Procyclical Transparency*

Diego Moreno† Tuomas Takalo‡

INCOMPLETE DRAFT, January 2011

Abstract

We show that given a bank's risk profile, increasing transparency has a procyclical effect on the bank's refinancing risk, encouraging debt roll over in booms and withdrawals in downturns. The effect of increased transparency on asset choices tends to be procyclical also, making banks more risk-taking in downturns but more prudent in booms. Society generally prefers opaque banks in downturns but transparent ones in booms. Only if social costs of bank failures are large and the asset returns are moderately sensitive to risk, society may want some transparency in downturns, too.

1 Introduction

The recent global financial crisis has intensified calls for increased bank transparency. The discussions surrounding, for example, the publication of the results from banks' stress-tests 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 a bank's refinancing risk on the liability side, its risk

*We thank Esa Jokivuolle and the seminar participants at HECER for useful comments. We gratefully acknowledge financial support from the Fundación BBVA, from the Spanish Ministry of Education, grants SEJ2007-67436 and Consolider-Ingenio 2010, and from the Comunidad de Madrid, grant Excelecon. Takalo also thanks the Yrjö Jahnsson Foundation for funding. This work was begun while the authors were visiting IDEI - Université Toulouse I. They are grateful for their hospitality.

†Departamento de Economía, Universidad Carlos III de Madrid.

‡Bank of Finland and University of Jyväskylä. tuomas.takalo@gmail.com

taking on the asset side and 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, for given investment choices of banks, greater disclosure of the quality of banks' asset portfolios, e.g., publication of stress-test results, has a procyclical effect on creditor confidence: Disclosure encourages banks' creditors to rollover their debt when the expected returns of the investments are high ("booms") but discourages debt rollover when the expected returns are low ("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 may help 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 constitutes 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 prompt creditors to withdraw their loans, which may be countered if the bank takes more risk. In a boom, where increased transparency makes creditors to rollover their debts, there is less need to compensate withdrawals by risk taking. This leads to less risk taking in booms. 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,

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

society prefers opaque banks in recessions but transparent ones in booms. The reason is that competitive banks will make asset choices that maximize their lenders' 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, the socially optimal transparency regulation always calls for maximal disclosure in booms and generally maximal opacity in recessions. Only if social costs of bank failures are large and only if the asset 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 Jaggannathan (1988) and Chen (1999) who study the role of depostitors' 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 enchances 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, the banks' incentives to invest in risk-management may be impaired. Our paper also has a connection to the literature (e.g. Admati and Pfleiderer, 2000, and Boot and Thakor, 2001) considering the desirability of financial disclosure regulation and voluntary information disclosure.

Since transparency almost by definition hints at problems of incomplete information, and since banks are inherently vulnerable to self-fulfilling runs, theoretical

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

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 , it has very little to say how to concretely assess the confidence vulnerability. 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).

That increased transparency might cause procyclical effects is not of course a new idea, but 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 depositors 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 competitive banks with illiquid asset portfolios that are funded by short-term debt needed to be rolled over. In the basic set up we take banks' asset choices given, endogenizing them 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 banks' creditors which we call depositors for brevity. The depositors are risk neutral, each with one unit of uninsured deposit. Banks invest their deposits 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 $h < 1$ of depositors are active and may withdraw their deposits before the asset matures. The remaining fraction $1 - h$ of depositors maintain their deposits until maturity, and therefore play a passive role. Henceforth we refer to active depositors simply as depositors. Although the assumption is made for a technical reason, it captures the fact that some loans (e.g. long-term retail deposits) to the bank are stickier than other (e.g. wholesale funding from the overnight interbank market).

Each depositor 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 depositor decides whether to *withdraw* or to *rollover* her deposit.

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 depositors signals around the realized probability of success p. The feasible levels of transparency are those of the interval $[\underline{\varepsilon}, \bar{\varepsilon}]$, where $0 < \underline{\varepsilon} < \bar{\varepsilon} \leq \varepsilon$. 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 early withdrawals. 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 "bank run" (a signifant fraction of depositors refuses to rollover) is costly in our model, it cannot lead to a bank failure. The only case in which a bank can fail in our model is when its asset-side risk taking is not successful (i.e., with probability $1 - p$).

The Depositors Game

The timing of the game that (active) depositors face is as follows: (i) The banks offer deposit contracts. ii) Nature draws the success probability p from $[1 - \mu, 1]$. (iii) Each depositor observes a noisy signal s of the realized p, and then decides whether to withdraw or to rollover her deposit. (iv) The returns are realized and the depositors are compensated according to the deposit contract.

Following the tradition of Diamond and Dybvig (1983) we focus on demand-deposit contracts where each depositor will get at least her money back if she withdraws. Such depositors 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 depositors are risk neutral and, hence, risk-sharing among depositors is not an issue. In other words, in contrast to the standard bank run model, withdrawing is never efficient in our model as there are no "impatient" depositors. Then, competition forces the banks to offer a contract where each depositor gets 1

[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.

if she withdraws but the full asset's return to those depositors who roll over. That is, the depositors who wait become residual claimants as in Diamond and Dybvig (1983). [4]

A depositor'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 depositors who withdraw their deposits early, $x \in [0, h]$, and her *decision* whether to withdraw or to rollover her deposit $a \in \{0, 1\}$. Since $x \leq h$ and $h < \lambda$[5] by assumption, a depositor who withdraws her deposit $(a = 0)$ gets back her monetary unit independently of her signal s and the fraction of depositor who withdraw x; i.e.,

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

A depositor who rolls over her deposit, however, must share the expected returns of the non-liquidated assets with the depositors who do not withdraw (either because they are not active or because they rollover their deposits), 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 depositors who do not withdraw effectively assume the liquidation costs necessary to pay early withdrawals.

We assume that each depositor follows a simple *switching strategy* consisting of withdrawing (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 depositor is a threshold specifying the highest signal for which the depositor withdraws.

An *equilibrium* of the game is a profile of thresholds such that an agent that receives a signal below (above) her threshold optimally withdraws (rolls over). Our

[4] Alternatively, we could think, e.g. in line with Rochet and Vives (2004), that the game begins from a situation where all the deposits are at the banks and their nominal value upon withdrawal is pre-determined and normalized to unity. The banks would then compete for renewals of these deposits by offering rates of returns for those depositors that wait until maturity. In that case we should assume that if a depositor 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 depositors 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.

analysis of the depositors 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 depositors game has a unique equilibrium, and that this equilibrium is symmetric. A symmetric equilibrium is easily described.

Assume that all depositor follow the same threshold strategy t. A depositor who receives signal s beliefs that the signals of the other depositors, $s_i \mid s$, are distributed uniformly on $[s - 2\varepsilon, s + 2\varepsilon]$. Thus, the depositor may calculate the fraction of depositors he expect to withdraw their deposit 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

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

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 depositor whose signal is equal to t indifferent between withdrawing and rolling over; i.e., t must satisfy

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

Equation 1 characterizes the equilibrium of the depositors 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 depositors 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 depositor's optimal action is to rollover her deposit, even if every other active depositor withdraws her deposit. The payoff to rolling over when a fraction $x = h$ of depositors withdraw 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 withdrawing is equal to 1. Hence the existence of an upper dominance region requires the existence of $\bar{p} < 1$ such that for $p \in (\bar{p}, 1]$ the inequality

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

holds. Define

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

If we assume that the inequality

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

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

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 depositors: when $\lambda = 1$ the return to a depositor is Q independently of the measure of depositors 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 depositor's optimal action is to withdraw even if no one else withdraws. The payoff to rolling over when the fration of depositors who rollover is zero ($x = 0$) is $(1 + R)p$, and the payoff to withdrawing is equal to 1. Hence the existence of an lower dominance region requires the existence of $\underline{p} > 1 - \mu$ such that for $p \in [1 - \mu, \underline{p})$ the inequality

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

holds. Define

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

If we assume that the inequality

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

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

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

Hence when condition (4) holds [DIEGO, THEN WHAT? THIS SENTENCE IS INCOMPLETE]

Equilibrium of the Depositor Game

Henceforth we assume that conditions (3) and (5) hold. Then the depositors' game has a unique equilibrium BY PROPOSITION X? IN M&S (2003) ??? 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 depositors who withdraw 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 depositor 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 depositor 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 depositor who withdraw is $x^* = h/2$; i.e., exactly half of the active depositors 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 of 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 depositors who withdraw) 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 $1-x^*$ could also be interpreted as the measure of confidence the depositors have on the banks; This is the fraction of depositors that rolls over their debt. Proposition 1 thus suggests that greater transparency may have positive or negative effect on depositors' confidence depending on whether the asset's mean return is high or low relative to $\hat{Q}$. Note also that since $\hat{Q}$ is an increasing function of h but a decreasing function of λ, it becomes less likely that transparency has positive effects on confidence (refinancing) if the fraction of active depositors is high or if 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 depositors, social welfare W only consists of depositors' 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 depositors who withdraw 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 depositors who do 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 an increasing function of h but a decreasing function of λ, we can predict that maximal transparency is more likely to be optimal if the fraction of active depositors is low or if the liquidation value of assets is high.

4 Transparency and Asset Risk Taking

So far we have taken the quality 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 $1 + R(\mu)$. As a result, the mean asset return can be re-expressed as

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

We assume 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 depositor. Now competition also forces the banks to choose the asset μ that maximizes the depositors' welfare. Using our results in the previous section, for $\mu \in [0, 1]$ the (ex-ante) expected welfare of depositors, 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 depositors who withdraws and get their unit deposit (recall that $x^* < h < \lambda$). The depositors who do not withdraw 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 depositors' 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 depositors' 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

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

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

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 depositor who withdraws 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 depositors' 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 depositors (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 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

[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.

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.

7 References

Admati, A. R. and P. Pfleiderer. Forcing Firms to Talk: Financial Disclosure Regulation and Externalities, *Review of Financial Studies* (2000) 13, 479-519.

Boot, A. and A. Thakor. The Many Faces of Information Disclosure, *Review of Financial Studies* (2001) 14, 1021-1057.

Chari, V.V. and R. Jagannathan, Banking Panics, Information, and Rational Expectations Equilibrium, *Journal of Finance* (1988), 43, 749-761.

Chen, Y., Banking Panics: The Role of the First-Come, First-Served Rule, and Information Externalities. *Journal of Political Economy* (1999) 107, 946-968.

References

[1] Chen, Y and I. Hasan, The Transparency of the Banking System and the Efficiency of Information-Based Bank Runs, *Journal of Financial Intermediatio*n, (2006) 15, 307-331.

Cordella, T. and E. Levy Yeyati, Financial Opening, Risk Taking and Risk in a Model of Banking Competition, *European Economic Review* (2002) 46, 471-485

Diamond, D. and P. H. Dybvig, Bank Runs, Deposit Insurance, Liquidity, *Journal of Political Economy* (1983) 91, 401-419.

Freixas, X., G. Lóránth, and A. D. Morrison (2007) Regulating Financial Conglomerates. *Journal of Financial Economics*, 16, 479-624.

Freixas, X. and J.-C Rochet, *Microeconomics of Banking* (2nd Edition). The MIT Press (2008), Cambridge, Ma.

References

[1] Goldstein, A. and A Pauzner, Demand Deposit Contracts and the Probability of Bank Runs, *Journal of Finance* (2005) 60,1293-1327.

[2] Hyytinen, A. and T. Takalo: Enchancing Bank Transparency: A Re-Assesment, *European Finance Review* (2002) 6, 429-445.

Laux, C. and C. Leuz, The Crisis of Fair Value Accounting: Making Sense of the Recent Debate. The Initiative on Global Markets Working Paper No. 33 (2009), University of Chicago, Booth School of Business

Matutes, C. and X. Vives, Imperfect Competition, Risk Taking, and Regulation in Banking, *European Economic Review* (2002) 44, 1–34.

Morris, S. and H. S. Shin, Social Value of Public Information, *American Economic Review* (2002) 92, 1521-1534.

References

[1] Morris, S. and H. S. Shin: Global Games: Theory and Applications, in *Advances in Economics and Econometrics* (Proceedings of the Eighth World Congress of the Econometric Society), edited by M. Dewatripont, L. Hansen and S. Turnovsky. Cambridge UP (2003).

[2] Morris, S. and H. S. Shin: Catalytic Finance: When Does It Work?, *Journal of International Economics* (2006) 70, 161-177.

Plantin, G., H. Sapra and H. S. Shin, Marking-to-Market: Panacea or Pandora's Box? *Journal of Accounting Research* (2008), 46, 435-460.

References

[1] Rochet, J.C. and X. Vives: Coordination Failures and the Lender of Last Resort: Was Bagehot Right After All?, *Journal of the European Economic Association* (2004) 2, 1116-1147.

Shaffer, S. Fair Value Accounting: Villain or Innocent Victim: Exploring the Links between Fair Value Accounting, Bank Regulatory Capital and the Recent Financial Crisis. Federal Reserve Bank of Boston Working Paper No. QAU10-01 (2010).