m(C(0)), m(y^G), m(y^B)), \quad (2)$$

and

$$C(0) = \max(m(y^G), m(y^B)). \quad (3)$$

$y^B$  is the worst state of the world, so this is a risk-free promise:

$$m(y^B) = y^B. \quad (4)$$

Let us now deal with the pricing of bonds with face value  $y^G$  and  $C(0)$ , respectively.

- In case the asset matures tomorrow, there will be full payment in the good state (state  $a$ ) and payment of  $\alpha x_2$  in state  $b$ . Otherwise, there will be liquidation, since  $C(\tau) < y^G$ . The liquidation value will be either  $V_0$  (in state  $c$ ) or  $V_{\tau+1}$ <sup>4</sup> (in state  $d$ ). So

$$m(y^G) = \varphi(\gamma_\tau y^G + (1 - \gamma_\tau)\alpha y^B) + \alpha(1 - \varphi)(p\gamma_\tau V_0 + (1 - p\gamma_\tau)V_{\tau+1}). \quad (5)$$

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<sup>4</sup>The bank's information is revealed during the liquidation process, so the final fundamental value will not be  $V_{\tau+1}$ . But since outsiders update correctly their belief  $q$  and the fundamental value is affine in  $q$ , the final fundamental value is indeed  $V_{\tau+1}$  on average.

- Payments in states  $a$ ,  $b$ ,  $c$  and  $d$  are respectively  $C(0)$ ,  $\alpha y^B$ ,  $C(0)$ ,  $\alpha V_{\tau+1}$ . So

$$m(C(0)) = \varphi(\gamma_\tau C(0) + (1 - \gamma_\tau)\alpha y^B) + (1 - \varphi)(p\gamma_\tau C(0) + \alpha(1 - p\gamma_\tau)V_{\tau+1}). \quad (6)$$

Combining Equations (2) to (6), I obtain the debt capacities  $C(\tau)$  for all  $\tau$ . Note that although the problem is recursive in nature, debt capacities are characterized directly, before computing the bond yields and without solving any recursive equation. This useful property hinges on the fact that the absence of disclosure is always bad news so that debt capacity must decrease. Hence we do not need to know  $C(\tau + 1)$  to compute  $C(\tau)$ . Figure 2 provides a graphical representation.

### 3.1.4 Endogenous Bond Yields

One-period yields are derived endogenously as a function of current debt  $D$  and the state  $\tau$ . They obtain in closed-form as the solution to a linear equation conditional on this solution being between pre-specified bounds. The remainder of this section details the procedure to obtain the yields by distinguishing between different cases. In Section 4 below, I show that each of these cases has a clear economic interpretation. For instance, when the promised face value  $F$  satisfies  $F \leq C(\tau + 1)$ , debt will be rolled over even if no news is disclosed. In that sense, it is "information-insensitive". Indeed,  $C(\tau + 1)$  is the maximal amount of financing available in state  $\tau + 1$ , i.e. absent news disclosure tomorrow.

*Fair pricing.* We are looking for  $F$  such that  $D = m(F)$ . The function  $m$  depends on the current state  $\tau$  and has the shape depicted in Figure 3.  $m$  increases linearly with  $x$  and jumps down when an additional default state appears, because of the proportional loss  $1 - \alpha$  incurred in the new default state. In some regions, multiple solutions exist. Clearly, it is optimal for the bank to offer the lowest one as face value, thereby lowering the probability of an inefficient liquidation. Therefore I define

$$F(D) = \min(x \geq 0, m(x) = D),$$

and the gross yield  $r = \frac{F}{D}$ . The next lines detail the analytical expression of  $m$ . The logic is similar to Equations (5) and (6).

If  $x \leq y^B$ , the promise of  $x$  is never defaulted upon:  $m(x) = x$ . If  $x > C(\tau)$ , by definition of debt capacity, there will always be default, so that  $m(x) < m(y^G)$ . Hence, there is no need to consider those values of  $x$ . Otherwise, if  $x \leq C(\tau + 1)$ , there is one default state

(state (b), see Section 3.1.3) and

$$m(x) = \varphi(\gamma_\tau x + (1 - \gamma_\tau)\alpha y^B) + (1 - \varphi)x.$$

If  $x \in (C(\tau + 1), C(0)]$ , there are two default states ((b) and (d)) and

$$m(x) = \varphi(\gamma_\tau x + (1 - \gamma_\tau)\alpha y^B) + (1 - \varphi)(p\gamma_\tau x + \alpha(1 - p\gamma_\tau)V_{\tau+1}).$$

If  $x$  belongs to  $(C(0), y^G]$ , there are three default states ((b), (c) and (d)) and

$$m(x) = \varphi(\gamma_\tau x + (1 - \gamma_\tau)\alpha y^B) + \alpha(1 - \varphi)(p\gamma_\tau V_0 + (1 - p\gamma_\tau)V_{\tau+1}).$$

## 3.2 Mandatory Disclosure

I now assume symmetric information between the bank and outside lenders: the bank has to reveal any signal it observes. There is still opacity in the sense that the asset value is only observed with probability  $p$  at each time.

### 3.2.1 State Variables

Let again denote  $q$  the probability of the asset being in state  $y^G$  (now the same for the bank and outsiders) and  $\tau$  be the time since the last disclosure of *the good state*. As in the voluntary disclosure case, there is a correspondence between  $\tau$  and  $q$ . The updating rule is modified. Here,  $q(\tau = 0) = 1$  and

$$q_{\tau+1} = q_\tau \lambda_{11} + (1 - q_\tau) \lambda_{21}.$$

Figure 1 provides a graphical representation.

Since asset observability is now independent from asset value, the weights on states after  $\tau$  periods without observation are simply given by the iterated transition matrix,  $\Lambda^{\tau+1}$ . The qualitative behaviour of  $q_\tau$  is the same as in the voluntary disclosure case. Here, it decreases to the stationary weight

$$q_M^* = \frac{\lambda_{21}}{1 + \lambda_{21} - \lambda_{11}},$$

which is much above the limit  $q_V^*$  of  $q_\tau$  in the voluntary disclosure case. The intuition is that with mandatory disclosure, no information does not mean a higher chance of bad news

being concealed. Under voluntary disclosure, a prolonged lack of disclosure seriously hints at the state being  $y^B$ .

I again define  $\gamma_\tau$  as the probability to be in state  $y^G$  tomorrow given  $\tau$  periods of non-disclosure. Here, we simply have

$$\gamma_\tau = q_{\tau+1}.$$

### 3.2.2 The Stationary Weights

There is an economic intuition behind  $q_M^*$ , which represents the asymptotic expected value of collateral, i.e. in an information-less economy. If even in the information-less economy, agents accept to roll over debt because the expected value of collateral is high enough (high  $q_M^*$ ), it is pointless to gather information. It would even be inefficient, since the (rare) bad banks would be inefficiently closed. This is one message of Gorton and Ordoñez (2014). However, there is no reason to believe that  $q_M^*$  is that high. Moreover, if we introduce strategic considerations regarding the bank (either moral hazard, or, as in this paper, disclosure following a sanitization strategy), it becomes clear that the expected value of the bond collateral in the information-less economy must be much lower. In particular, the money-like property of the bond is lost. In the model, indeed,  $q_V^* \ll q_M^*$ .

### 3.2.3 Fundamental Value

The formula for  $V(q)$  established above is still valid. We now have that the fundamental value after  $\tau$  periods without disclosure is  $V_\tau \equiv V(q = q_\tau)$ , where the probability  $q_\tau$  is computed assuming mandatory disclosure.

### 3.2.4 Debt Capacity

There is an additional state of the world, since the bad state  $y^G$  must now be disclosed if it is observed before maturity by the bank. Denote  $C_b$  the debt capacity in that state. The method used is the same as before. Again denoting  $C(\tau)$  the debt capacity in state  $\tau$ , we have

$$C(\tau) = \max(m(y^G), m(y^B), m(C(0)), m(C(\tau + 1)), m(C_b)).$$

Since  $C(\tau + 1) < C(\tau)$  and  $C_b < C(\tau)$ , this reduces to

$$C(\tau) = \max(m(y^G), y^B, m(C(0))),$$

and

$$C(0) = \max(m(y^G), y^B).$$

Also,

$$C_b = \max(m(y^G), y^B, m(C(0))).$$

The fair pricing of promises  $y^G$  and  $C(0)$  when currently in the bad state is:

$$m(y^G) = \varphi(\lambda_{21}y^G + \alpha(1-\lambda_{21})y^B) + (1-\varphi)\alpha(p\lambda_{21}V(q=1) + p(1-\lambda_{21})V(q=0) + (1-p)V(q=\lambda_{21})),$$

$$m(C(0)) = \varphi(\lambda_{21}C(0) + \alpha(1-\lambda_{21})y^B) + (1-\varphi)(p\lambda_{21}C(0) + p\alpha(1-\lambda_{21})V(q=0) + (1-p)\alpha V(q=\lambda_{21})).$$

These two equations allow to compute  $C_b$ . A condition for a run to always occur after disclosure of the bad state is

$$C_b \leq D_0. \tag{7}$$

With this condition satisfied we do not need to consider the case  $q = 0$  since if  $q = 0$ , there is immediate liquidation. Hence, the one-for-one correspondence between the possible values of  $q$  and the time since the last disclosure of the good state  $\tau$  holds.

Note that  $C(\tau)$ , the debt capacity after  $\tau$  periods of non-disclosure, does *not* go to  $C_b$ . Indeed, under mandatory disclosure, absent any information, the weight on the good state goes to the stationary weight, namely  $q_M^* = \frac{1}{2}$  (when  $1 - \lambda_{11} = \lambda_{21}$ ). Disclosure of the bad state implies  $q = 0$  and therefore a significantly lower fundamental value. It is not surprising, therefore, that disclosing the bad state immediately triggers a run.

When  $\tau$  increases, the expectations about asset value decrease more in the voluntary disclosure case, implying a lower debt capacity. Nevertheless, it is not possible to assess directly that mandatory disclosure is "better". For instance, any disclosure of bad news would imply a run. When disclosure is voluntary, bad news are concealed and a run is not immediately triggered, leaving room for subsequent recovery.

### 3.2.5 Endogenous Bond Yields

Section 4 details the economic interpretation of the procedure used to compute bond yields. It is qualitatively similar to the voluntary disclosure case: yields jump upwards as soon as debt becomes information-sensitive. Again, the face value solves  $m(F) = D$  and the gross yield is defined by  $r = \frac{F}{D}$ . *All the intuitions of the voluntary disclosure case still apply, see in particular Figure 3.* The only difference is that there is an additional state and therefore,

potentially (i.e. if  $C_b > y^B$ ) an additional downwards jump for  $m$ . For completeness, the procedure is rephrased for the mandatory disclosure case.

Let  $D$  be the current level of debt,  $\tau$  the time since last disclosure and let us look for (the smallest) admissible face value  $F$  to refinance  $D$ . The probability of an announcement tomorrow is  $p\gamma_\tau$ . The probability of no announcement is  $1 - p$ . Otherwise, state  $y^B$  is disclosed (probability  $p(1 - \gamma_\tau)$ ). First, if  $x \leq y^B$ ,  $m(x) = x$ . If  $x \in (y^B, C_b]$  (if this interval is non-empty)) then

$$m(x) = \varphi(1 - \gamma_\tau)\alpha y^B + (1 - \varphi(1 - \gamma_\tau))x.$$

If  $C_b < x \leq C(\tau + 1)$ , then

$$m(x) = \varphi(\gamma_\tau x + (1 - \gamma_\tau)\alpha y^B) + (1 - \varphi)((1 - p(1 - \gamma_\tau))x + p(1 - \gamma_\tau)\alpha V(q = 0)).$$

If  $C(\tau + 1) < x \leq C(0)$ , then

$$m(x) = \varphi(\gamma_\tau x + (1 - \gamma_\tau)\alpha y^B) + (1 - \varphi)(p\gamma_\tau x + (1 - p)\alpha V(\tau + 1) + p(1 - \gamma_\tau)\alpha V(q = 0)).$$

If  $C(0) < x \leq y^G$ , then

$$m(x) = \varphi(\gamma_\tau x + (1 - \gamma_\tau)\alpha y^B) + \alpha(1 - \varphi)(p\gamma_\tau V(q = 1) + (1 - p)V(\tau + 1) + p(1 - \gamma_\tau)V(q = 0)).$$

Again, for any  $D \leq C(\tau)$  we now define

$$F(D) = \min(x \geq 0, m(x) = D).$$

## 4 Results

### 4.1 Opacity, Information Sensitivity and Rollover Risk

#### 4.1.1 Notions of Information Sensitivity

The notion of *information sensitivity* is at the heart of a recent series of papers: Dang, Gorton and Holmström (2012, 2013), and Gorton and Ordoñez (2014). A security is information-insensitive when agents accept to trade it without paying to obtain a costly signal about it, and has a high information sensitivity when agents are ready to spend a lot to obtain a signal. Debt is in many instances information-insensitive: agents can trade it without trying to know more about the value of collateral.



*Adverse selection.* In the papers of Dang et al., this property is desirable mainly because it allows to sidestep adverse selection issues. Debt is liquid because agents are not concerned that the next buyer knows more about the collateral than they do. In this context, opacity is efficient since it makes debt information-insensitive in more states of the world.

*Pooling.* In Gorton and Ordoñez (2014), opacity permits the pooling of firms with good collateral with firms with bad collateral. If the average quality of collateral is high enough, firms obtain credit from lenders who do not verify firm-specific collateral quality. This financing is invested in positive NPV projects, and opacity is therefore desirable. To the contrary, when information about a firm’s collateral is cheap, debt becomes information-sensitive: lenders verify collateral quality and lend only conditional on good news. Firms with bad collateral are deprived of credit and welfare is lower. In my model, a related notion of information sensitivity appears<sup>5</sup>:

**Definition.** Let  $(D, q)$  be the state today, and  $F(D, q)$  the promised face value due tomorrow. I say that debt is *information-insensitive* if the full repayment of  $F(D, q)$  does not imply disclosure tomorrow. To the contrary, debt is *information-sensitive* if the absence of disclosure tomorrow entails a run.

#### 4.1.2 Rollover Risk Regimes

Figure 4 plots yields (computed in Section 3) after  $\tau = 1$  period of non-disclosure in the voluntary disclosure case. The plot is qualitatively similar for other values of  $\tau$ . The jumps correspond to a change of region in the fair pricing problem. These regions have the following economic interpretations.

When  $D \leq y^B = 70$ , debt is completely risk-free.

In the *II* (information-insensitive) region, debt is safe: the face value satisfies  $F \leq C(\tau + 1)$ . The face value is below tomorrow’s debt capacity if there is no disclosure. Hence, unless the asset matures tomorrow in the bad state, debt will necessarily be rolled over. In the *II* region, debt is money-like.

The *IS* (information-sensitive) region corresponds to face values  $F$  between  $C(\tau + 1)$  and

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<sup>5</sup>In the literature mentioned above, opacity is a cost of accessing information. In my model, the chain  $(y_t)$  is observable with probability  $p$ , which can be interpreted as a time-varying cost of accessing information: with probability  $p$  this cost is 0, and with probability  $1 - p$  it is  $+\infty$ .

$C(0)$ . The face value is higher than tomorrow's debt capacity if there is no disclosure. Hence, the lack of disclosure tomorrow will entail a run. However, it is below  $C(0)$ , the debt capacity following the disclosure of state  $y^G$ . Avoiding liquidation is contingent on good news.

The pre-liquidation region corresponds to  $F$  above  $C(0)$ : liquidation will happen tomorrow unless the project matures in state  $y^G$ . Finally, the liquidation region corresponds to levels of debt where a run occurs today, for lack of an admissible face value to roll debt over.

As Figure 5 shows, the behaviour of bond yields in the mandatory disclosure case is qualitatively similar. Note that now, the bank can survive long periods of non-disclosure (here  $\tau = 4$ ) because investors know that it is genuinely uninformed. As in the model, the probability to fall into the bad state is very low, the asset has still a good chance to be in the good state after several non-disclosure periods.

I now present a series of analytical results implied by the expression of yields found in Section 3. In turn, a first set of economic conclusions are derived from these results.

### Propositions.

**(a) (Safer Information-Insensitive Debt)** *If regions II and IS both exist, short-term debt is less risky in the II region.*

**(b) (Opacity and Information Sensitivity)** *For high opacity, i.e. small values of  $p$ , debt is always information-insensitive. To the contrary, when  $p \rightarrow 1$ , the information-insensitive region shrinks: if  $D > V(q = 0)$  then for any  $\tau$ ,  $(D, \tau)$  can not be in the II zone for  $p$  close enough to 1.*

**(c) (Bond Yield Discontinuity)** *Bond yields are discontinuous in the value of debt for a given  $\tau$ . As debt reaches the information-sensitivity threshold, yields jump upward.*

**(d) (The Opacity Component of Short-Term Spreads)** For a given  $(D, q)$ , short-term spreads can vary with the opacity level:

**(1)** *If  $(D, q)$  is at the right of the information-sensitive region for opacity parameters  $p_1$  and  $p_2$  with  $p_1 < p_2$  then  $F^{[p_1]}(D, q) > F^{[p_2]}(D, q)$ .*

**(2)** *If  $(D, q)$  is in the information-insensitive region for opacity parameters  $p_1$  and  $p_2$  with  $p_1 < p_2$  then  $F^{[p_1]}(D, q) \leq F^{[p_2]}(D, q)$ , with equality if and only if disclosure is voluntary.*

**Proofs.** See the Appendix. As in these Propositions, the superscript  $[p]$  designates a variable relative to the model solution for opacity parameter  $p$ .

Propositions (a) and (b) confirm that information-insensitivity makes short-term debt safer, and that opacity increases the size of the information-insensitive region. However, under opacity, the probability of disclosure is low and  $\tau$  is likely to keep increasing. Thus, with high probability, the right end of the  $II$  zone (threshold of Proposition (c)) is reached, leaving the bank exposed to runs.

Finally, Proposition (d) contains the testable prediction that there is an opacity component of short-term spreads. Spreads are primarily linked to future rollover decisions, not to the asset fundamental value. But rollover decisions occur at each node of the asset tree, whose structure depends on disclosures. Therefore opacity can matter for short-term spreads even if the collateral process is fixed. More specifically, the model predicts that in "good times" ( $D$  low, or  $q$  high) transparency increase spreads, while in "crisis" (at the right of the  $IS$  zone) transparency decrease spreads.

So far, the analysis was *local*, since I focused on the behaviour of short-term yields. The model suggests while opacity indeed makes debt safer and money-like in the short-run, it may induce a high exposure to runs in the longer run, when  $q$  becomes too low, or  $D$  too high. The next Sections attempt to quantify *globally* this trade-off, i.e. study the impact of opacity and disclosures on the run probability (stability) and the expected output of the asset (efficiency).

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### Remarks about the model.

*Continuity.* As explained below, run probabilities and expected payoffs depend on time-to-default, say  $t(D)$ , the time before liquidation occurs starting from  $D_0 = D$ . Since time is discrete, these functions  $t$  are necessarily discontinuous. When we average over different asset paths to obtain expected values, discontinuities do not disappear since states are discrete too. Since the moments of interest in this model depend on the  $t(D)$  (see, e.g. Section 4.2.2), the graphs of the moments exhibit discontinuities when  $t(D)$  jumps.

*Parameter values and the  $IS$  zone.* As the Figures show, the  $IS$  zone is in general tiny,

and can also not exist. In that case, the debt directly switches from being information-insensitive to being defaulted upon, making the trade off between short-term protection and long-term exposure even clearer. The *IS* zone becomes larger as  $\alpha$  increases or as  $\lambda_{11}$  decreases. A high  $\alpha$  shifts the run threshold to the right, making it unlikely that the debt can be *II* up to this threshold, while a low  $\lambda_{11}$  means that bad news are more likely, so that the absence of disclosure is worse news. In turn, the *II* zone shrinks.

## 4.2 Secret Keeping or Transparency?

### 4.2.1 Runs, Efficiency, and Pooling

*Remark.* I refer to the case  $p = 0$  as "secret keeping" although, strictly speaking, the bank itself does not observe the asset value. Nevertheless, it is equivalent to the case where the bank does observe the asset value but can commit not to reveal any information, the assumption of Dang, Gorton, Holmström and Ordoñez (2014). Note that information revealing can occur directly (disclosure) or indirectly (signaling when offering a face value to roll debt over).

I interpret  $(1 - \alpha)V$  as a deadweight loss, so runs are always inefficient here. Liquidation multiplies the maturity payoff by  $\alpha < 1$  in each state. If a social planner or a long-term investor initially buys the debt and holds it until maturity, the asset pays off weakly more than in the model in all states (i.e. for every path  $(y_t)$ , every sequence of asset observability, and every maturity) and strictly more in some states. Therefore there exists a Pareto-improving arrangement, in which premature liquidation never occurs. Note that because lenders make zero profit on average, the bank bears the costs of inefficient runs. In other words, optimality for the bank coincides with the social planner's optimality in the model, that is, maximizing the expected payoff of the asset.

Based on these observations, I measure efficiency in this section by the expected output  $U$ . Formally,

$$U = \mathbb{E}[\alpha y_{\tau_l} \mathbf{1}_{\tau_l \leq \tau_\varphi} + y_{\tau_\varphi} \mathbf{1}_{\tau_\varphi < \tau_l}].$$

Equivalently, the measure of *inefficiency* is the expected deadweight cost

$$\mathbb{E}[(1 - \alpha)y_{\tau_l} \mathbf{1}_{\tau_l \leq \tau_\varphi}] = V(q = 1) - U.$$

The run probability is

$$P = \mathbb{P}(\tau_l \leq \tau_\varphi).$$

I now recap the economic effects at play in our discussion.

*Effect 1: Short-term protection of opacity.* Starting from  $y_0 = y^G$ , the expected value of the asset is initially high enough: there is no need of transparency in order to roll debt over. The bond is information-insensitive and almost immune to default and is therefore *money-like*, the argument of Gorton and Ordoñez (2014).

*Effect 2: Long-term exposure effect of opacity.* After several periods, however, the expected value of collateral becomes small, and information is required to continue rolling over the debt. Under opacity, this information is never available, forcing liquidation. Opacity protects from runs in the short term, but exposes strongly to runs in the longer term.

*Effect 3: Highly inefficient liquidations.* Runs are inefficient, but runs on good banks are *the most* inefficient. If the asset is in the good state, a run entails a loss of welfare of  $(1 - \alpha)V(1) > (1 - \alpha)V(0)$ , the loss in case it is in the bad state. For the social planner, or the bank, the goal is therefore not primarily to minimize run probability, but to *minimize liquidation costs*. The fact that runs on good institutions are more inefficient has an important consequence: while opacity indeed permits pooling and rolling debt over at low cost, it also prevents from distinguishing between good and bad institutions. When the information-sensitive zone is finally reached, liquidation will occur independently of the quality of collateral, and *can affect a healthy bank*. To the contrary, *under full information, runs only occur on bad-quality collateral banks*<sup>6</sup>.

The next section derives run probabilities and expected output in closed-form in the polar cases  $p = 0$  and  $p = 1$  and shows when the benefits of secret keeping (effect 1) are outweighed by its downsides (effects 2 and 3).

#### 4.2.2 Two Polar Cases

When  $p = 0$ , the only random variable actually observed is maturity. Hence, before maturity, the paths of debt and beliefs about the current state are deterministic. Given an initial debt  $D_0$ , there is a deterministic  $t_0(D_0)$  such that liquidation always occurs at  $t_0$  if maturity is not reached yet.  $t_0$  is obtained by computing the path of debt using the formulas for bond yields derived above. Figure 8 plots  $t_0$  as a function of  $D_0$ .

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<sup>6</sup>In my model, a run also occurs after a long time even if the asset stays in the good state, because debt increases at each time while the best state remains the same. But this event has very low probability.

$t_0$  can be interpreted as a "time-to-crisis". Until time  $t_0 - 1$ , Effect 1 is at play and the bond is money-like. The key point here is that the quasi-absence of risk in the beginning is *only due to the possibility to liquidate the asset in the future*. The bond is has no risk because it will always be possible to run when the liquidation value approaches the debt level. Short-term spreads are by no means informative about the longer-term risk of the project and are low precisely because of the option to run. Figure 9 evidences this effect: spreads are very low, explode at  $t_0 - 1$ , and liquidation occurs.

Denote  $\mathbf{e}_1$  the column vector  $(1 \ 0)^T$ ,  $q_0 = \mathbf{e}_1^T \Lambda^{t_0} \mathbf{e}_1$  the probability to be in state  $y^G$  at time  $t_0$ , let  $\lambda = \lambda_{12} = \lambda_{21}$  be the switching probability. Also recall that  $V(q)$  stands for the fundamental value when the probability to be in state  $y^G$  is  $q$ .

**Proposition 1.1.** *Under secret keeping ( $p = 0$ ), run probability and expected output are respectively given by*

$$\begin{aligned} P(p = 0) &= (1 - \varphi)^{t_0}, \\ U(p = 0) &= \mathbf{y}\varphi\Lambda(Id_2 - (1 - \varphi)^{t_0}\Lambda^{t_0})(Id_2 - (1 - \varphi)\Lambda)^{-1}\mathbf{e}_1 \\ &\quad + (1 - \varphi)^{t_0} \underbrace{\alpha V(q_0)}_{\text{Liq. value of average bank.}}. \end{aligned}$$

**Proof.** See the Appendix.

Assume  $C_b = y^B$  (see Equation (7)) and  $p = 1$ . Any switch to the bad state triggers a run. Conditional on  $y_t = y^G$  for all  $t$ , there is a deterministic time  $t_1(D)$  such that liquidation occurs at  $t_1$  as soon as  $\tau_\varphi > t_1$ . This is because debt grows while the states remain the same.

**Proposition 1.2.** *Under transparency ( $p = 1$ ), run probability and expected output are respectively given by*

$$\begin{aligned} P(p = 1) &= 1 - \varphi \frac{1 - (1 - \lambda)^{t_1}(1 - \varphi)^{t_1}}{1 - (1 - \lambda)(1 - \varphi)}, \\ U(p = 1) &= \alpha(1 - \varphi)^{t_1}((1 - \lambda)^{t_1}V(1) + (1 - (1 - \lambda)^{t_1})V(0)) + \alpha(1 - (1 - \varphi)^{t_1})V(0) \\ &\quad + \varphi \left( (1 - \lambda)y^G - \underbrace{\alpha V(0)}_{\text{Liq. value of bad bank.}} + \alpha y^B \lambda \right) \frac{1 - (1 - \varphi)^{t_1}(1 - \lambda)^{t_1}}{1 - (1 - \varphi)(1 - \lambda)}. \end{aligned}$$

**Proof.** See the Appendix.

**Proposition 2.** *For low  $\alpha$ , transparency dominates opacity in terms of efficiency: Effects 2 and 3 outweigh Effect 1.*

**Proof.** This is a consequence of the closed-forms obtained in Proposition 1. Figure 10 plot the efficiency of the two regimes (opacity and transparency) for  $\alpha \in [0.7; 1]$ . The intuition is the following: when  $\alpha$  is low, the debt capacity decreases and it is more likely to reach the information-sensitive zone before maturity. As explained before, there is a run as soon as this zone is reached, since no information can be provided under full opacity. Hence, when  $\alpha$  is low, the short-term protection effect is even shorter. Finally, it is clear that Effect 3 (inefficiency of liquidation of good banks) is stronger as the liquidation cost grows.

**Proposition 3.** *For some parameter values, transparency dominates opacity in terms of efficiency even if the run likelihood is higher under transparency: Effect 3 is at play.*

**Proof.** This is a consequence of the closed-forms obtained in Proposition 1. Figure 11 shows a case where the run probability is lower under opacity for all  $\alpha \in [0.7, 1)$ , but efficiency is always higher under transparency.

## 4.3 Disclosures and Efficiency

### 4.3.1 Some Examples

Figures 6 and 7 plot two sample paths of debt for both disclosure regimes. They are of particular interest because they illustrate well the economic effects at play. Figure 6 depicts a *commitment run*, i.e. a situation when the bank could reach maturity under mandatory disclosure, but not under voluntary disclosure. In the short run, interest rates are lower under voluntary disclosure. This is because bad news are not revealed. The only risk for early lenders is that maturity occurs tomorrow, in the bad state. The stock of debt grows slower under voluntary disclosure in the beginning. But a run suddenly occurs: this is because news have not been released for a prolonged time, leading to a sharp decline in the voluntary debt capacity. The bank has no way to credibly communicate that it *really* did not observe the asset value and is therefore fragile. Under mandatory disclosure, however, the bank is resilient to long opacity periods because there is no longer a concern that the bank conceals bad news.

Figure 7 shows an example where voluntary disclosure provides higher welfare. On that sample path, information was regularly released so that debt always remained information-insensitive. The bank can refinance its debt at lower spreads under voluntary disclosure for the reasons explained above. Unlike in the mandatory case, the bank was able to reach maturity in the voluntary case because of this lower debt level.

As is apparent from these examples, two opposite forces are at play and it is not clear a priori which one dominates, i.e. whether mandatory disclosure dominates voluntary disclosure in terms of welfare. This question is explored in the next section.

### 4.3.2 Model Simulation

When  $p$  is strictly between 0 and 1, I can no longer fully solve for run probability and expected output in closed-form. I therefore simulate the model a large number of times to obtain the moments of interest. The procedure is the following. First, I simulate maturity  $\tau_\varphi$  according to a geometric distribution with parameter  $\varphi$ . Second, I simulate independent Bernoulli variables with parameter  $p$ ,  $a_t \in \{0; 1\}$ .  $a_t = 0$  indicates that the asset value was not observable at time  $t$ ,  $a_t = 1$  indicates that it was observable. Third, I simulate the chain  $(y_t)$  according to the transition matrix  $\Lambda$ . Then, I compute the path of debt, the time of run (if any) and the final output (either maturity payoff or liquidation payoff) assuming mandatory disclosure. To compare both disclosure regimes "ω by ω" I use the same values for  $\tau_\varphi$ ,  $(y_t)$  and  $(a_t)$  and compute the path of debt, the time of run (if any) and the final output assuming voluntary disclosure. This way, I can not only count the number of runs under both disclosure regimes, but also distinguish between cases where disclosure policy did not matter (e.g. a run would have occurred under both regimes) from cases where it did (e.g. voluntary disclosure triggered an inefficient run while the project reached maturity in the mandatory disclosure case). For each value of  $p$ , this procedure is repeated a large number of times,  $N$ . Table 1 plots the results when the baseline parameters are fixed and the opacity level  $p$  varies. Table 2 plots the results when  $p = 0.5$  and the liquidity parameter varies.  $D_0$  is set to a value such that  $D_0 > C_b$  (see Equation (7)) is always satisfied.

*Choice of  $N$  and confidence intervals.* The standard deviation of a random variable with support  $[a, b]$  is smaller than  $\frac{b-a}{2}$ . The variable  $\mathbf{1}_{\text{Run}}$  takes values in  $[0, 1]$  (actually  $\{0; 1\}$ ), the output takes values in  $[\alpha y^B, y^G]$ , and so does the debt payment. Hence the asymptotic standard deviation of the Monte-Carlo error is smaller than  $\frac{1}{2\sqrt{N}}$  for the run probabilities and smaller than  $\frac{y^G - \alpha y^B}{2\sqrt{N}}$  for expected output and debt payments. Since in all simulations,



$\alpha \geq 0.8$ , this bound is itself smaller than  $\frac{y^G - 0.8y^B}{2\sqrt{N}} = \frac{22}{\sqrt{N}}$ .

To obtain expected output and debt payments correct up to  $\pm 0.01$  at the 1% confidence level, we need  $\frac{2.58 \times 22}{\sqrt{N}} \leq 0.01$ , i.e.  $N \geq 32.2 \times 10^6$ . I set  $N = 33 \times 10^6$ . As for the precision on run probabilities, it is better than  $\pm 0.001$  at the 1% confidence level. Therefore, Tables 1 and 2 report expected output and debt payments up to the second decimal and run probabilities up to the third decimal, rounded above if the next decimal is above 5.

Finally, note that for  $p = 1$  (last column of Table 1) the two disclosure regimes are equivalent, and the results can also be obtained with the closed-form formulas obtained in Section 4.2.2.

Table 1. **Opacity, Runs and Efficiency.**  $D_0 = 70.1$

$p$	0.2	0.5	0.95	1
$\mathbb{E}[\text{Residual Claim}] - \text{Voluntary}$	23.74	23.49	24.10	24.84
$\mathbb{E}[\text{Residual Claim}] - \text{Mandatory}$	24.43	24.71	24.83	24.84
$\mathbb{P}(\text{Run under V and M})$	0.066	0.072	0.091	0.105
$\mathbb{P}(\text{Run only under M})$	0.027	0.028	0.013	0
$\mathbb{P}(\text{Commitment Run})$	0.040	0.066	0.039	0
$\mathbb{P}(\text{Run under M})$	0.093	0.099	0.104	0.105
$\mathbb{P}(\text{Run under V})$	0.107	0.138	0.130	0.105
$\mathbb{E}[\text{Debt Payment}] - \text{Voluntary}$	70.10	70.10	70.10	70.10
$\mathbb{E}[\text{Debt Payment}] - \text{Mandatory}$	70.10	70.10	70.10	70.10

Table 2. **Liquidity, Runs and Efficiency.**  $D_0 = 74$

$\alpha$	0.8	0.9	0.95	1
$\mathbb{E}[\text{Residual Claim}] - \text{Voluntary}$	17.73	21.59	22.27	22.74
$\mathbb{E}[\text{Residual Claim}] - \text{Mandatory}$	19.49	21.87	22.31	22.74
$\mathbb{P}(\text{Run under V and M})$	0.149	0.052	0.043	0.034
$\mathbb{P}(\text{Run only under M})$	0.019	0.036	0.044	0.053
$\mathbb{P}(\text{Commitment Run})$	0.095	0.033	0.013	0.003
$\mathbb{P}(\text{Run under M})$	0.168	0.088	0.087	0.087
$\mathbb{P}(\text{Run under V})$	0.244	0.085	0.056	0.037
$\mathbb{E}[\text{Debt Payment}] - \text{Voluntary}$	74.00	74.00	74.00	74.00
$\mathbb{E}[\text{Debt Payment}] - \text{Mandatory}$	74.00	74.00	74.00	74.00

Rows 1 and 2 give the expected residual claim under both voluntary and mandatory disclosure. Note that given that debt payment is on average equal to  $D_0$ , the residual claim is equal to output up to the constant  $D_0$ . Row 3 gives the probabilities that a run occurs under both disclosure regimes. Row 4 gives the probabilities that a run occurs only under mandatory disclosure. This can be the case when the bank survives because bad news are concealed and recovery happens afterwards. Row 5 gives the probabilities of commitment runs, i.e. that occurs only under voluntary disclosure. Rows 6 and 7 show run probability under each regime. Finally rows 8 and 9 confirm that the lenders make zero profit on average.

### 4.3.3 Interpretation

*Full transparency vs opacity.* Table 1 shows that the efficiency under full transparency (Column  $p = 1$ ) is always higher, although this regime may feature more runs. The intuition is as in Effect 3 detailed above: under full transparency, the bank is exposed to the revelation of a bad shock. However, in the long term, the likely absence of information will prevent the bank from keeping rolling debt over, while a transparent bank with the asset in the good state could do it.

*Commitment runs.* In Table 1, voluntary disclosure always induces more runs than mandatory disclosure, as suggested by Effect 2. Table 2, however, shows that for high liquidity levels ( $\alpha$  large), this is no longer true. The intuition is that a large  $\alpha$  shifts the run thresholds to the right, so that it takes a longer time to leave the information-insensitive zone. This is also true when initial debt  $D_0$  is low or when switching to  $y^B$  is unlikely ( $\lambda_{11}$  close to

1). In those cases, disclosing in less states of the world protects against runs, i.e. Effect 1 dominates Effect 2 as far as the run probability is concerned.

*Mandatory vs voluntary disclosure.* Mandatory disclosure is always more efficient than voluntary disclosure. In many instances, the run probability is also higher under voluntary disclosure, meaning that Effect 2 alone can explain the higher efficiency of mandatory disclosure. Table 2, column  $p = 0.95$ , however, demonstrates that voluntary disclosure can lower the run probability without increasing the efficiency. The intuition, again, is given by Effect 3. Even if commitment runs are infrequent, they induce a significant loss of welfare. Indeed, by definition, they occur on institutions whose asset was good enough to roll debt over under mandatory disclosure.

Disclosing less protects against runs when the information-insensitive zone is large, i.e. the danger zone is far. As in the literature on opacity mentioned above, the paradox is that protection works when it is less needed, i.e. when the run probability is low anyway. When the information-insensitive zone becomes smaller, the run probability becomes lower under mandatory disclosure. In terms of efficiency, however, disclosing more is always more efficient, suggesting that Effect 3 evidenced in this paper plays an important role.

## Conclusion

Opacity protects financial institutions from rollover risk in the short term, but increases their exposure in the longer term. The tension between these two effects is stronger when disclosure is voluntary: as long as debt remains information-insensitive, the institution enjoys very low spreads, but as uncertainty about the collateral quality increases, it becomes vulnerable to runs. The model predicts that the latter effect is the stronger and that opacity - especially when combined with voluntary disclosure - triggers avoidable and inefficient runs. These additional runs have the interesting property to behave like panic runs, since they do not start after a news release. The model also highlights another effect of opacity: not only opaque assets are associated to more runs once the information-insensitive zone is left, but these runs are particularly inefficient because of a pooling effect. In future research, it could be interesting to allow for state-contingent disclosure regulation and to soften the maturity mismatch by considering other sources of financing than short-term debt before maturity, e.g. cash reserves or costly equity issuance.

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# Appendix

## Proof: No Strategic Default

The expected payment to bond holders is  $D_0$  by the zero profit condition. If the bank never defaults strategically, its profit writes

$$y_\theta \mathbf{1}_{\tau_\varphi < \tau_l} + \alpha V_{\tau_l} \mathbf{1}_{\tau_\varphi \geq \tau_l} - d_\Theta, \quad (8)$$

where  $\Theta = \min(\tau_l, \tau_\varphi)$ .  $d$  is the actual payment to bondholders:  $d = D \mathbf{1}_{D \leq y} + \alpha y \mathbf{1}_{D > y}$ . We have  $\mathbb{E}[d_\Theta] = D_0$ . If  $V$  denotes fundamental value today, strategic liquidation today pays off  $\alpha V - D_0$ . But  $V$  and  $\mathbb{E}[y_\Theta \mathbf{1}_{\tau_\varphi = \Theta} + V_\Theta \mathbf{1}_{\tau_\varphi > \Theta}]$  are equal. Indeed, they both average values of  $y$  at maturity with the same weights. Given that the factor  $\alpha$  applies to  $V$  but only to the second term of formula (8), we conclude that expected profit under the no-strategic-default strategy is always higher than under immediate liquidation. Therefore, it is at no time optimal to force liquidation.

## Proofs of Propositions (a) to (d)

Proofs are presented in the voluntary disclosure case, and work identically in the mandatory disclosure case. I first need to introduce the

**Lemma.** Let  $\tau$  be a fixed integer and  $0 < p^* < 1$ . If  $\alpha < 1$ , there is  $K_\tau > 0$  such that for all  $p \leq p^*$ ,

$$C^{[p]}(\tau) \geq \alpha V_\tau^{[p]} + K_\tau,$$

where the superscript  $[p]$  designates a variable relative to the model solution under the opacity parameter  $p$ .

**Proof.** We consider the promise of the face value  $y^G$ : we have  $C^{[p]}(\tau) \geq m(y^G)$ <sup>7</sup> and

$$\begin{aligned} m(y^G) &= \varphi(\gamma_\tau^{[p]} y^G + (1 - \gamma_\tau^{[p]}) \alpha y^G) + \alpha(1 - \varphi)(p \gamma_\tau^{[p]} V_0 + (1 - p \gamma_\tau^{[p]}) V_{\tau+1}^{[p]}) \\ &= \varphi(1 - \alpha) \gamma_\tau^{[p]} y^G + \alpha \mathbb{E}[y_{\tau_\varphi} | \tau_\varphi = t + 1] \mathbb{P}(\tau_\varphi = t + 1) + \alpha \mathbb{E}[y_{\tau_\varphi} | \tau_\varphi > t + 1] \mathbb{P}(\tau_\varphi > t + 1) \\ &= \varphi(1 - \alpha) \gamma_\tau^{[p]} + \alpha V_\tau^{[p]}, \end{aligned}$$

---

<sup>7</sup>The operator  $m(\cdot)$  always depends on the opacity parameter  $p$  and the current state  $\tau$ . I only indicate the dependency in brackets ( $m^{[p]}$ ) when necessary for the clarity of the proof.

hence the result, setting  $K_\tau = \varphi(1 - \alpha)\gamma_\tau^{[p^*]}$ .

(a) Debt in the *II* region satisfies

$$D = \varphi(\gamma_\tau F + (1 - \gamma_\tau)\alpha y^B) + (1 - \varphi)F,$$

with  $F \leq C(\tau + 1)$ . Thus, the inverse yield verifies

$$\frac{D}{F} \geq \varphi\gamma_\tau + \varphi(1 - \gamma_\tau)\frac{\alpha y^B}{C(\tau + 1)} + 1 - \varphi. \quad (9)$$

Debt in the *IS* region satisfies

$$D = \varphi(\gamma_\tau F + (1 - \gamma_\tau)\alpha y^B) + (1 - \varphi)(p\gamma_\tau F + \alpha(1 - p\gamma_\tau)V_{\tau+1}),$$

with  $C(\tau + 1) < F \leq C(0)$ . From there,

$$\begin{aligned} \frac{D}{F} &\leq \varphi\gamma_\tau + \varphi(1 - \gamma_\tau)\frac{\alpha y^B}{C(\tau + 1)} + (1 - \varphi)\left(p\gamma_\tau + \alpha\frac{(1 - p\gamma_\tau)V_{\tau+1}}{F}\right) \\ &\leq \varphi\gamma_\tau + \varphi(1 - \gamma_\tau)\frac{\alpha y^B}{C(\tau + 1)} + 1 - \varphi, \end{aligned}$$

where the last inequality holds because of the Lemma. We conclude by comparison with Equation (9).

(b) We first need to show that for  $p$  small,  $m(C(0)) < m(C(\tau + 1))$ . This implies that considering promising face values between  $C(\tau + 1)$  and  $C(0)$  does not allow to roll over other debt levels than the ones in the *II* zone. In other words, there is no *IS* zone. Given the expressions of  $m(C(0))$  and  $m(C(\tau + 1))$ , the desired inequality is equivalent to

$$p\gamma_\tau^{[p]}C(0) + \alpha(1 - p\gamma_\tau^{[p]})V_{\tau+1}^{[p]} \leq C^{[p]}(\tau + 1).$$

We conclude by letting  $p \rightarrow 0$  and using the Lemma. For the case  $p \rightarrow 1$ , we notice that debt capacity is always below the fundamental value of the asset (which is the long-term, frictionless debt capacity). As  $p$  goes to 1,  $q_{\tau+1}$  goes to 0, so the fundamental value goes to  $V(0)$ . Now let  $D > V(0)$ . We have

$$m(C^{[p]}(\tau + 1)) < C^{[p]}(\tau + 1) \leq V_{\tau+1}^{[p]} \rightarrow y^B,$$

hence  $D$  can not be in the  $II$  zone for  $p$  close enough to 1.

(c) is a consequence of the fact that  $m(C(\tau + 1) + \varepsilon) < m(C(\tau + 1))$  for  $\varepsilon$  close to 0 and  $\alpha < 1$ . Recall that this is because the face value is only infinitesimally higher, but there will be default in one more state of the world (the non-disclosure state), meaning that the proportional cost  $1 - \alpha$  now applies to an additional, non-zero probability, state of the world.

(d) (1) Let  $(D, q)$  be the state today, and  $p_1 < p_2$ ,  $\tau_1, \tau_2$  such that

$$q_{\tau_1}^{[p_1]} = q_{\tau_2}^{[p_2]} = q.$$

The probability to be in state  $y^G$  tomorrow is  $q' = \lambda_{11}q + \lambda_{21}(1 - q) = \gamma_{\tau_1}^{[p_1]} = \gamma_{\tau_2}^{[p_2]}$ . Then, the probability to be in state  $y^G$  tomorrow conditional on no disclosure under parameter  $p_1$  is  $\frac{(1-p_1)q'}{1-p_1q'}$ . Using the expression of the yield in the  $IS$  region, we find

$$\begin{aligned} m^{[p_1]}(F) &= \varphi(q'y^G + (1 - q')\alpha y^B) \\ &+ (1 - \varphi) \left( q'p_1F + \alpha(1 - p_1q') \left[ \frac{(1 - p_1)q'}{1 - p_1q'} V(q = 1) + \frac{1 - q'}{1 - p_1q'} V(q = 0) \right] \right). \end{aligned}$$

From there,

$$m^{[p_1]}(F) - m^{[p_2]}(F) = (p_2 - p_1)q'(\alpha V(q = 1) - F),$$

which is negative for  $F$  close to  $C(0)$  by the Lemma. Given that  $D = m^{[p_1]}(F^{[p_1]}(D, q))$ , we have  $D < m^{[p_2]}(F^{[p_1]}(D, q))$ , from which we deduce that  $F^{[p_1]}(D, q) > F^{[p_2]}(D, q)$ . Indeed, it is assumed that  $(D, q)$  belongs to the  $IS$  zone for both  $p_1$  and  $p_2$ , and  $m(\cdot)$  is increasing over this region, and must also satisfy  $D = m^{[p_2]}(F^{[p_2]}(D, q))$ .

(2) This part of the proposition is clear from the expression of yields. There is equality in the voluntary disclosure case, and strict inequality in the mandatory disclosure, because increasing  $p$  increases the probability of having to disclose bad news.

## Proof of Proposition 1

**Secret Keeping Case.** The first equality is because a run never happens before  $t_0$  and always happens at  $t_0$  if maturity is not reached yet ( $\tau_l$  is either  $t_0$  or  $+\infty$ ). Thus  $P_0 = \mathbb{P}(\tau_\varphi >$



$t_0$ ). To compute expected output, write

$$\mathbb{E}[\text{Output}] = \sum_{t=0}^{t_0-1} \varphi(1-\varphi)^t \mathbb{E}[\text{Output}|\tau_\varphi = t+1] + \mathbb{E}[\text{Output}|\tau_\varphi > t_0] \mathbb{P}(\varphi > t_0).$$

Note that

$$\mathbb{P}(\tau_\varphi > t_0) = (1-\varphi)^{t_0},$$

and

$$\mathbb{E}[\text{Output}|\tau_\varphi > t_0] = V(q_0)$$

by the Markov property and given that  $\mathbf{P}(\tau_\varphi = t+k|\tau_\varphi \geq t) = \mathbf{P}(\tau_\varphi = k)$ . Then

$$\mathbb{E}[\text{Output}|\tau_\varphi = t+1] = \mathbf{y}\Lambda^{t+1}\mathbf{e}_1,$$

and the result obtains by computing the geometric sum.

**Transparency Case.** Note that liquidation occurs in two cases: either maturity is not reached at  $t_1$  or the state switches to  $y^B$  before  $t_1$ . Therefore

$$\begin{aligned} \mathbb{P}(\text{No Run}) &= \mathbb{P}(\tau_\varphi \leq t_1, \tau_l > \tau_\varphi) \\ &= \sum_{t=0}^{t_1-1} \mathbb{P}(\tau_\varphi = t+1) \mathbb{P}(\tau_l > t+1) \\ &= \sum_{t=0}^{t_1-1} \varphi(1-\varphi)^t (1-\lambda)^t \\ &= \varphi \frac{1 - (1-\lambda)^{t_1} (1-\varphi)^{t_1}}{1 - (1-\lambda)(1-\varphi)}. \end{aligned}$$

And

$$\mathbb{E}[\text{Output}] = \sum_{t=0}^{t_1-1} \varphi(1-\varphi)^t \mathbb{E}[\text{Output}|\tau_\varphi = t+1] + \mathbb{E}[\text{Output}|\tau_\varphi > t_1] \mathbb{P}(\varphi > t_1).$$

Now write

$$\begin{aligned} &\mathbb{E}[\text{Output}|\tau_\varphi > t_1] \\ &= \mathbb{E}[\text{Output}|\tau_\varphi > t_1, y_0 = \dots = y_{t_1} = y^G] \mathbb{P}(y_0 = \dots = y_{t_1} = y^G) \\ &+ \mathbb{E}[\text{Output}|\tau_\varphi > t_1, \exists k \leq t_1, y_k = y^B] \mathbb{P}(\exists k \leq t_1, y_k = y^B) \\ &= (1-\lambda)^{t_1} \alpha V(1) + (1 - (1-\lambda)^{t_1}) \alpha V(0). \end{aligned}$$

Similarly,

$$\begin{aligned}
& \mathbb{E}[\text{Output}|\tau_\varphi = t + 1] \\
= & \mathbb{E}[\text{Output}|\tau_\varphi = t + 1, y_0 = \dots = y_{t+1} = y^G]\mathbb{P}(y_0 = \dots = y_{t+1} = y^G) \\
+ & \mathbb{E}[\text{Output}|\tau_\varphi = t + 1, \exists k \leq t, y_k = y^B]\mathbb{P}(\exists k \leq t, y_k = y^B) \\
+ & \mathbb{E}[\text{Output}|\tau_\varphi = t + 1, y_0 = \dots = y_t = y^G, y_{t+1} = y^B]\mathbb{P}(y_0 = \dots = y_t = y^G, y_{t+1} = y^B) \\
= & y^G(1 - \lambda)^{t+1} + (1 - (1 - \lambda)^t)\alpha V(0) + \lambda(1 - \lambda)^t\alpha V(0).
\end{aligned}$$

The result finally obtains by computing the geometric sums.

Figure 1: **Probability  $q_\tau$  to be in state  $y^G$  after  $\tau$  periods of non-disclosure.**

When no information arrives, outsiders' perceived probability to be in the good state decreases and goes to a limit weight. When disclosure is mandatory, this weight is given by the stationary measure of  $(y_t)$ , and is equal to  $\frac{1}{2}$  when  $\lambda_{21} = 1 - \lambda_{11}$ . When disclosure is voluntary, the downgrade is much faster because the bank is increasingly likely to be concealing bad news. The limit weight on state  $y^G$  is very low.

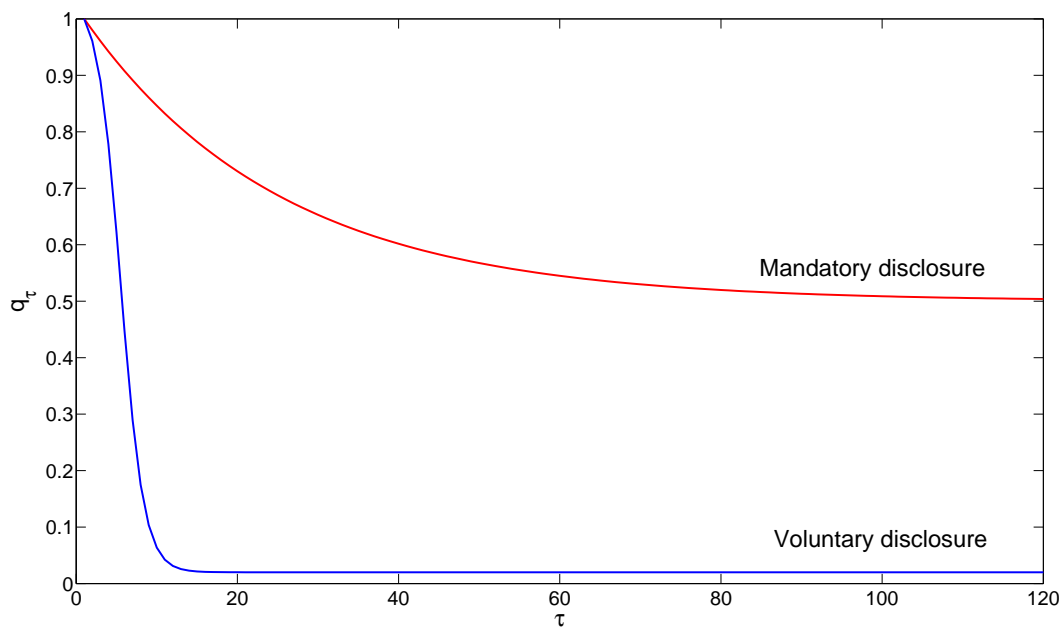


Figure 2: Debt capacities under both regimes.

Under mandatory disclosure, the bank is more robust to long sequences of non-disclosure. If, however, the bank observes the low state and disclosure is mandatory, liquidation occurs immediately. Under voluntary disclosure, the bank may survive and recover.

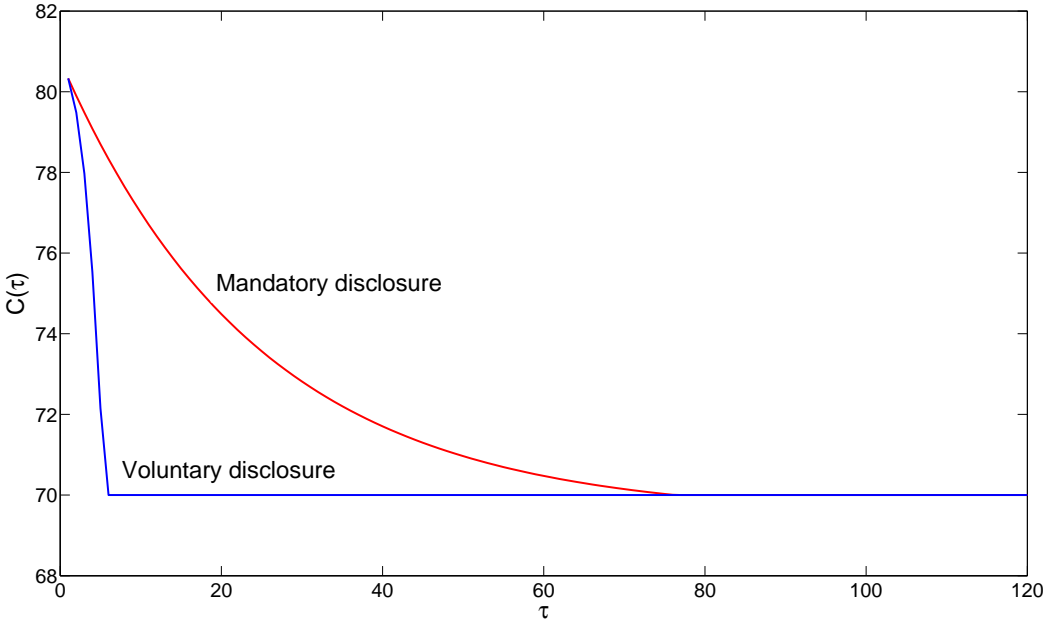


Figure 3: The fair pricing function  $m$  in the voluntary disclosure case when  $\tau = 1$ .

$m$  increases linearly as  $F$  increases and jumps down when there is an additional default state, over which the proportional loss  $1 - \alpha$  is incurred.

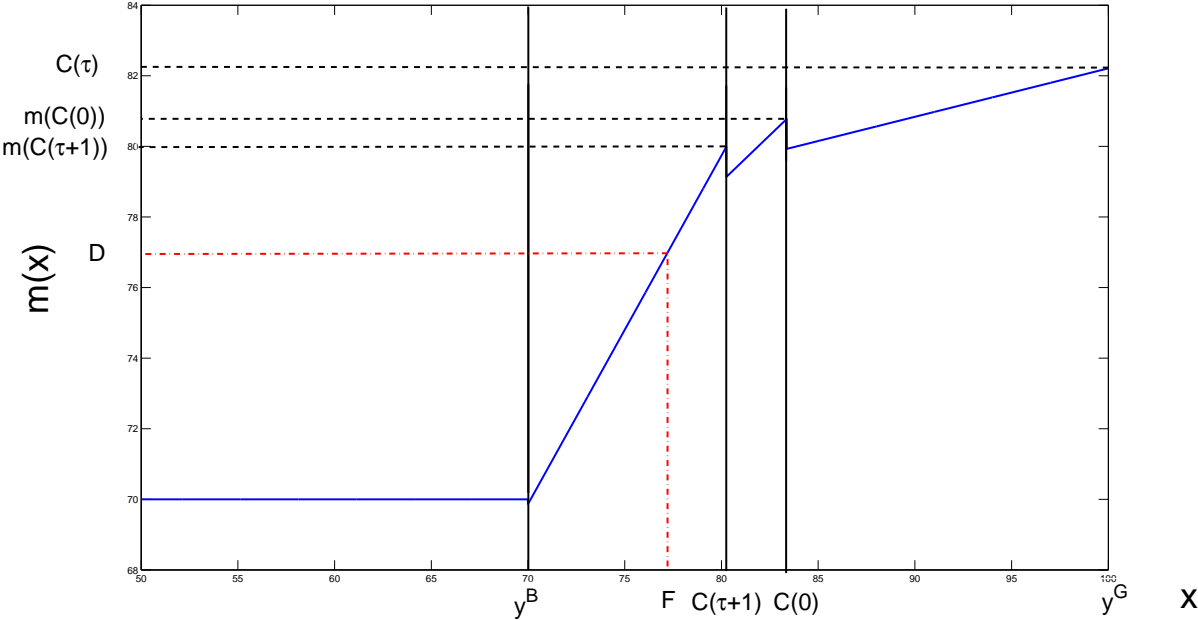


Figure 4: **Bond yields as a function of debt for  $\tau = 1$  under voluntary disclosure.**  
 $\alpha = 0.85, \lambda_{11} = 0.97, \lambda_{21} = 0.03$

When  $D \leq y^B = 70$ , debt is entirely risk-free (*RF*). For moderate values of  $D$ , debt is information insensitive and safe (*II*): debt will be rolled over even absent disclosure tomorrow, unless the asset matures in the bad state. For higher values of  $D$ , debt becomes information sensitive and more risky (*IS*): debt will be rolled over only if good news are disclosed. The pre-liquidation zone corresponds to values of debt so high that they can only be sustained by promising a face value that will only be paid in full if the asset matures in the good state tomorrow. The liquidation zone corresponds to values of debt such that liquidation occurs immediately, that is, values above debt capacity  $C(\tau = 1)$ .

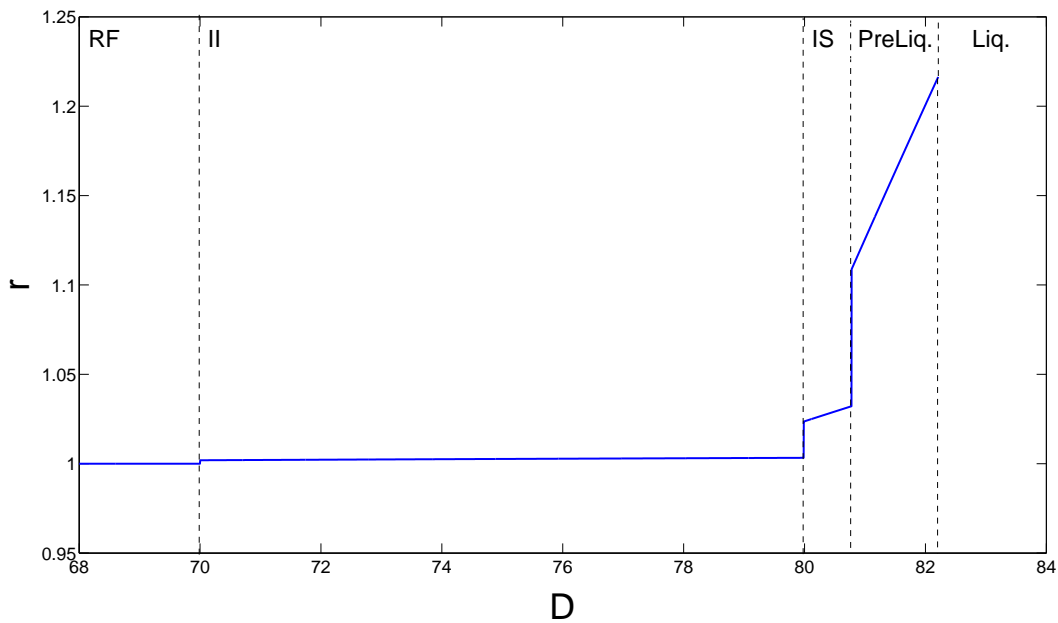


Figure 5: **Bond yields as a function of debt for  $\tau = 4$  under mandatory disclosure.**  
 $\alpha = 0.85, \lambda_{11} = 0.97, \lambda_{21} = 0.03$

Interpretation is similar to Figure 4. When disclosure is mandatory, yields are slightly higher in the short run because the bank could disclose bad news. But good banks are more robust in the long run because investors know it is not possible to conceal bad news.

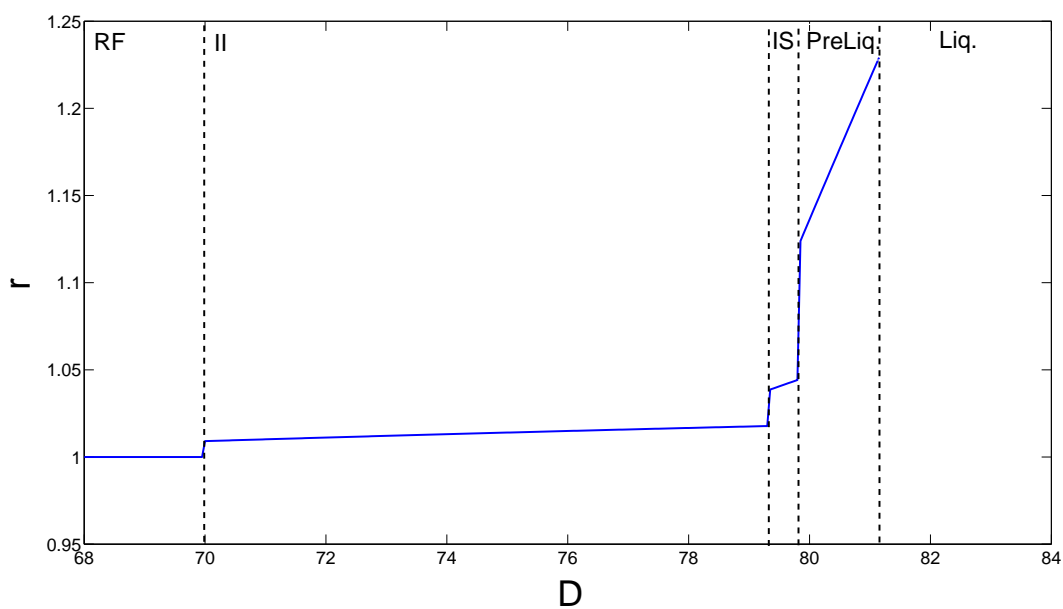


Figure 6: **Debt dynamics in a commitment run.**  $\varphi = 0.02$ ,  $\alpha = 0.85$ ,  $\lambda_{11} = 0.97$ ,  $\lambda_{21} = 0.03$

On this particular path, maturity is  $\tau_\varphi = 43$ , and  $y_t = y^G$  for all  $t \leq \tau_\varphi$ . The difference between the two disclosure regimes is well highlighted. In the short term, while the asset does not go through long periods of non-observability, debt is cheaper under voluntary disclosure. However, at  $t = 21$ , such a long period starts. Since opacity is not credible under voluntary disclosure, debt capacity decreases strongly and triggers a sudden run. Under mandatory disclosure, the bank is resilient and reaches maturity.

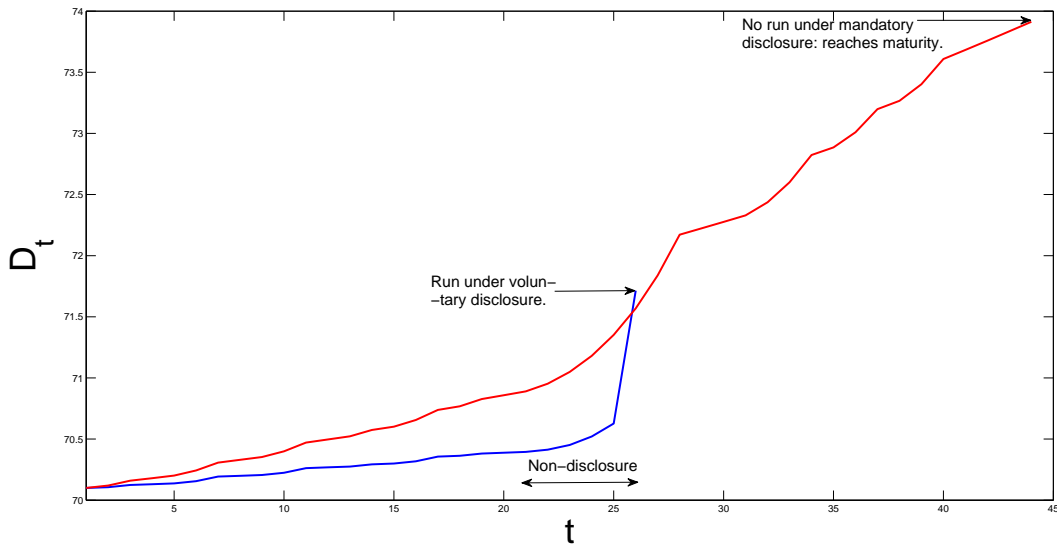




Figure 7: **Debt dynamics in a case where voluntary disclosure has protected the bank.**  $\varphi = 0.02$ ,  $\alpha = 0.85$ ,  $\lambda_{11} = 0.97$ ,  $\lambda_{21} = 0.03$

On this particular path, maturity is  $\tau_\varphi = 92$ , and  $y_t = y^G$  for all  $t \leq \tau_\varphi$ . There were no long periods of non-observability. Hence, the yields were lower under voluntary disclosure. In turn, the debt was easier to sustain and the bank could reach maturity under voluntary disclosure.

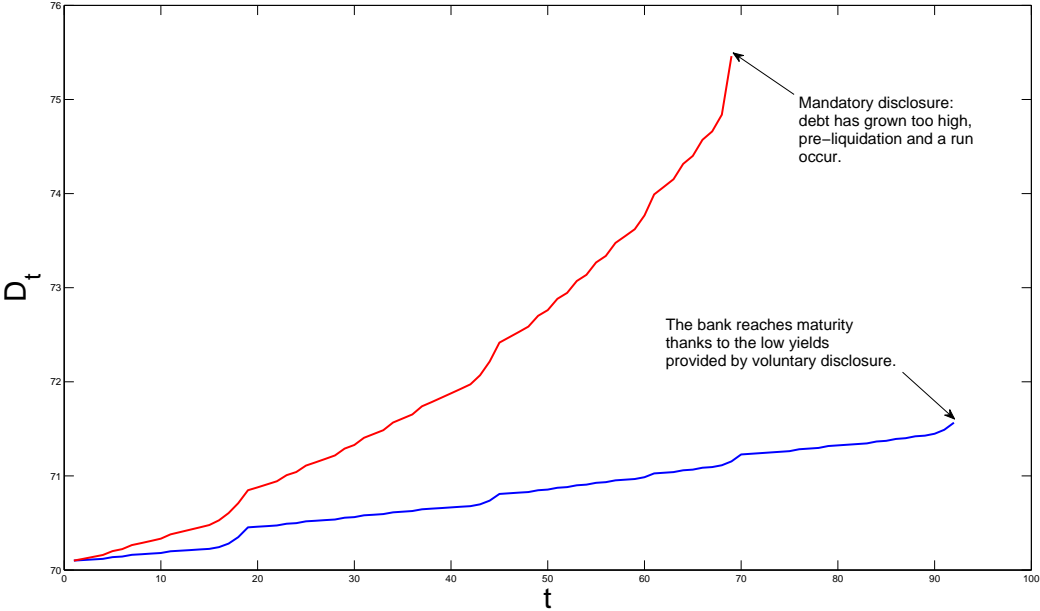


Figure 8: **Time-to-crisis  $t_0$  under full opacity ( $p = 0$ )**

Because of the absence of information for outsiders, the expected value of the asset (the collateral) decreases. At time  $t_0$ , this expected value is no longer high enough to allow for rollover.

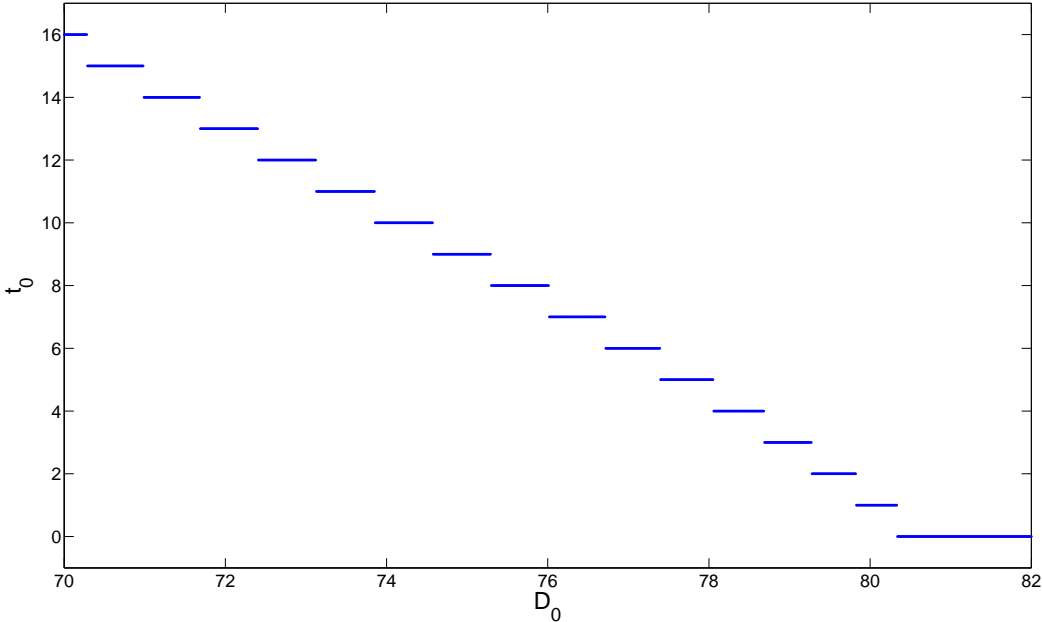


Figure 9: **The dynamics of bond spreads under opacity**

Debt is almost risk-free because of the option to liquidate in the future. If maturity does not occur early enough, spreads suddenly explode before liquidation (at time  $t_0$ , see Figure 8), when the debt level approaches the expected liquidation value.

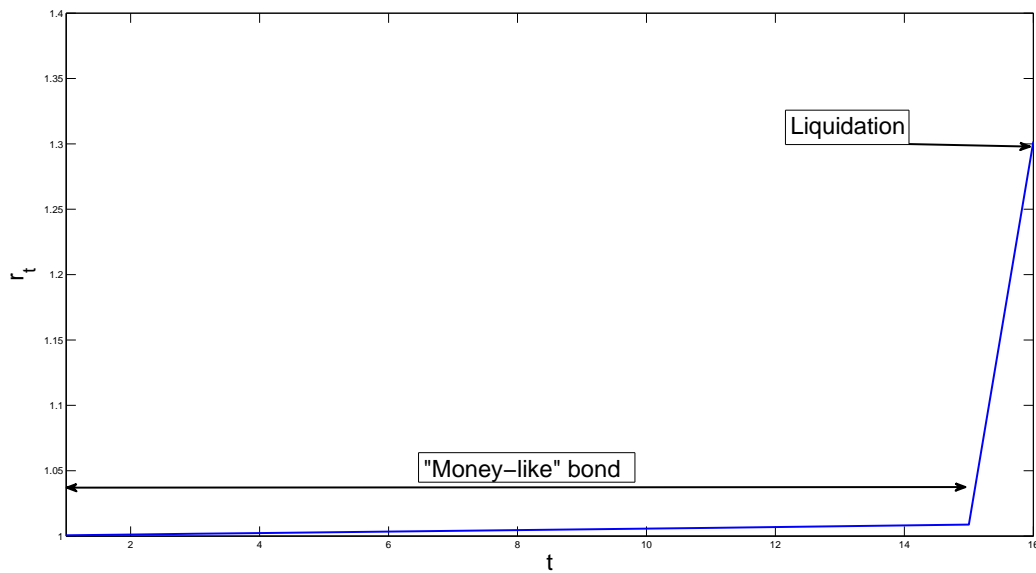


Figure 10: **Efficiency as a function of the liquidity parameter  $\alpha$**

For low  $\alpha$ , the short-term protection of opacity is even shorter, and runs, when they occur on good banks, are particularly harmful in terms of efficiency. Hence, opacity is dominated by transparency for low levels of liquidity.

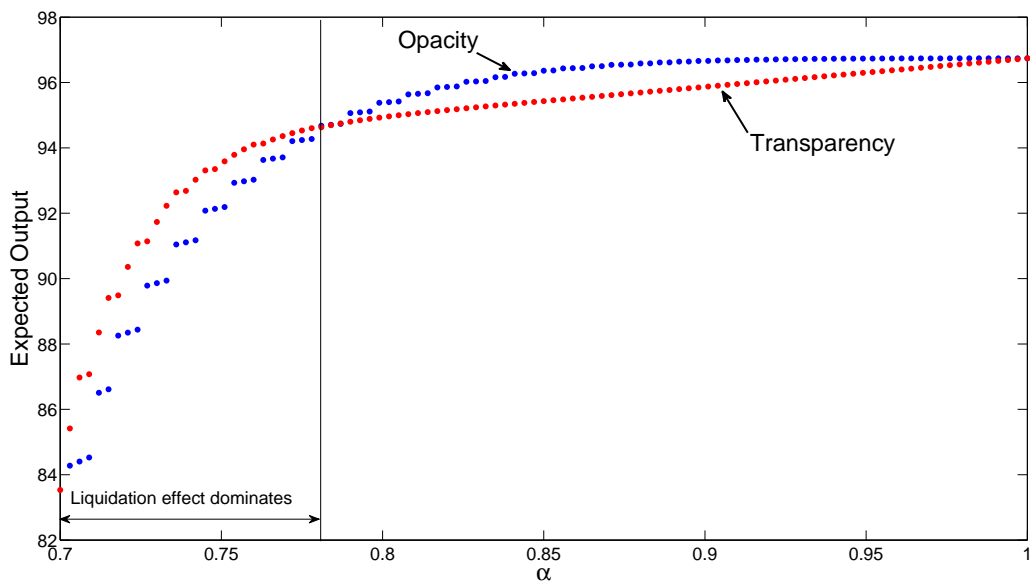


Figure 11: **A case where transparency causes more runs but is nevertheless more efficient.**  $y^B = 0, D_0 = 40$ .

The top panel plots expected output for both disclosure regimes and  $\alpha \in [0.7, 1]$ , the bottom panel plots the run probabilities.

