Procyclical Transparency*

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Abstract

We show that given a bank's risk profile, increasing transparency has a procyclical effect on the level of credit available to the bank to refinance its risky assets. The effect of increased transparency on asset choices tends to be procyclical also, making banks more risk-taking in booms, and more prudent in downturns. The socially desirable level of transparency tends to be procyclical also – in downturns, only if social costs of bank failures are large and the asset returns are moderately sensitive to risk, the socially desirable level of transparency may not be the minimal.

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1 Introduction

The recent global financial crisis has intensified calls for increased bank transparency. The discussions on whether the results of banks' stress-tests suggest should be the publicized suggest, however, that the case for increased transparency is not clear-cut. The purpose of this paper is to provide a simple setting to study the effect of increased bank transparency on the level of credit available to refinance banks' risky assets, on banks' risk taking, and on welfare. Our results suggest a reason for the elusiveness of transparency: its effects vary over the business cycle, even in the absence of any price or collateral effects.

We first show that, given a bank's investment choices, greater disclosure of the quality of the bank's asset portfolio, e.g., publication of stress-test results, has a procyclical effect on creditors' confidence: Disclosure encourages creditors to rollover their debt when the expected returns of the investments are high (i.e., in booms), but discourages debt rollover when the expected returns are low (i.e., in recessions). This is intuitive: when the returns of banks investments are likely to be high, transparency helps spreading the good news to creditors. But if the returns are likely to be low, opacity helps limiting the negative impact of bad news on debt rollover.

We also study the effect of transparency on banks' risk taking incentives. If the expected returns of investments are increasing in the level of risk, transparency has two effects on the incentives to take risk. The first effect is one of the key justifications for increased bank transparency: increased transparency discourages risk taking as it enhances market discipline, making the bank's creditors more sensitive to the bank's risk profile. The second effect is more nuanced: the bank's risk choices may reduce or amplify the effect of transparency on creditors' confidence. In a recession, increased transparency tends to discourage creditors to rollover their debts, which may lead banks to take more risk in order to compensate this effect. In a boom, where increased transparency encourages creditors to rollover their debts, there is less need to compensate withdrawals by risk taking. Hence this second effect reinforces the procyclical effects of increased transparency. If the risk level does not affect the expected returns of banks' investments (e.g., if the riskiness of returns is characterized by a mean-preserving spread), then the first effect is eliminated (the standard argument for transparency), and only procyclical elements remain. In other words, increased transparency may make banks more prudent in downturns, but only if the mean asset returns are moderately sensitive to risk level. [1]

Irrespective of whether increased transparency leads to more or less risk taking, the socially desirable level of transparency is the minimal one in recessions but the maximal one in booms. The reason is that competitive banks' asset choices maximize their creditors' utility, and therefore banks' asset choices are irrelevant for social welfare. Hence transparency has a procyclical effect on welfare solely because it affects creditors' confidence procyclically. We show that these welfare conclusions of bank transparency are fairly robust, even if we add social costs to bank failures or to premature liquidations of banks' assets – only if social costs of bank failures are large and assets' returns are moderately sensitive to risk, the socially optimal level of transparency may not be the minimal one in recessions.[2]

Our model is inspired by the classical bank-run model of Diamond and Dybvig (1983) and is hence related to some work in this tradition, such as Chari and Jagannathan (1988) and Chen (1999) who study the role of creditors' information in generating panic-based bank runs. In particular, Chen and Hasan (2006) show that increased transparency may lead to a bank run which then disciplines banks' risk taking.

There is also a related literature on banking competition where transparency plays an important role. Matutes and Vives (2000) and Cordella and Levy Yeati (2002) study the interaction of deposit insurance and bank transparency. They formalize the standard justification for transparency showing that it enhances market discipline but that a flat premium deposit insurance eliminates the disciplining effect of transparency. Hyytinen and Takalo (2002) study the costs of transparency regulation. They show that if the direct compliance costs of mandatory disclosure regulation are high, or if such regulation warrants disclosure of proprietary information, then banks' incentives to invest in risk-management may be impaired. Our paper also has a connection to the literature studying the desirability of financial disclosure regulation

[1] As we show, assets' returns must be sufficiently sensitive to the level of risk in order to render risk taking as a decreasing function of transparency in downturns. However, if assets' returns are very sensitive to risk, banks will always choose a maximal level of asset risk irrespective of the degree of transparency.

[2] The conditions generating this special case might nonetheless be most relevant in practice.

and voluntary information disclosure – see, e.g., Admati and Pfleiderer, 2000, and Boot and Thakor, 2001.

Since transparency almost by definition hints at problems of incomplete information, and since banks are inherently vulnerable to self-fulfilling runs, theoretical models of bank transparency easily generate multiple equilibria, which often renders comparative statics and welfare analyses inconclusive. For example, while the literature on bank runs has been influential in pointing out the importance of condidence and its dependence on the expectations of banks' lenders, does not allow an assessment of the vulnerability of confidence. In our set up, standard results from the theory of global games guarantee the existence of a unique equilibrium. This allows us to compute the volume of withdraws and relate this amount to the exogenous parameters of the model, facilitating comparative statics and welfare analyses exercises. In this respect, our paper is closely related to the papers that use global game methodology to study the problems of banking and lending such as Rochet and Vives (2004), Goldstein and Pauzner (2005), Morris and Shin (2006), and Plantin, Sapra, and Shin (2008). Moreover, there is also a link to the global game literature studying the value of public information stemming from Morris and Shin (2002).

Of course, that increased transparency might cause procyclical effects is not a new idea, although the recent crisis brought the issue to the fore. For example, the crisis prompted a large literature on the role of credit rating agencies and fair-value accounting where the notion of procyclical transparency has been recognized (see, e.g., Plantin et al. 2008, Laux and Leuz, 2009, and Shaffer, 2010). However, the procyclical effects of transparency have typically been associated with excessive price volatility. For example, fair-value accounting combined with collateral or capital adequacy requirements may enable banks to leverage and make larger investments in booms, which raises asset prices further, but may prompt deleveraging and firesales in downturns, depressing asset prices. In our model the procyclical effects arise even if asset transactions cause no price effects and the investment size is invariant. We also show that the transparency can generate a procyclical effect on the banks' asset choices, and that the socially optimal level of transparency is procyclical.

The paper is organized as follows. In Section 2 we layout the basic setting, solve for the equilibrium of the creditors game, and characterize the equilibrium taking as given the banks' asset choices. In Section 3 we study the impact of transparency on asset risk taking. In Section 4 we characterize the socially optimal level of transparency. Section 5 concludes.

2 The Model

We consider a competitive bank whose illiquid asset portfolio is funded by short-term debt that needs to be rollover. In the basic set up we take the bank's asset choice given, but we endogenize it in Section 3. In order to introduce the coordination aspect, as an ingredient often present in models of banking, we assume that there is a continuum of risk neutral creditors, each with one unit of uninsured credit. We normalize to one the measure of creditors. The bank invests its funds in an asset that at maturity pays a return of $1 + R > 1$ with probability p and zero with probability $1 - p$, where p is drawn from a uniform distribution on $[1 - \mu, 1]$. Thus, the return of the asset at maturity,

$$Q = (1 + R)\, p,$$

is distributed uniformly $[(1 - \mu)(1 + R), 1 + R]$, and the the mean return is

$$\bar{Q} = (1 + R)\, \rho(\mu),$$

where $\rho(\mu) = 1 - \mu/2$ is the mean probability of success. In this setting $\mu \in (0, 1)$ captures the level of risk of the asset: the larger μ the more likely it is that the asset pays no return. (Naturally the asset's returns R will generally depend on μ. We deal with this issue in Section 3 below).

A fraction of creditors, h, are *active* and may not rolleover their credits until the asset matures. The remaining fraction $1 - h$ of creditors mantain their unit of credit until the asset matures, and therefore play a passive role. Henceforth we refer to the active creditors simply as creditors. (Although the assumption that only a fraction h of creditors are active is made technical reasons, it captures the fact that some of the bank's loans, e.g. long-term retail deposits, are stickier than others, e.g. wholesale funding from the overnight interbank market.)

Each creditor observes a noisy signal of the realized probability of success p,

$$s_i = p + \eta_i,$$

where the noise terms η_i are independently and uniformly distributed on $[-\varepsilon, \varepsilon]$. Then each creditor decides whether or not to *rollover* her credit.

We may identify the level of transparency with a more precise signal of the probability that the asset will pay a positive return, i.e., with variations in the value of ε that determines the support of the creditors signals around the realized probability of success p. The feasible levels of transparency are those of the interval $[\underline{\varepsilon}, \bar{\varepsilon}]$, where $0 < \underline{\varepsilon} < \bar{\varepsilon}$. Alternative levels of transparency may result from specific regulation on information disclosure of the banks' assets, e.g.., from the disclosure policy of stress-tests of banks. [3]

We assume that a bank's asset (portfolio) is divisible and can be liquidated before maturity to pay the creditors who do not rolleover. Such liquidations of assets before maturity are costly: one unit of the asset liquidated before its maturity yields $\lambda < 1$ monetary units. We assume that $\bar{Q} > 1 > \lambda > h$. This assumption implies, first, that it is never efficient to liquidate the asset ($\bar{Q} > 1 > \lambda$) and, second, that the bank is always liquid ($\lambda > h$). In other words, even if a signifant fraction of creditors refuses to rollover, it cannot lead to a bank failure. In our model a bank fails only when its asset is not successful (i.e., with probability $1 - p$).

The Creditors Game

The timing of the game that (active) creditors face is as follows: (i) The banks offer credit contracts. ii) Nature draws the success probability p from $[1 - \mu, 1]$. (iii) Each creditor observes a noisy signal s of the realized p, and then decides whether or not to rollover her credit. (iv) The returns are realized and the creditors are compensated according to the credit contract.

Following the tradition of Diamond and Dybvig (1983) we focus on contracts where each creditor will get at least her money back if she does not rolleover her credit. Such creditors will thus get more than the liquidation value of the asset at the expense of those who wait until maturity. However, in contrast to the standard bank run models, our creditors are risk neutral and, hence, risk-sharing among creditors is not

[3] The literature that studies the value of public information following Morris and Shin (2002) introduce a noisy public signal in addition to a similar private signal which we have. Because in our set up adding such a noisy public signal of p does not yield additional insights, we work directly with ε.

an issue. In other words, in contrast to the standard bank run model, rollingover is always efficient as in our model there are no "impatient" creditors . Then, competition forces the banks to offer a contract where each creditor gets 1 if she does not rolleover, and the full asset's return to a creditor who rolls over. That is, the creditors who wait become residual claimants as in Diamond and Dybvig (1983). [4]

A creditor's payoff u depends on her *signal* of the probability of success $s \in [p-\varepsilon, p+\varepsilon]$, her *expectation* of the fraction of the other creditors who do not rolleover, $x \in [0, h]$, and her *decision* whether or not to rollover $a \in \{1, 0\}$. Since $x \leq h$ and $h < \lambda$[5] by assumption, a creditor who does not rolleover her credit ($a = 0$) gets back her monetary unit independently of her signal s and the fraction of creditors who do not rollover x; i.e.,

$$u(s, x, 0) = 1.$$

A creditor who rolls over her credit, however, must share the expected returns of the non-liquidated assets with the other creditors who maintain their credit (either because they are not active or because they rollover their credits), and therefore her expected payoff is

$$u(s, x, 1) = E\left(\left. \frac{\left(1 - \frac{x}{\lambda}\right) Q}{1 - x} \right| s \right).$$

Thus, the creditors who rollover effectively assume the liquidation costs necessary to pay those who do not rollover.

We assume that each creditor follows a simple *switching strategy* consisting of (not) rolling over whenever her signal of the probability that the asset will pay a positive return is (below) above a threshold $t \in [1 - \mu - \varepsilon, 1 + \varepsilon]$; i.e., a strategy for a creditor is a threshold specifying the lowest signal for which a creditor rolles over.

[4] Alternatively, we could think, e.g. in line with Rochet and Vives (2004), that the game begins from a situation where all the creditors are at the banks and their nominal value if they do not rolleover is pre-determined and normalized to unity. The banks would then compete for renewals of these credits by offering rates of returns for those that rolleover until maturity. In that case we should assume that if a creditor is indifferent between an offer from her existing bank and from its rival, she will stay at her existing bank.

[5] The assumption $h < \lambda$ simplifies the analysis of the game faced by active creditors as it implies that the bank is liquid (i.e., is able to pay early withdraws). Note that the bank fails if the realized return of the asset is zero.

An *equilibrium* of the game is a profile of thresholds such that an agent that receives a signal (below) above her threshold optimally (does not) rollover. Our analysis of the creditors game uses the theory of global games as developed by, e.g., Morris and Shin (2001). Applying this theory we obtain conditions that guarantee that the creditors game has a unique equilibrium, and that this equilibrium is symmetric. A symmetric equilibrium is easily described.

Assume that all creditors follow the same threshold strategy t. A creditor who receives signal s beliefs that the signals of the other creditors , $s_i \mid s$, are distributed uniformly on $[s-2\varepsilon, s+2\varepsilon]$. Thus, the creditor may calculate the fraction of creditors he expect not to rollover as

$$\begin{aligned} x(s,t) &= h \Pr(s_i < t \mid s) \\ &= h \int_{s-2\varepsilon}^{t} \frac{dy}{4\varepsilon} = h \left(\frac{1}{2} + \frac{t-s}{4\varepsilon} \right). \end{aligned}$$

The threshold t is a *symmetric equilibrium threshold* if

$$u(s, x(s,t), 1) \leq u(s, x(s,t), 0)$$

whenever $s < t$, and

$$u(s, x(s,t), 1) \geq u(s, x(s,t), 0)$$

whenever $s > t$. Since

$$u(s, x(s,t), 1) = E\left((1 - x(s,t)/\lambda)\, Q/1 - x(s,t) \middle| \, s \right)$$

is increasing in the singal s, and $u(s, x(s,t), 0) = 1$, then an *interior* symmetric equilibrium threshold $t \in (1-\mu, 1)$ must leave a creditor whose signal is equal to t indifferent between rolling over or not; i.e., t must satisfy

$$E\left(\frac{\left(1 - \frac{x(t,t)}{\lambda}\right) Q}{1 - x(t,t)} \middle| \, s \right) = 1. \tag{1}$$

Equation 1 characterizes the equilibrium of the creditors game.

Dominance Regions

In order to apply the theory of global games one must guarantee the existence of *dominance* or *contagious regions* with extremely large and small expected asset returns, in which agents behavior depends solely on their signal, and not on the strategies of the other agents. The existence of these extreme regions implies that the creditors game has a unique equilibrium, and that this equilibrium is symmetric and interior. We derive some parameter restrictions that guarantee the existence of these regions.

The existence of an *upper dominance* region requires that there be an interval of values for the probability of success sufficiently high that a creditor's optimal action is to rollover her deposit, even if all the other active creditors do not rollover her credits. The payoff to rolling over when a fraction $x = h$ of creditors do not rollover is $\left(1 - \frac{h}{\lambda}\right) Q / (1 - h)$ which can be written as

$$\frac{(\lambda - h)(1 + R)}{\lambda (1 - h)} p.$$

And the payoff to not rolling over is equal to 1. Hence the existence of an upper dominance region requires the existence of $p_u < 1$ such that for $p \in (p_u, 1]$ the inequality

$$\frac{(\lambda - h)(1 + R)}{\lambda (1 - h)} p > 1 \tag{2}$$

holds. Define

$$p_u := \frac{\lambda (1 - h)}{(\lambda - h)(1 + R)}.$$

If we assume that the inequality

$$\frac{\lambda(1 - h)}{\lambda - h} < 1 + R. \tag{3}$$

holds, then $p_u < 1$, and condition (2) holds for each $p \in (p_u, 1]$.

Note that our assumption $\bar{Q} > 1$ implies $1 + R > 1$, and therefore the inequality (3) holds if $\lambda = 1$. But this is a trivial case in which there are no externalities in the actions of creditors: when $\lambda = 1$ the return to a creditor is Q independently of the measure of creditors that rollover their deposits.

The existence of a *lower dominance* region requires that there be an interval of values for the probability of success sufficiently low that a creditor's optimal action is to rollover even if everyone else rolls over. The payoff to rolling over when the fraction of creditors who do not rollover is zero ($x = 0$) is $(1 + R)p$, and the payoff to not rolling over is equal to 1. Hence the existence of an lower dominance region requires the existence of $p_l > 1-\mu$ such that for $p \in [1-\mu, p_l)$ the inequality

$$(1+R)p < 1. \tag{4}$$

holds. Define

$$p_l := 1-\mu + \frac{1-(1+R)(1-\mu)}{2(1+R)}.$$

If we assume that the inequality

$$(1+R)(1-\mu) < 1 \tag{5}$$

holds, then $p_l > 1-\mu$, and for $p \in [1-\mu, p_l)$ we have

$$\begin{aligned}(1+R)\,p &\leq (1+R)\,p_l \\ &= (1+R)\left(1-\mu+\frac{1-(1+R)(1-\mu)}{2(1+R)}\right) \\ &= \frac{1}{2}\left((1+R)(1-\mu)+1\right) < 1.\end{aligned}$$

Hence when condition (4) holds.

Equilibrium of the Depositor Game

Henceforth we assume that conditions (3) and (5) hold. Then the creditors' game has a unique equilibrium, which is symmetric. This equilibrium is interior and symmetric, and is therefore identified by a common threshold t that solves the equilibrium condition (1). Since

$$x(t,t) = h\left(\frac{1}{2}+\frac{t-t}{4\varepsilon}\right) = \frac{h}{2},$$

the equilibrium condition (1) may be written as

$$\frac{2\lambda - h}{(2-h)\,\lambda}E(Q|\,t) = 1.$$

For our distributional assumptions we have

$$E(Q|\,t) = (1+R)\,t.$$

Hence the equilibrium threshold t solves the equation

$$\frac{2\lambda - h}{(2-h)\,\lambda}(1+R)\,t = 1; \tag{6}$$

i.e.,

$$t^{*} = \frac{(2-h)\,\lambda}{(2\lambda - h)\,(1+R)}. \tag{7}$$

Note that condition (3) implies $t^{*} < 1$, and that (5) implies $t^{*} > 1-\mu$; i.e., $t^{*} \in (1-\mu, 1)$.

The equilibrium fraction of creditors who do not rollover is

$$x^{*} = h\int_{1-\mu-\varepsilon}^{t^{*}} \frac{ds}{\mu+2\varepsilon} = h\frac{\mu+\varepsilon-(1-t^{*})}{\mu+2\varepsilon}. \tag{8}$$

Note that $t^{*} < 1$ implies $x^{*} < h$, and $t^{*} > 1-\mu$ implies $x^{*} > 0$; i.e., $x^{*} \in (0, h)$.

Asset's Return and the State of the Economy

The asset's return may depend upon aggregate factors, as well as the level of risk, that are described by the state of the economy. If we want to evaluate the impact of transparency taking into account whether the economy is in a boom (i.e., when assets mean return is high), or in a recession (i.e., when assets mean return is low), we may want to identify the levels of the mean return associated to these states of the economy.

Recall that the equilibrium threshold t^{*} is the value of the probability that the asset will pay its return that leaves the creditor indifferent between withdrawing and rolling over. When the mean returns of the asset is exactly

$$\hat{Q} = \frac{(2-h)\,\lambda}{(2\lambda - h)},$$

then the equilibrium threshold is simply $\rho(\mu) = 1-\mu/2$, i.e., the creditor withdraws (rolls over) if her signal of p is below or (above) the average probability $\rho(\mu)$. Also for this mean return $\hat{Q}$ the measure of active creditor who do not rollover is $x^{*} = h/2$; i.e., exactly half of the active creditors rollover. We therefore take $\hat{Q}$ is an obvious critical value to distinguish between booms and recessions; i.e., we associate booms (recessions) with the states where the mean return Q is above (below) $\hat{Q}$.

3 Transparency and Refinancing Risk

The effect of variations of ε on the banks' liability side is measured by its impact on *refinancing risk;* i.e., by the derivative $\partial x^*/\partial\varepsilon$. From (8) we get

$$\frac{\partial x^*}{\partial \varepsilon} = \frac{h\left(2\left(1-t^*\right)-\mu\right)}{\left(\mu+2\varepsilon\right)^2}.$$

Substitution t^* from (7) yields (after some algebra)

$$\frac{\partial x^*}{\partial \varepsilon} = \frac{2h}{\left(\mu+2\varepsilon\right)^2\left(1+R\right)}\left(\left(1+R\right)\left(1-\frac{\mu}{2}\right)-\frac{\left(2-h\right)\lambda}{\left(2\lambda-h\right)}\right).$$

Since $\left(2-h\right)\lambda/\left(2\lambda-h\right)=\hat{Q}$ and $\left(1+R\right)\left(1-\frac{\mu}{2}\right)=\left(1+R\right)\rho\left(\mu\right)=\bar{Q}$, we can write

$$\frac{\partial x^*}{\partial \varepsilon} = \frac{2h\left(\bar{Q}-\hat{Q}\right)}{\left(\mu+2\varepsilon\right)^2\left(1+R\right)}.$$

Hence

$$\frac{\partial x^*}{\partial \varepsilon} \gtreqless 0 \Leftrightarrow \bar{Q}-\hat{Q} \gtreqless 0.$$

Thus, increasing transparency (i.e., decreasing ε) facilitates refinancing (i.e., decreases the fraction of creditors who do not rollover) when the mean return is high relative to $\hat{Q}$ (i.e., in booms), but worsens refinancing possibilities if returns are low (i.e., in recessions).

Proposition 1. *For a given the level of risk μ, increasing transparency may mitigate or worsen refinancing risk depending on whether asset's mean return is high or low relative to $\hat{Q}$.*

Note that $1-x^*$, the fraction of creditors that roll over, may also be interpreted as the measure of creditors' *confidence* on banks. Proposition 1 thus suggests that greater transparency may have positive or negative effect on creditors' confidence depending on whether the asset's mean return is high or low relative to $\hat{Q}$. Note also that $\hat{Q}$ is increasing in h and decreasing in λ; i.e., transparency is less likely to have a positive effect on confidence (refinancing) when the fraction of active creditors is high or the liquidation value of assets is low.

Welfare Analysis

Let us assume that a Financial Supervision Authority (FSA) regulates the level of transparency in order to maximize social welfare. Since competitive banks promise the full asset returns to creditors, social welfare W only consists of creditors' utility, and is hence given by

$$W(\varepsilon, \mu) = E\left[x^* + \left(1 - \frac{x^*}{\lambda}\right) Q\right] = x^* + \left(1 - \frac{x^*}{\lambda}\right) \bar{Q}.$$

Here x^* represents the payoff of the creditors who do not rollover and get their unit deposit (recall that $x^* < h < \lambda$), and $(1 - x^*/\lambda)\, Q$ represents the return of the non-liquidated assets, which are shared by creditors who rollover. The FSA's problem is thus

$$\max_{\varepsilon \in [\underline{\varepsilon}, \bar{\varepsilon}]} W(\varepsilon, \mu),$$

where $\underline{\varepsilon}$ and $\bar{\varepsilon}$ represent the minimum and maximum feasible levels of transparency.

We have

$$\frac{\partial W}{\partial \varepsilon} = -\frac{(\bar{Q} - \lambda)}{\lambda} \frac{\partial x^*}{\partial \varepsilon}.$$

Since $Q > 1 > \lambda$, the sign of $\frac{\partial W}{\partial \varepsilon}$ is given by the the sign of $-\frac{\partial x^*}{\partial \varepsilon}$. Proposition 1 then implies that W is either decreasing or increasing in ε depending on whether $\bar{Q} - \hat{Q}$ is positive or negative. Hence the socially optimal level transparency is either the maximal $\varepsilon^* = \underline{\varepsilon}$ or the minimal $\varepsilon^* = \bar{\varepsilon}$.

Proposition 2. *For a given the level of risk μ, the socially optimal level of transparency is either the maximal level or the minimal level feasible depending on whether the asset's mean return is high or low relative to $\hat{Q}$.*

An advantage of our model is that it naturally yields the critical value of asset returns, $\hat{Q}$, that distinguishes booms and recession without need to resort to separate variables capturing the state of the economy. However, one may wonder what is the optimal level of transparency through the cycle. Answering the question fully would require embedding a theory of business cycle into our model and is hence beyond the scope of this study. But since $\hat{Q}$ is increasing in h and decreasing in λ, we can anticipate that maximal transparency is more likely to be optimal if the fraction of active creditors is low or if the liquidation value of assets is high.

4 Transparency and Asset Risk Taking

So far we have taken the riskiness of banks' asset portfolio as given. Let us now allow the banks choose the level of asset risk, μ, and write the asset return, conditional on success, explicitly as a function μ as $1 + R(\mu)$, and the mean asset return as

$$\bar{Q}(\mu) = (1 + R(\mu))\,\rho(\mu)\,.$$

In order to guarantee the existence of an lower dominance region, we assume that

$$(1 + R(\mu))(1 - \mu) < 1$$

for $\mu \in [0,1]$. Also we assume that the asset return satisfies that the mean return is non-decreasing in the level of risk μ (i.e., $\bar{Q}' \geq 0$) which implies that $R' > 0$ (recall that $\rho(\mu) = 1 - \mu/2$). In words, choosing a riskier asset involves a lower expected probability of success but higher returns conditional on success. An important special case is when the mean asset's return is not affected by the level of risk, i.e., $\bar{Q}' = 0$ (e.g., when riskiness of the asset returns is characterized by a mean-preserving spread).

As before, competition forces banks to pay the actual return of the asset in full to the creditor. Now, competition also forces the banks to choose the asset μ that maximizes the creditors' welfare. Using our results in the previous section, for $\mu \in [0,1]$ the (ex-ante) expected welfare of creditors, denoted by $V(\mu)$, is

$$V(\mu) = E\left[x^* + \left(1 - \frac{x^*}{\lambda}\right)Q\right] = x^* + \left(1 - \frac{x^*}{\lambda}\right)\bar{Q}.$$

Here x^* represents the measure of creditors who do not rollover and get their unit deposit (recall that $x^* < h < \lambda$). The creditors who rollover get the returns of the non-liquidated assets, $(1 - x^*/\lambda)\,Q$.

Thus, in equilibrium μ^* solves the problem

$$\max_{\mu \in [\underline{\mu}, \bar{\mu}]} V(\mu).$$

The first order condition for a maximum is

$$\frac{dV}{d\mu} = \frac{1}{\lambda}[(\lambda - x^*)\,\bar{Q}' - (\bar{Q} - \lambda)\frac{\partial x^*}{\partial \mu}] = 0. \tag{9}$$

Since $x^* \leq h < \lambda$ and $\bar{Q}' \geq 0$, the banks' problem has an interior solution only if

$$\frac{\partial x^*}{\partial \mu}(\bar{Q} - \lambda) \geq 0. \tag{10}$$

If (10) does not hold, or if $\bar{Q}'$ is very high, then the creditors' welfare is increasing in the level of risk, i.e., $V'(\mu) > 0$, and therefore a competitive bank will choose the maximal level of risk, i.e., $\mu^* = \bar{\mu}$. Note that if $\bar{Q}' = 0$, then the interior solution is given by $\partial x^*/\partial \mu = 0$.

We proceed under the assumption that an interior solution exists. Of course, welfare maximization also requires that a second order condition hold i.e., that

$$\frac{d^2 V}{d\mu^2} \leq 0. \tag{11}$$

Let us consider the impact of transparency regulation on the level of the risk chosen by banks. Since in equilibrium banks maximize the creditors' welfare, in an interior equilibrium the level of asset's risk μ^* solves

$$\frac{\partial V}{\partial \mu} = 0.$$

Hence

$$\frac{\partial V^2}{\partial \mu^2} d\mu + \frac{\partial V^2}{\partial \mu \partial \varepsilon} d\varepsilon = 0,$$

and therefore

$$\frac{d\mu^*}{d\varepsilon} = \frac{\partial V^2}{\partial \mu \partial \varepsilon}\left(-\frac{\partial V^2}{\partial \mu^2}\right)^{-1}.$$

Moreover, assuming that second order condition for welfare maximization holds, i.e.,

$$\frac{\partial V^2}{\partial \mu^2} \leq 0,$$

then the sign of impact of changes in the level of transparency ε on the level of risk chosen by the banks μ is

$$sign\left(\frac{d\mu^*}{d\varepsilon}\right) = sign\left(\frac{\partial V^2}{\partial \mu \partial \varepsilon}\right).$$

From (9) we get that

$$\frac{\partial^2 V}{\partial \mu \partial \varepsilon} = -\frac{1}{\lambda}\left(\frac{\partial x^*}{\partial \varepsilon}\bar{Q}' + \frac{\partial^2 x^*}{\partial \mu \partial \varepsilon}\left(\bar{Q} - \lambda\right)\right), \tag{12}$$

and from (8) that

$$\frac{\partial x^*}{\partial \varepsilon} = h\frac{2(1-t^*)-\mu}{(\mu+2\varepsilon)^2}, \tag{13}$$

$$\frac{\partial x^*}{\partial \mu} = h\frac{\varepsilon+(1-t^*)+\frac{\partial t^*}{\partial \mu}(\mu+2\varepsilon)}{(\mu+2\varepsilon)^2}, \tag{14}$$

and

$$\frac{\partial^2 x^*}{\partial \mu \partial \varepsilon} = h\frac{\mu-2\varepsilon-4(1-t^*)-2\frac{\partial t^*}{\partial \mu}(\mu+2\varepsilon)}{(\mu+2\varepsilon)^3}. \tag{15}$$

Substituting (13) and (15) for (12) and rearranging yields

$$\frac{\partial^2 V}{\partial \mu \partial \varepsilon} = \frac{hA}{\lambda(\mu+2\varepsilon)^3},$$

where

$$A = (2(1-t^*)-\mu)\left[\left(\bar{Q}-\lambda\right)-(\mu+2\varepsilon)\bar{Q}'\right]+2\left(\bar{Q}-\lambda\right)\left[\varepsilon+(1-t^*)+\frac{\partial t^*}{\partial \mu}(\mu+2\varepsilon)\right]. \tag{16}$$

Then, substituting (14) and (8) for (9) and simplifying yields

$$\left(\lambda-h\frac{\mu+\varepsilon-(1-t^*)}{\mu+2\varepsilon}\right)\bar{Q}' = (\bar{Q}-\lambda)h\left(\frac{\varepsilon+(1-t^*)+\frac{\partial t^*}{\partial \mu}(\mu+2\varepsilon)}{(\mu+2\varepsilon)^2}\right),$$

i.e.,

$$\left(\frac{\lambda}{h}(\mu+2\varepsilon)-(\mu+\varepsilon-(1-t^*))\right)(\mu+2\varepsilon)\bar{Q}' = (\bar{Q}-\lambda)\left[\varepsilon+(1-t^*)+\frac{\partial t^*}{\partial \mu}(\mu+2\varepsilon)\right]. \tag{17}$$

Inserting (17) into (16) and simplifiying yields

$$A = \frac{(\mu+2\varepsilon)^2}{h}(2\lambda-h)\bar{Q}' + \left(\bar{Q}-\lambda\right)(2(1-t^*)-\mu),$$

which, by (13), is equivalent to

$$A = \frac{(\mu+2\varepsilon)^2}{h}\left[(2\lambda-h)\bar{Q}' + \left(\bar{Q}-\lambda\right)\frac{\partial x^*}{\partial \varepsilon}\right]$$

Thus,

$$sign\left(\frac{d\mu^*}{d\varepsilon}\right) = sign\left[(2\lambda-h)\bar{Q}' + \left(\bar{Q}-\lambda\right)\frac{\partial x^*}{\partial \varepsilon}\right]. \tag{18}$$

Since $1 > \lambda > h$, then $2\lambda - h > \lambda > 0$. Therefore, if $\bar{Q}' > 0$, then the first term on the right hand side of (18) is positive. And since $\bar{Q} > 1 > \lambda$, the sign of the second term on the right hand side of (18) is determined by the sing of $\partial x^*/\partial\varepsilon$ (which recall is equal to the sign of $\bar{Q}-\hat{Q}$). If $\bar{Q}-\hat{Q}>0$, then both terms defining the sign of $d\mu^*/d\varepsilon$ are positive, and so is $d\mu^*/d\varepsilon$. If $\bar{Q}-\hat{Q}<0$, however, then the sign of $d\mu^*/d\varepsilon$ is ambiguous. An interesting particular case is when the mean asset's return is not affected by the level of risk, i.e., $\bar{Q}'=0$, and the return of the asset is low (relative to $\hat{Q}$), i.e., $\bar{Q}-\hat{Q}<0$. In this case $d\mu^*/d\varepsilon<0$; i.e., increasing the level of transparency (i.e., decreasing the value of ε) results in more risk taking by bank.

Proposition 3. *If the mean return is high relative to $\hat{Q}$, then the level of risk decreases with the level of transparency (i.e., $d\mu^*/d\varepsilon>0$). If the mean return is low relative to $\hat{Q}$, then the impact of transparency on the level of risk is ambiguous; in particular, if the sensitivity of the mean return to the level of risk $\bar{Q}'$ is small, then the level of risk may increase with the level of transparency (i.e., $d\mu^*/d\varepsilon<0$).*

Recall that risk taking (higher μ) is associated with a larger probability of a bank failure in our model. Thus, Proposition 3 implies that effects of transparency on risk taking are procyclical in the sense that greater transparency implies less risk taking (less bank failures) in booms but more risk taking (more bank failures) in recessions except for the case when asset returns are sufficiently sensitive to the risk level to render (18) positive even when $\bar{Q}-\hat{Q}<0$. Note from (9), however, that if the asset returns are very sensitive to the risk level, the banks will choose the maximal level of risk, i.e., $\mu^*=\bar{\mu}$, irrespective of the level of transparency.

Transparency, Risk Taking, and Refinancing

As above, we identify changes in the level of transparency with variations in the value of ε. Note that now a change in the level of transparency has a *direct effect* on a bank's refinancing risk through its impact of the measure of creditor who do not rollover given the banks' asset risk choice, but also has an *indirect effect* as it influences the banks' asset risk choice. That is,

$$\frac{dx^*}{d\varepsilon}=\frac{\partial x^*}{\partial\varepsilon}+\frac{\partial x^*}{\partial\mu}\frac{d\mu^*}{d\varepsilon}.$$

By Proposition 1, the sing of the direct effect $\partial x^*/\partial\varepsilon$ may be either positive or negative depending on whether $\bar{Q}$ is larger or smaler than $\hat{Q}$. As for sign of the indirect effect, there are two cases to consider. First, if the mean asset returns are very sensitive to risk level ($\bar{Q}'$ is very large) or if (10) does not hold, the banks will choose the maximal level of risk irrespective of the level of transparency. Hence there is no indirect effect, and $dx^*/d\varepsilon$ is equivalent to $\partial x^*/\partial\varepsilon$. Second, if (10) holds, the sign of $\partial x^*/\partial\mu$ must be non-negative, and the sign of the indirect effect is given by the sign of $d\mu^*/d\varepsilon$. Proposition 3 suggests then that the sign of the indirect effect is the same as the sign of the direct effect, except perhaps for the case when the asset returns are appropriately sensitive to the risk level and $\bar{Q} < \hat{Q}$. Even in that case, $d\mu^*/d\varepsilon$ may still have the same sign as $\partial x^*/\partial\varepsilon$ and even if it had an opposite sign, the direct effect can still dominate over the indirect effect. In particular, note that when $\bar{Q}'$ is positive but small, not only is the sign of $d\mu^*/d\varepsilon$ likely to be equivalent to the sign of $\partial x^*/\partial\varepsilon$ but also $\partial x^*/\partial\mu$ is likely to be small (by (9)). In sum, the effects of transparency on refinancing generally remain procyclical (are positive when $\bar{Q} > \hat{Q}$ and negative when $\bar{Q} < \hat{Q}$) even if we take account the bank's asset risk choice. The only potential exception is the case when asset returns are appropriately sensitive to the risk level and $\bar{Q} < \hat{Q}$.

Proposition 4. *Even taking into account the bank's asset risk choice, the effects of transparency on a bank's refinancing risk tends to be procyclical: When $\bar{Q} > \hat{Q}$, refinancing risk decreases with the level of transparency, and when $\bar{Q} - \hat{Q} < 0$, refinancing risk may not increase with the level of transparency only if the sensitivity of the mean return to the level of risk $\bar{Q}'$ is moderate. In that case, the impact of transparency on refinancing risk may be ambiguous.*

Transparency, Risk Taking, and Welfare

As in sections 2 and 3 assume that FSA authority chooses the level of transparency to maximize social welfare given by

$$\max_{\varepsilon\in[\underline{\varepsilon},\bar{\varepsilon}]} W(\varepsilon,\mu^*(\varepsilon)) = x^*(\varepsilon,\mu^*(\varepsilon)) + \left(1 - \frac{x^*(\varepsilon,\mu^*(\varepsilon))}{\lambda}\right)\bar{Q}(\mu^*(\varepsilon)),$$

where $\mu^*(\varepsilon)$ is the banks' risk choice given the level of transiency ε. Thus,

$$\frac{dW}{d\varepsilon} = \frac{\partial W}{\partial\varepsilon} + \frac{\partial W}{\partial\mu}\frac{\partial\mu^*}{\partial\varepsilon}.$$

However, since banks select $\mu = \mu^*$ in order to maximize creditors' welfare, the Envelope Theorem implies that

$$\frac{dW}{d\varepsilon} = \frac{\partial W}{\partial \varepsilon}.$$

Thus, the first order condition for a maximum is

$$\frac{\partial W}{\partial \varepsilon} = 0,$$

the same is in the version of the model μ was exogenous. Therefore W is either increasing or decreasing in ε, and thus the socially optimal level transparency is either the maximal one or the minimal one.

We summarize our finding on this section in Proposition 5 below.

Proposition 5. *The socially optimal level of transparency is either the maximal level or the minimal level feasible depending on whether the asset's mean return is high or low relative to $\hat{Q}$.*

5 Transparency and Welfare

When the FSA's and the bank's objectives are perfectly aligned as we assumed above, it may be argued that there is no need for a regulation: if the absence of regulation competitive pressure would lead the bank to choose the socially optimal level of transparency. However, the social impact of transparency may include external effects that do not directly affect the welfare of banks' creditors, which may lead to a misalignment of the objectives of banks and society. We now consider the impact of these externalities of the optimal level of transparency.

Assume that the FSA's objective is

$$\max_{\varepsilon \in [\underline{\varepsilon}, \bar{\varepsilon}]} \hat{W}(\varepsilon, \mu^*(\varepsilon)),$$

where social welfare $\hat{W}$ is given by

$$\hat{W}(\mu^*(\varepsilon), \varepsilon) = x^*(\mu^*(\varepsilon), \varepsilon) + \left(1 - \frac{x^*(\mu^*(\varepsilon), \varepsilon)}{\lambda}\right) \bar{Q}(\mu^*(\varepsilon)) - Dx^*(\mu^*(\varepsilon), \varepsilon) - F(1 - \rho(\mu^*(\varepsilon)).$$

Here D and F are positive constants. We may assume as, e.g., Freixas, Lóránth and Morrison (2007), that a bank failure has some exogenous social costs beyond the costs the failure imposes on the bank's creditors. For example, a bank's failure leaves its customers without the bank's services which may lead to misallocation of savings and investments. This effect is exacerbated if bank failures are contagious: a bank's failure may trigger failures of other banks, leading to a general credit crunch. These external effects are captured by parameter F. Similarly, we may imagine that refusals to rolling over credit to the bank have some exogenous social costs, captured by parameter D here. For example, such decisions can also be contagious: withdrawals from one bank may prompt withdrawals from other banks and hence inefficient liquidation of assets of other banks. Finally, both D and F can be motivated by the need to protect small creditors (e.g. the fraction $1-h$ of the bank's creditors that are inactive in our model). These reasons constitute the standard justifications for banking regulation (see, e.g., Freixas and Rochet, 2008). [6]

We can rewrite $\hat{W}$ as

$$\hat{W}(\mu^*(\varepsilon),\varepsilon) = V^*\left(\mu^*(\varepsilon),\varepsilon)\right) - Dx^*(\mu^*(\varepsilon),\varepsilon) - F(1-\rho(\mu^*(\varepsilon)).$$

Since $\partial V/\partial\mu = 0$ and $\partial\rho/\partial\mu = -1/2$, the first-order condition that characterizes the socially optimal level of transparency is

$$\frac{\partial W(\mu^*(\varepsilon),\varepsilon)}{\partial\varepsilon} = \frac{\partial V}{\partial\varepsilon} - D\left(\frac{\partial x^*}{\partial\varepsilon} + \frac{\partial x^*}{\partial\mu}\frac{d\mu^*}{d\varepsilon}\right) - \frac{F}{2}\frac{d\mu^*}{d\varepsilon}. \tag{19}$$

Using our results above, we can rewrite this equation as

$$\frac{\partial W(\mu^*(\varepsilon),\varepsilon)}{\partial\varepsilon} = \frac{\partial x^*}{\partial\varepsilon}\left(\frac{\lambda-\bar{Q}}{\lambda} - D\right) - \left(\frac{\partial x^*}{\partial\mu}D + \frac{F}{2}\right)\frac{d\mu^*}{d\varepsilon}. \tag{20}$$

Recall that $\bar{Q} > \lambda$. Let us consider first the case when $\bar{Q}' > 0$ is very large or if (10) does not hold. Then, as explained above, banks will choose the maximal level of risk irrespective of the level of transparency, and hence $d\mu^*/d\varepsilon = 0$. As a result, the sign of $\partial W/\partial\varepsilon$ is given the opposite of the sign of $\partial x^*/\partial\varepsilon$, and the socially optimal level of transparency is the maximum feasible $\varepsilon^* = \underline{\varepsilon}$ when $\bar{Q} > \hat{Q}$, and the minimum feasible $\varepsilon^* = \bar{\varepsilon}$ when $\bar{Q} < \hat{Q}$. Note that, if anything, adding an external social costs on withdrawals D amplifies the procyclical welfare effects of transparency. The same

[6] Yet another justification for D and F would follow if we assumed that the banks' investments generated some social returns in addition to private returns. Such social spillovers (e.g. consumer surplus) of investment projects are a standard feature in the IO literature.

conclusions arise when $\bar{Q}' \approx 0$. Then $\partial x^*/\partial\mu \approx 0$, and $\partial x^*/\partial\varepsilon$ and $d\mu^*/d\varepsilon$ have the same sign. As a result, if $\bar{Q}' \approx 0$, the socially optimal level of transparency is the maximum feasible $\varepsilon^* = \underline{\varepsilon}$ when $\bar{Q} > \hat{Q}$, and the minimum feasible $\varepsilon^* = \bar{\varepsilon}$ when $\bar{Q} < \hat{Q}$.

Finally, when $\bar{Q}'$ is positive and moderately high, $\partial x^*/\partial\mu > 0$. Both $\partial x^*/\partial\varepsilon$ and $d\mu^*/d\varepsilon$ are positive when $\bar{Q} > \hat{Q}$, and maximal transparency is optimal. When $Q < \overline{Q}$, however, $\partial x^*/\partial\varepsilon$ is negative but $d\mu^*/d\varepsilon$ *may* be positive when $\bar{Q} < \hat{Q}$. Hence the optimal level of transparency *may* be interior if F is large enough and $\bar{Q} < \hat{Q}$. Note that the net effect of the presence of the constant D is ambiguous when $\bar{Q} < \hat{Q}$ and $d\mu^*/d\varepsilon$ is positive. These results are summarized in Proposition 6.

Proposition 6. *Even if bank failures and premature liquidations of bank assets have social costs beyond those imposed on their creditors, the socially optimal level of transparency tends to be procyclical: When $\bar{Q} - \hat{Q} > 0$, the optimal level of transparency is the maximum feasible, and when $\bar{Q} - \hat{Q} < 0$, the optimal level of transparency is not the minimum feasible only if F is large and $\bar{Q}'$ is moderetely high.*

6 Conclusion

We consider a competitive banking sector with illiquid asset portfolios that have been funded by short-term debt needed to be rolled over, and study the effects of greater disclosure of banks' expected asset returns on refinancing risk, on the banks' asset risk taking incentives, and on welfare. We find that these effects are generally procyclical: When the mean asset returns are high (a boom), greater transparency reduces refinancing risk and discourages asset risk taking, but when the mean asset returns are low (a recession), transparency tends to worsen efinancing risk and encourage risk taking. The only potential exception arises in recessions when the mean asset returns are moderately sensitive to the asset risk level. In that case, the effects of transparency on refinancing risk and asset risk taking may be ambigous. Similarly, society prefers transparent banks in booms and opaque banks in receissions. Only if the mean asset returns are moderately sensitive to the asset risk level and external costs of bank failures are large, the socially optimal level of transparency may not be minimal in recessions. That we find these procyclical effects of transparency in the absence of price effects is noteworthy.

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