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Subordinated debt, market discipline, and bank risk

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Subordinated debt, market discipline, and bank risk

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Abstract

This paper demonstrates that subordinated debt ('subdebt' thereafter) regulation can be an effective mechanism for disciplining banks. Under our proposal, investors buy the subdebt of a bank only if they receive favourable information about the bank, and the bank is subject to a regulatory examination if it fails to issue subdebt. By forcing banks to be examined when they are likely weak, subdebt regulation not only reduces the chance that managers of distressed banks can take value-destroying actions to benefit themselves, but may also encourage banks to lower asset risk. It shows that subdebt regulation and bank capital requirements can be complements for alleviating the banks' moral hazard problems. It also suggests that to make subdebt regulation effective, regulators may need impose ceilings on the interest rates of subdebt, prohibit collusion between banks and subdebt investors, and require the subdebt to convert into the issuing bank's equity when the government takes over or provides open assistance to the bank.

Keywords: subordinated debt regulation, bank capital regulation, market discipline, moral hazard, contingent capital certificate

JEL classification numbers: G21, G28

Pääomalainat, markkinakuri ja pankkien riskinotto

Suomen Pankin keskustelualoitteita 20/2011

Yehning Chen – Iftekhar Hasan
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Tässä tutkimuksessa osoitetaan, että pääomalainoihin perustuva viranomaissääntely − pääomalainojen sääntely − voi olla tehokasta pankkien liiallisen riskinoton hillitsemisen kannalta. Työssä ehdotetaan menettelyä, jonka mukaan sijoittajat myöntävät pankille pääomalainaa vain kun niiden käytettävissä oleva informaatio pankin tilasta puoltaa lainaamista. Toisaalta silloin, kun pankki ei onnistu laskemaan liikkeeseen pääomalainaa, sääntelyviranomaisten pitäisi ehdotuksen mukaan tarkastaa pankki. Pakottamalla heikosti menestyvät pankit viranomaistarkastukseen pääomalainojen sääntely pienentää mahdollisuutta, että ahdinkoon joutuneen pankin johto harjoittaa pankin markkina-arvoa alentavaa liiketoimintaa itse siitä hyötyäkseen. Pääomalainojen sääntely voi samalla vahvistaa pankin kannusteita vähentää omaisuusriskejä. Työssä argumentoidaan myös, että pääomalainojen sääntelyä ja pankkien pääomavaatimuksia voidaan käyttää toisiaan täydentävästi pyrittäessä hallitsemaan epäsymmetrisestä informaatiosta aiheutuvia pankkien kannustinongelmia. Pääomalainoihin perustuvan sääntelyn tehostamiseksi näiden lainojen koroille olisi ehkä välttämätöntä asettaa katto, millä pyrittäisiin estämään pankkien ja pääomalainoittajien salainen liittoutuminen. Valvonta- ja sääntelyviranomaisten tulisi myös vaatia pääomalainojen muuntamista niitä myyvien pankkien osakepääomaksi silloin, kun julkinen valta ottaa pankin vastuulleen tai myöntää avointa tukea sille.

Avainsanat: pääomalainojen sääntely, pankkien pääomien sääntely, markkinakuri, piilotettu informaatio ja kannustinongelma, ehdollinen pääomatodistus

JEL-luokittelu: G21, G28

Contents

1. Introduction

Ensuring that banks behave prudently is a main purpose of bank regulation. Among the alternatives that regulators can use, capital requirements have become the main mechanism for enforcing prudential regulation after the passage of the Basel Accord in 1988. However, capital regulation alone is not a perfect solution to the banks' moral hazard problems. Because the majority of banks' assets are opaque and do not have liquid market prices, capital ratios are usually lagging indicators of banks' financial health.[1] Also, as shown in Hellmann et al. (2000), because capital is a costly funding source, a strict bank capital requirement may worsen the banks' moral hazard problems through reducing their franchise values.

Given the limitations of bank capital regulation, other mechanisms should be employed to enhance prudential regulation. In this paper, we study the feasibility of inducing investors of the banks' subordinated debt (subdebt thereafter) to monitor banks. Subdebt regulation has become a popular idea among regulators and academics for years. Various proposals for implementing subdebt regulation have been advocated and widely discussed.[2] These proposals suggest that subdebt regulation may create both direct and indirect disciplining effects. For direct discipline, because banks with higher asset risk have to pay higher interest rates on subdebt, subdebt regulation can induce banks to lower asset risk in order to reduce interest payments. Indirect discipline means that regulators can take prompt corrective actions against banks with high subdebt yields or banks unable to roll over subdebt. These corrective actions not only prevent further losses of problem banks, but also stop bank managers from pursuing unsound risk.

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[1] The financial crisis of 2008-2009 provides good examples to illustrate this point. According to Duffie (2009), Citibank's tier-1 capital ratio never fell below 7% during the financial crisis, and was 11.8% in December 2008, when it was in a very poor financial condition.

[2] Appendix A of Board of Governors of the Federal Reserve System (2000) contains a nice review of the subdebt proposals. Also see Evanoff and Wall (2001, 2002), Calomiris (1999), Flannery (2001), Flannery and Sorescu (1996), Lang and Robertson (2002), and Evanloff and Jagtiani (2004) for discussions of proposals for implementing subdebt regulation.

However, there are concerns about the effectiveness of subdebt regulation and how it should be implemented. Some worry that issuing public subdebt is too costly for small banks; some suggest that subdebt regulations will not work if the government cannot commit not to bail out subdebt holders or if bank insiders can buy the subdebt. Moreover, even though many empirical papers find that subdebt spreads are informative about the issuing banks' financial conditions,[3] Evanoff and Wall (2001, 2002) point out that the information implied by subdebt spreads may be too noisy to serve as triggers of corrective actions.

Another concern about subdebt regulation is the "double endogeneity problem" discussed in Birchler and Facchinetti (2007 and Bond et al. (2009), who argue that regulations using market prices as the triggers of regulatory actions may fail if market participants believe that they would work.[4] Blum (2002) also shows that, when a bank cannot pre-commit the level of its asset risk, requiring it to issue subdebt will result in higher bank risk through increasing the bank's debt burden. Finally, Flannery and Sorescu (1996) and Flannery (2001) suggest that investors are good at evaluating banks' risk, but poor in influencing the banks' behavior. If this is true, the direct disciplining effect of subdebt will be limited.

This paper establishes a model to investigate whether subdebt regulation can be an effective mechanism for disciplining banks. In the model, a bank is owned and controlled by its manager. The manager determines the level of the bank's asset risk, and his choice of risk is unobservable to others. Two types of moral hazard problems may arise. First, as a debtor, the bank's manager may pursue

[3] See Flannery and Sorescu (1996), Flannery (2001), Jagtiani, Kaufman, and Lemieux (2000), Morgan and Stiroh (2001), Hancock and Kwast (2001), Sironi (2001a, b), and Evanoff and Wall (2001, 2002). However, there are some exceptions. Avery, Belton, and Goldberg (1988) and Gorton and Santomero (1990) find that subdebt spreads and the bank risk implied by the spreads are not related to accounting measures of bank risk. Also, Krishnan, Pitchken, and Thomson (2005) find that changes in credit spreads of subdebts do not reflect changes in firm-specific risks.

[4] If investors believe that the regulation using subdebt spreads as the triggers of corrective actions is effective, they will expect risky banks with high subdebt spreads to be timely disciplined and become safe. As a result, they will not require high yields on these banks, so the expected corrective actions may not be triggered. It can be shown that there may be no equilibrium in which this regulation can effectively discipline banks.

excessive risk when determining asset risk. Second, once the bank is likely to fail, the bank manager may take value-destroying actions, such as gambling for resurrection or tunneling bank resources into his own pocket, to benefit himself at the expense of depositors and deposit insurance funds.

The bank is supervised by the government, which can impose capital requirements and subdebt regulation. Both capital and subdebt are costly funding sources: the required rates of return for them are higher than that for deposits. The bank manager has to put part of his own wealth in the bank as bank capital. Also, the bank is required to issue short-term subdebt, and the government can impose a cap on the interest rate of the debt. If the bank fails to issue subdebt, it will be subject to a costly regulatory examination. In case the examination reveals that the bank is weak, the government takes over the bank and the banker is deprived of the opportunity to take value-destroying actions.

Under this setting, we show that subdebt regulation can complement bank capital regulation for disciplining banks. The natures of these two regulations are different. While capital regulation reduces the bank shareholders' incentives to seek risk, subdebt regulation induces outsiders who cannot enjoy the upside gains of the banks' profits to monitor banks. Even though a sufficiently high capital requirement can eliminate all the banks' moral hazard problems, it may be too costly, either in terms of social welfare or to the banker. Subdebt regulation can help in this case. Under appropriate design, investors will buy the debt only if they receive favorable information about the bank. By forcing the bank to be examined when it is likely weak, the subdebt requirement reduces the chance that the bank manager can engage in value-destroying actions when the bank is in poor financial conditions. As will be shown, this effect lowers the bank manager's ex ante incentive to pursue risk if regulatory forbearance is common and/or if bank capital ratio cannot timely reflect the financial conditions of banks. In these cases, the bank capital requirement can be relaxed when subdebt regulation is imposed.

The subdebt regulation proposed in this paper has several interesting features. First, regulatory actions are triggered by the bank's failure to issue subdebt rather than high secondary market subdebt

yields. Because of this feature, the subdebt need not be public,[5] and the regulation does not suffer the double endogeneity problem. Second, the bank's violation of the subdebt requirement is followed by a regulatory examination, so both market information and supervisory information are used.[6] Since subdebt regulation just serves as a trap wire to trigger a regulatory examination, it may still work even if the information of subdebt investors is not very precise.

Third, in our proposal the government can impose ceilings on interest rates of subdebt. As will be seen, these ceilings may be necessary to prevent banks from bribing subdebt investors not to monitor banks. Fourth, to avoid a government bailout of subdebt investors, the subdebt in our proposal has a conversion feature: it converts into the issuing bank's equity at a predetermined price if the government takes over or provides open assistance to the bank. The conversion price is set high so that subdebt investors will suffer losses when conversion occurs. The fear of losses will motivate subdebt investors to monitor banks. Finally, the disciplining mechanism in our paper is indirect rather than direct discipline. That is, investors evaluate the subdebt issued by the bank, and regulators take the corrective actions. In this sense, it is consistent with the idea in Flannery (2001) that investors have a comparative advantage in monitoring, while supervisors have a comparative advantage in influencing.

In the literature, several articles study how to construct debt contracts to induce optimal monitoring from creditors. Calomiris and Kahn (1991) demonstrate that the first-come, first-served rule can be part of the optimal banking contract that induces depositors to monitor banks. Chen (1999) and Chen and Hasan (2006) discuss how to implement efficient depositor discipline through designing the deposit insurance system. Rajan and Winton (1995) show that covenants and collateral can

[5] Calomiris (1999) suggests that subdebt may take the form of uninsured time deposits held by other banks. In this case, banks are monitored by peer banks. As shown in Furfine (2001), banks can effectively monitor other banks in the overnight federal funds markets.

[6] The proposals in Evanoff and Wall (2002) and Hart and Zingales (2009) also have this feature. Evanoff and Wall propose that prompt corrective actions imposed on banks that violate subdebt regulation can be waived if regulators provide strong evidence that the banks are indeed financially strong. Hart and Zingales suggest that regulators take a stress test on a large financial institution if the institution's credit default swap price rises above a critical threshold. According to the test results, regulators either announce that the financial institution is safe, or take corrective actions against it.

enhance the banks' incentives to monitor borrowers. Carletti (2004) and Carletti et al. (2007) suggest that multiple-bank lending may be the optimal arrangement when the banks' monitoring efforts are unobservable. Park (2000) proposes that monitoring creditors should hold senior claims.

Similar to these papers, our paper also investigates how to arrange debt contracts to induce creditor monitoring. In terms of how to discipline banks, our model extends Calomiris and Kahn's work in two ways. First, we endogenize the bank manager's choice of risk to see how subdebt regulation affects his incentives to pursue risk. Second, we study subdebt holder discipline rather than depositor discipline. In contrast to Park (2000), we show that subdebt holders will monitor even if their claims are junior.

The merit of capital requirements in reducing the banks' risk-taking incentives has been documented in various papers, including Holmstrom and Tirole (1997), Chiesa (2001, 2008), Hellmann et al. (2000), Santos (1999), and Acharya (2003). Hellmann et al. suggest that bank capital regulation alone cannot solve the banks' risk-taking problems, so other types of regulation, such as interest rate ceilings, are needed. Complementing their work, we show that subdebt regulation is valuable even if bank capital requirements have been implemented.

Blum (2002) and Niu (2008) also study how subdebt regulation affects bank risk. Both papers discuss the direct discipline effect of subdebt, but they reach very different conclusions. While Blum (2002) proposes that the subdebt requirement will result in higher bank risk through increasing the bank's debt burden, Niu (2008) suggests that subdebt regulation can induce banks to lower interest rates on deposits, thus reduce their risk-seeking incentives.[7] Unlike these papers, the focus of our paper is the indirect rather than direct discipline effect of subdebt. We investigate the feasibility of imposing subdebt regulation to extract valuable information from investors, and use this information to prevent financially weak banks from taking value-destroying actions. Neither Blum (2002) nor Niu (2008) models private information of subdebt investors and the value-destroying actions of bank

[7] In Niu (2008), a bank sets the deposit rate before the interest rate of subdebt is determined. If the bank sets the interest rate of deposits high, subdebt investors will infer that the bank's debt burden and asset risk will be high, so they will require a high interest rate on subdebt.

managers.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 analyzes the case where only capital requirements are used to deal with the banks' moral hazard problems. Assuming that capital regulation has already been in place, Section 4 studies how the use of subdebt regulation may affect bank risk. Section 5 investigates the welfare effects of subdebt regulation. Section 6 discusses practical concerns for implementing subdebt regulation and the connection between our proposal and the proposals that require banks to issue contingent capital certificates. Concluding remarks are in Section 7.

2. The Model

Consider a three-period (dates 0, 1, and 2) model in which the risk-free interest rate is zero. At date 0, a banker has an opportunity to establish a bank. If established, the bank issues securities to finance an investment project. The banker can choose between two exclusive projects, projects S (safe) and R (risky). For i = S, R, undertaking project i requires one dollar invested at date 0, and the project matures at date 2. Project i will either succeed or fail. At date 0, it is common knowledge that project i will succeed with probability p_i, and will fail with probability $1 - p_i$. At date 2, project i yields X_i if it succeeds, and yields Y if it fails, where $X_R > X_S > 1 > Y$, and[8]

$$p_S X_S + (1 - p_S) Y > 1 > p_R X_R + (1 - p_R) Y. \qquad (1)$$

Equation (1) implies that project R should not be undertaken. Define

$$G \equiv \frac{p_S X_S - p_R X_R}{p_S - p_R}, \qquad (2)$$

where G is a proxy for the relative attractiveness of project S to the banker compared to project R.[9]

[8] There are other ways to model the bank's risk-taking behavior. For example, see Dell'Ariccia and Marquez (2006, 2009). Our main results will still hold if we model the bank's risk-taking behavior according to their models.

[9] Intuitively, project S is more attractive than project R to the banker if it generates a higher expected cash flow

The higher the G, the more attractive is project S. By equation (1), we know that G is greater than Y. The banker's choice of project is unobservable to any other party. Without loss of generality, assume that he will choose project S if he is indifferent between the two projects.

At date 2, after the project's cash flow is realized and before depositors and subdebt investors are paid, the banker can take a value-destroying action to benefit himself at the expense of others. This assumption reflects the moral hazard problems of distressed banks. As the chance that a weak bank will recover dwindles, its managers have strong incentives to either gamble for resurrection, or grab something for themselves before the bank fails. This problem is serious in the real world. As many authors point out, during the U.S. Savings and Loan Crisis of 1980s zombie savings and loan associations with negative economic values took advantage of deregulation to pursue high risk, and their risk-taking behavior aggravated the social costs of the crisis.[10] The concern for this problem motivates many countries, including the United States, to require regulators to take prompt corrective actions when banks' financial conditions deteriorate.

To simplify the exposition, suppose that the value-destroying action the banker takes is absconding with the money at the bank. Whether the project succeeds or not, if the banker absconds, he receives b, and nothing is left for other claimholders, where b is a constant with $0 < b < Y$.[11] The assumption that the banker can take the money and run is not critical. Our main qualitative results will hold if we assume that the banker takes other types of value-destroying actions.

Under this setting, two types of moral hazard problems may arise. First, if debt financing is used, the banker may have excessive incentives to pursue risk. In our model, project R is riskier than project S, so the banker may prefer project R to project S even if the expected return of project R is negative. Second, the banker may abscond at date 2. We will investigate how bank capital and subdebt

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(that is, $p_S X_S - p_R X_R - (p_S - p_R) Y$ becomes larger) or if it becomes riskier (that is, $p_S - p_R$ becomes smaller).

[10] For a more detailed discussion, see Cole et al. (1995) and Kane (1989).

[11] The assumption that the value of b is independent of whether the project succeeds is not critical. Our results will still hold if the bank receives more from absconding when the project succeeds.

regulations can alleviate these problems.

The banker maximizes expected profits. At date 0, he establishes a bank and becomes its sole shareholder if his payoff from doing so is non-negative. The bank is subject to capital regulation: for each dollar invested by the bank, the banker has to put k dollars of his own wealth in the bank as bank capital,[12] where $0 < k < 1$. The bank issues deposits to raise the remaining amount for the investment. Deposits are fully insured by the government, so under the zero risk-free rate assumption, depositors are willing to deposit as long as the return form depositing is non-negative.

Following Hellmann et al. (2000), we assume that bank capital is a costly funding source, and the opportunity cost of bank capital from dates 0 to 2 is $1 + r_k$, where $r_k > 0$. In other words, r_k is the required rate of return for bank capital for two dates. There are several possible reasons for why bank capital is more expensive than deposits. First, bank capital does not have the tax shield of debt. Second, Kashyap, Rajan, and Stein (2008) suggest that a higher capital ratio gives bank management more discretion, which worsens the agency problems between bank management and shareholders. Third, using a general equilibrium framework, Gorton and Winton (1997) show that the adverse selection problem in equity trading creates a "lemons cost", which makes bank equity more expensive than deposits. Finally, as argued in Hellmann et al. (2000), the fact that regulators do not use capital regulation to eliminate all the moral hazard problems in banking implies that bank capital is costly. If capital were not costly, regulators would simply require banks to hold sufficient capital to ensure that banks behave prudently.

For simplicity, assume that the government does not charge any deposit insurance premium from the bank. If deposit insurance could be risk-based and fairly priced, the banking industry's moral hazard problems would be reduced because risk-chasing banks would be punished by high deposit insurance premiums. However, in the real world deposit insurance premiums are usually underpriced.

[12] We assume that the banker does not face any wealth constraint. If the banker has no wealth and sells the bank's equity to investors, our results will still hold as long as he maximizes welfare of all the shareholders.

More importantly, they are often not very sensitive to bank risk because it is difficult to find precise and objective proxies for bank risk. Our assumptions about deposit insurance reflect these observations.

In addition to the capital requirement, the government may also implement subdebt regulation. Subdebt is junior to deposits, and is not covered by deposit insurance. The regulation requires the bank to raise α dollars at date 1 by issuing subdebt that matures at date 2, where α is an exogenous parameter with $0 < \alpha < 1 - k$. We will discuss the case where α is endogenized in Section 5. The regulation also requires that deposits of α dollars mature at date 1, and the remaining deposits mature at date 2, so the proceeds from issuing subdebt are used to replace the maturing deposits.[13]

Because subdebt is junior to deposits and it may convert into the issuing bank's equity under our proposal, investors may require a higher rate of return on subdebt. Therefore, we assume that subdebt is a costly funding source, and the opportunity cost of subdebt for one date is $1 + r_{SD}$, where r_{SD} is strictly positive.[14]

We also assume that the banker cannot collude with subdebt investors, and the government is not allowed to bail out subdebt investors under any circumstance. In Section 6, we will discuss how the collusion between the banker and subdebt investors and a possible government bailout of subdebt investors will affect the effectiveness of subdebt regulation.

There are many investors who may buy the subdebt, and they are willing to invest in subdebt as long as the expected profit from investing is non-negative. At date 1, investors can receive a signal, s, about the bank's project at a cost c_I. The signal is not verifiable in courts, and its value is either H or L. If the bank's project will succeed, s = H with probability q and s = L with probability $1 - q$; if the project will fail, s = H with probability $1 - q$ and s = L with probability q, where $0.5 < q < 1$ and q

[13] The assumption that subdebt is required only at date 1 simplifies the exposition without changing our results. All of our qualitative results hold if the bank is also required to issue subdebt at date 0.

[14] The assumption that subdebt is expensive is not critical. All of our main results will hold if $r_{SD} = 0$. In fact, subdebt regulation is more likely to be welfare improving if r_{SD} becomes lower.

represents the precision of the signal. For simplicity, assume that all the investors who spend c_I receive the same signal.

Regulatory actions are tied to the subdebt requirement. The bank will be examined by a regulator if it cannot successfully issue subdebt at date 1. After the examination, the regulator learns perfectly whether the bank's project will succeed. He allows the bank to be reopened if the project will succeed. The reopened bank can issue insured deposits to repay the deposits that mature at date 1.[15] If the bank's project will fail, the regulator will take over the bank. The takeover is beneficial: once the bank is taken over, the banker no longer has the opportunity to abscond at date 2.[16]

The regulatory examination is costly: whether the bank's project will succeed or not, the examination reduces the project's date-2 cash flow by c_M. That is, for i = S, R, if the banker undertakes project i and the bank is examined, the project's date-2 cash flow becomes $X_i - c_M$ if it succeeds, and becomes $Y - c_M$ if it fails. Obviously, if c_M is sufficiently low, the regulator should always examine the bank at date 1. We assume that always having the bank examined at date 1 is not socially optimal. In the next section, we will provide a condition under which this assumption holds.

For issuing subdebt, at date 1 the bank randomly chooses an investor, offering to sell him the subdebt for α dollars and pay him back D dollars at date 2, where D is determined by the banker.[17] This investor first decides whether to acquire s; he then considers whether to buy the subdebt given the information he has.[18] If the investor rejects the offer, the bank is examined by a regulator.

Following Calomiris (1997, 1999), we assume that the government can impose a cap on D,

[15] As will be shown, the banker will not abscond with money when the project succeeds. Since the project of the reopened bank always succeeds, there is no need to impose subdebt regulation on it.

[16] We assume that the banker can abscond only at date 2 but not at date 1. Subdebt regulation will not work if the banker can always abscond at date 1 before the regulator takes over the bank. Our baseline assumption is that the information extracted from subdebt regulation is timely enough (at least sometimes) to stop managers of weak banks from taking value-destroying actions.

[17] For simplicity, we assume that the subdebt is bought by only one investor. If the subdebt is bought by multiple investors, the main results of the paper will remain the same qualitatively as long as all the investors receive the same signal and investors cannot observe the others' decisions when they make decisions.

[18] If the investor acquires s, his investment decision is based on s and his conjecture on which project the banker undertakes. If he does not acquire s, his decision is based only on his conjecture on the banker's project choice.

which is equivalent to a cap on the interest rate of subdebt because the interest rate is equal to $D/\alpha - 1$. As will be seen, such a cap may be necessary for subdebt regulation to work. To reflect the fact that a bank's franchise value will be damaged when it fails, suppose that the banker will lose franchise value F if the bank is either taken over by the regulator at date 1 or is unable to pay off its debts at date 2, where $F > 0$.[19] Assume that

$$b < F < 1 + b - G. \tag{3}$$

As will be shown, equation (3) implies that the banker will choose project R if no regulation is imposed. Note that, to avoid losing the franchise value, the banker may have the incentive to inject his own wealth into the bank at date 2 to repay depositors and the subdebt investor if there is not enough money at the bank.

When designing subdebt regulation, we make two important assumptions about the government. First, it cannot spend c_I to acquire the signal s and take the right actions according to s.[20] If the government could do so, there would be no need to use subdebt regulation to extract the information of investors. This assumption is consistent with the idea in Flannery (2001) that investors have an advantage over regulators in monitoring. It also reflects the fact that, to avoid pressures from interest groups or lobbyists, regulators are usually reluctant to take actions against a bank unless there is hard evidence (rather than non-verifiable information) showing that the bank is in weak financial positions. Second, the government can commit itself to take the right corrective actions once the bank fails to issue subdebt. This assumption is reasonable because the bank's violation of the subdebt requirement sends a strong message to the public that the bank may be in trouble. Even if the government's incentives are distorted against taking over weak banks, the costs and the risk for it to cover up the problem will be high once the public has already learned the problem. By making weak banks more

[19] One interpretation of the franchise value F is that it is the sum of the future profits that the bank can earn if it does not fail. Note that F will *not* be incurred if the bank is examined and reopened.

[20] Signal s contains information about whether the bank's project will succeed. Because both projects may either succeed or fail, the signal is still valuable to the government even if the government can infer the banker's project choice from the model parameters.

visible to the public, subdebt regulation forces the government to take timely corrective actions against these banks.

For simplicity, we assume that the bank behaves as a monopolist when it issues deposits and subdebt.[21] Under this assumption, it will offer zero interest rate to depositors. Also, to simplify the exposition, we only consider cases that satisfy the following two conditions. First, the bank is able to pay off all the debts when its project succeeds, that is,[22]

$X_S \geq Max\{1 - k - \alpha + D,\ 1 - k + c_M\}$.

Second, $Y < 1 - k - \alpha$, which implies both the banker and the subdebt investor receive nothing if the bank's project fails and the banker neither absconds with money nor injects funds into the bank.

The time line of the model is shown in the following figure.

[Please insert the Figure here]

3. Disciplining the Bank by Capital Requirements

In this section, we assume that the government relies only on capital requirements, but not subdebt regulation, to deal with the bank's moral hazard problems, so $\alpha = 0$. We solve the game backwards. First consider the banker's decision on whether to abscond at date 2. For i = S, R, suppose the banker chooses project i at date 0. If the project succeeds, his payoffs for absconding and not absconding are $b - F - (1 + r_k)\,k$ and $X_i - (1 - k) - (1 + r_k)\,k$, respectively. Because $b < F$ and $X_i > 1 -$

[21] As well documented in the literature, market structures have significant impacts on the banks' behavior (for example, see Boyd and Nicolo (2005), Hellmann et al. (2000), and Wagner (2010)). However, since the focus of our paper is designing subdebt regulation to induce investors to monitor banks, the intuitions of the paper are not related to the structures of the deposit or subdebt markets. If depositors or subdebt investors have bargaining power, our main results will still hold qualitatively as long as the signal that subdebt investors receive contains information about bank risk. Assuming a monopolistic bank does greatly simplify our analysis of the banker's and the subdebt investors' decisions.

[22] If the bank successfully issues subdebt and its project succeeds, at date 2 it pays $1 - k - \alpha$ dollars to depositors, and pays D to the subdebt investor. The cash flow of the project is at least X_i in this case. If the bank is taken over by the regulator and its project succeeds, at date 2 it pays $1 - k$ dollars to depositors and the cash flow generated by the project is $X_i - c_M$. Given that $X_R > X_S$, if $X_S > Max\{1 - k - \alpha + D,\ 1 - k + c_M\}$, the bank can always pay off its deposits and subdebt.

k, the banker will not abscond if the project succeeds.

Alternatively, if the project fails, the banker's payoff for absconding is $b - F - (1 + r_k) k$. In case he does not take the money and run, he may either do nothing or inject his own wealth into the bank to repay depositors. For the banker, the advantage of the latter choice is to keep the franchise value. His payoff is $-F - (1 + r_k) k$ if he does nothing, and is $Y - (1 - k) - (1 + r_k) k$ if he injects funds into the bank.[23] Therefore, the banker will inject funds if

$$k \geq k_2 \equiv 1 + b - F - Y, \tag{4}$$

and will abscond otherwise. By (3) and the fact that $Y < G$, k_2 is strictly positive.

Now consider the banker's project choice at date 0. From the above discussion, for i = S, R, the banker's payoff for choosing project i is[24]

$$\Pi_k(i, k) \equiv p_i (X_i - 1 + k) + (1 - p_i) \max\{b - F, Y - 1 + k\} - (1 + r_k)k. \tag{5}$$

Given k, the banker will choose project S if and only if $\Pi_k(S, k) \geq \Pi_k(R, k)$. The following proposition documents the banker's choices at date 0 and date 2. The proofs of all the propositions and the lemma are in the Appendix.

Proposition 1. Suppose that only capital regulation is imposed, and that the banker establishes the bank at date 0.

(a) If $k < k_1$, the banker chooses project R, and will abscond with money when the project fails, where

$$k_1 \equiv 1 + b - F - G \tag{6}$$

is strictly positive, and is smaller than k_2.

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[23] The banker will offer zero interest rate to depositors, so he pays $1 - k$ dollars to depositors at date 2. Also, because the game ends right after the banker injects funds into the bank, we assume that the required rate of return for the money he injects into the bank is zero.

[24] Equation (5) can be explained as follows. If the project succeeds, the banker's payoff is $X_i - 1 + k$ before deducting the cost of bank capital. If the project fails, the banker can choose between absconding and injecting funds to pay off the deposits. Before deducting the cost of bank capital, his payoff is $b - F$ if he absconds and is $Y - 1 - k$ if he injects funds. The banker will choose the alternative that gives him the higher payoff.

(b) If $k_1 \leq k < k_2$, the banker chooses project S, and will abscond with money when the project fails.

(c) If $k \geq k_2$, the banker chooses project S, and will inject funds to the bank when the project fails.

The results in Proposition 1 are intuitive. By reducing the bank's debt burden from one dollar to $1 - k$ dollars, bank capital regulation lowers the banker's incentives to choose project R as well as his incentives to take the value-destroying action when the project fails. If $k \geq k_2$, the capital requirement is so high that the bank's moral hazard problems totally disappear. If $k_1 \leq k < k_2$, capital regulation will induce the banker to choose project S, but cannot stop him from absconding when the project fails. If $k < k_1$, capital regulation is not useful for alleviating the bank's moral hazard problems. From the result that $k_1 > 0$, the banker will choose project R if no bank regulation is imposed, which means some form of bank regulation is necessary in our model.

We next investigate the optimal amount of bank capital for a welfare-maximizing government. Social welfare under bank capital regulation can be written as[25,26]

$$W_k(k) \equiv \begin{cases} p_S X_S + (1-p_S) Y - 1 - k r_k & \text{if } k \geq k_2; \\ p_S X_S + (1-p_S)(b-F) - 1 - k r_k & \text{if } k_1 \leq k < k_2. \end{cases} \tag{7}$$

To simplify the exposition, in the rest of the paper we will focus on the case where $\Pi_k(S, k_1) \geq 0$ and $W_k(k_1) \geq 0$, which means using capital requirements to reduce bank risk is a feasible choice for the government.

By (7), obviously the government should set k equal to either k_1 or k_2. The following lemma states the optimal k for the government when only bank capital regulation is imposed.

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[25] Neglecting the costs of bank capital, the net present value of the bank's project is $p_S X_S + (1 - p_S) Y - 1$ if $k \geq k_2$, and is $p_S X_S + (1 - p_S)(b - F) - 1$ if $k_1 \leq k < k_2$. The $k r_k$ is the extra cost incurred when bank capital is used.

[26] In equation (7), whether the bank's loss of franchise value should be counted as a social loss is debatable. It should be counted if F represents the economic rents from the bank's better lending technology or its relationship with borrowers. It should not be counted if F just reflects the value of a bank license, and a new bank will be set up to replace the failed one. As will be shown in Section 5, the condition under which subdebt regulation can improve welfare does not depend on F. Therefore, our results will still hold if the bank's loss of franchise value is not regarded as a social loss.

The Lemma. Suppose that only capital regulation is imposed on the bank. The optimal k for the government is k_2 if $\Pi_k(S, k_2) \geq 0$ and

$$(k_2 - k_1)\ r_k \leq (1 - p_S)(Y - b), \tag{8}$$

and is k_1 otherwise.

The lemma says that the government should completely eliminate the bank's moral hazard problems by setting k equal to k_2 if this requirement does not prevent the banker from establishing the bank, and the social gain from solving the banker's absconding problem (which is $(1 - p_S)(Y - b)$) outweighs the extra capital cost incurred (which is $(k_2 - k_1)\ r_k$). Although setting $k = k_2$ can completely deter the bank's moral hazard problems, doing so may be too costly in terms of welfare if (8) fails to hold, and may even be an infeasible choice for the government if $\Pi_k(S, k_2) < 0$. The government should set k equal to k_1 in these cases.

When the government imposes capital regulation, one alternative it can choose is to require the regulator to always examine the bank at date 1, so the banker cannot steal money from the bank. Obviously, this choice will not be attractive to the government if c_M is sufficiently high. It can be verified that if

$$c_M > (1 - p_S)\ (Y - b) + k_1\ r_k, \tag{9}$$

then always having the bank examined is strictly dominated by capital regulation with $k = k_1$.[27] In the rest of the paper, we assume that (9) holds, so always having the bank examined is not optimal for the

[27] Compared to imposing capital regulation with $k = k_1$, always having the bank examined has two merits. One is the gain from deterring the banker's absconding problem, which equals $(1 - p_S)\ (Y - b)$. The other is the savings from reduction in bank capital used, which is no larger than $k_1\ r_k$. These benefits are shown in the right-hand-side of (9). If (9) holds, the cost of the examination exceeds its benefits. Note that for the comparison, we suppose that when the bank is always examined, the banker will choose project S even if $k = 0$. If this assumption is violated, the government has to set $k > 0$ to induce the bank to choose project S. In this case, the savings from reduction in bank capital are smaller than $k_1\ r_k$, which makes always having the bank examined at date 1 even less attractive.

government.

4. The Role of Subdebt Requirements in Prudential Regulation

This section investigates the case where both capital and subdebt requirements are implemented. Assume that $k < k_2$. If $k \geq k_2$, the bank's moral hazard problems are completely solved by bank capital regulation, and there would be no role for subdebt regulation to play. The game is solved backwards. First consider what happens *after* the investor offered to buy the subdebt has made his decisions. In case he buys the debt, the banker considers whether to abscond with money at date 2. By the discussions in the previous section and the assumption $k < k_2$, he will not abscond if the project succeeds, and will if the project fails.

Now suppose the investor refuses to buy the debt at date 1. In this case, the bank is examined, and is reopened if and only if the project will succeed. If the bank is reopened, the banker will not abscond at date 2 because his payoff from absconding is strictly lower.[28] If the bank is taken over, the banker's date-2 payoff is $-F-(1+r_k)k$.

Next consider the investor's decisions when he is invited to buy the subdebt. Because the investor does not observe the banker's project choice, he has to form conjecture on the banker's action. Suppose the investor believes that the banker undertakes project j. Given the bank's offer, he has three choices. First, he can buy the debt without acquiring s. Second, he can acquire s and buy the debt if and only if s = H.[29] Third, he can neither acquire s nor buy the debt. His payoffs from these choices are[30]

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[28] For i = S, R, suppose the banker chooses project i. His payoffs for absconding and not absconding are $b-F$ and $X_i-1+k-c_M$, respectively. Because $X_i-1+k-c_M > 0 > b-F$, the banker will not abscond in this case.

[29] Because it is costly to acquire s, the investor will acquire s only if his decision on whether to buy the debt is contingent on s. Since the bank's project is more likely to succeed when s = H, the investor will buy the debt only when s = H if he acquires s.

[30] In (11), $p_j q+(1-p_j)(1-q)$ is the probability of s = H, and $p_j q$ is the probability of s = H and the bank's project will succeed. To simplify the exposition, we assume that the investor's required rate of return for the money he spends on acquiring s is zero. If the investor requires a positive rate of return r_I on the information

$p_j\ D\ -\ (1\ +\ r_{SD})\ \alpha$, (10)

$$p_j\, q\, D - [p_j\, q + (1 - p_j)(1 - q)](1 + r_{SD})\,\alpha - c_I\,, \tag{11}$$

and *0*, respectively. The investor will choose the one with the highest payoff. Without loss of generality, we assume that the investor will buy the debt if he is indifferent between buying and not buying. Also, given that he will buy the debt, he will not acquire *s* if he is indifferent between acquiring and not acquiring *s*. For *j* = S, R, define

$$\underline{\alpha}_j \equiv \frac{c_I}{(1 + r_{SD})(1 - p_j)(2q - 1)}; \tag{12}$$

$$\underline{D}_j \equiv (1 + \frac{(1 - p_j)(1 - q)}{p_j\, q})(1 + r_{SD})\alpha + \frac{c_I}{p_j\, q}; \tag{13}$$

$$\overline{D}_j \equiv (1 + \frac{(1 - p_j)\, q}{p_j\,(1 - q)})(1 + r_{SD})\alpha - \frac{c_I}{p_j\,(1 - q)}. \tag{14}$$

The following proposition states the investor's choice.

Proposition 2. Suppose the investor offered to buy the subdebt believes that the banker chooses project *j*. The investor's decisions can be described as follows.

(a) In case $\alpha < \underline{\alpha}_j$, the investor will buy the debt without acquiring *s* if $D \geq (1 + r_{SD})\ \alpha / p_j$, and will neither acquire *s* nor buy the debt if $D < (1 + r_{SD})\ \alpha / p_j$.

(b) In case $\alpha \geq \underline{\alpha}_j$, the investor will

(i) buy the debt without acquiring *s* if $D \geq \overline{D}_j$;

(ii) acquire *s* and buy the debt only when *s* = H if $\underline{D}_j \leq D < \overline{D}_j$;

(iii) neither acquire *s* nor buy the debt if $D < \underline{D}_j$.

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acquisition cost, then c_I in all the equations should be replaced by $(1 + r_I)\ c_I$.

(c) $\underline{\alpha}_S > \underline{\alpha}_R$. Moreover, if $\alpha \geq \underline{\alpha}_S$, then $\overline{D}_R > \overline{D}_S$ and $\underline{D}_R > \underline{D}_S$.

Proposition 2 suggests that to induce the investor to acquire *s*, *D* should not be too high or too low. By (10) and (11), if *D* is sufficiently high, the return from buying the debt is so large that the investor will buy the debt without bothering to acquire *s*. If *D* is too low, the return from investing in subdebt is too low, so the investor will neither acquire *s* nor buy the debt. The proposition also says that α has to be high enough in order to induce the investor to acquire the signal. If α is low, the investor's gain from monitoring will not be large enough to cover the information acquisition cost c_I. Finally, from part (c) of the proposition, the riskier is the project, the less attractive is the subdebt to the investor, so it takes a higher *D* to induce the investor to acquire *s* or to buy the debt without acquiring *s*.

Among the cases discussed in Proposition 2, we are especially interested in case (ii) in part (b), where the investor acquires *s*, and buys the debt only if *s* = H. We will say that the investor monitors if he does so. We assume it is always possible to induce monitoring by the investor, that is,

$$\alpha \geq \underline{\alpha}_S . \tag{15}$$

We next consider the banker's choices of the project and *D*. Suppose all the investors believe that the banker chooses project *j*, and the banker chooses project *i*. According to the investor's decision rule specified in part (b) of Proposition 2, for *i* = S, R, and *j* = S, R, the banker's payoff can be written as:

$$V_j(i, D, k) \equiv \begin{cases} \Pi_{NM}(i, D, k) & \text{if} \quad D \geq \overline{D}_j; \\ \Pi_M(i, D, k) & \text{if} \quad \underline{D}_j \leq D < \overline{D}_j; \\ \Pi_{EX}(i, k) & \text{if} \quad D < \underline{D}_j; \end{cases} \tag{16}$$

where[31,32,33]

[31] Equation (17) can be explained as follows. When the investor does not monitor, the bank pays $1 - k - \alpha$ dollars to depositors and *D* dollars to the subdebt investor at date 2 if its project succeeds, and the banker absconds if the project fails. Before deducting the cost of bank capital, the banker's payoffs in these two

$$\Pi_{NM}(i,D,k) \equiv p_i\,[X_i - (1-k-\alpha) - D] + (1-p_i)(b-F) - (1+r_k)k\,; \tag{17}$$

$$\begin{aligned}\Pi_{M}(i,D,k) \equiv\ & p_i\,q[X_i - (1-k-\alpha) - D] + (1-p_i)(1-q)(b-F) + \\ & p_i(1-q)(X_i - c_M - 1 + k) - (1-p_i)\,q\,F - (1+r_k)k;\end{aligned} \tag{18}$$

$$\Pi_{EX}(i,k) \equiv p_i\ (X_i - c_M - 1 + k) - (1-p_i)\,F - (1+r_k)k\,. \tag{19}$$

In the above equations, Π_{NM}, Π_M, and Π_{EX} are the banker's payoffs when the investor buys the subdebt without monitoring, monitors, and does not buy the subdebt, respectively. By equations (17) and (18), the banker's payoff is strictly decreasing in D if the investor may buy the subdebt. Therefore, the banker will set D equal to either $\overline{D}_j$ or $\underline{D}_j$ if he wants to induce the investor to buy the debt.

By (16), one choice for the banker is to set D lower than $\underline{D}_j$, so that the investor refuses to buy the subdebt and the bank is examined by the regulator. Since it is unlikely that any bank would enjoy a regulatory examination in the real world, we assume

$$c_M > \underline{D}_R - \alpha \tag{20}$$

to exclude this uninteresting case. By (18), (19) and the fact that $\underline{D}_R > \underline{D}_S$, when (20) holds, setting D lower than $\underline{D}_j$ is strictly dominated by setting $D = \underline{D}_j$ to induce monitoring by the investor.[34]

Even if subdebt regulation is imposed, the banker can avoid monitoring by the subdebt investor by setting D equal to $\overline{D}_j$ to induce the investor to buy the debt without monitoring. We may say

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situations are $X_i - (1 - k - \alpha) - D$ and $b - F$, respectively.

[32] Equation (18) can be explained as follows. Suppose that the investor monitors. (i) If the bank's project succeeds and s = H, the bank pays $1 - k - \alpha + D$ at date 2. (ii) If the project fails and s = H, the banker absconds. (iii) If the project succeeds and s = L, the bank is examined. In this case, the reopened bank pays $1 - k$ dollars to depositors at date 2, but the cash flow realized becomes $X_i - c_M$. (iv) If the project fails and s = L, the bank is examined and is taken over. The probabilities of the four events are $p_i\,q$, $(1 - p_i)(1 - q)$, $p_i\,(1 - q)$, and $(1 - p_i)\,q$, respectively.

[33] If the bank is examined and its project succeeds, the project yields $X_i - c_M$, and the bank has to pay $1 - k$ to depositors. If the project fails, the banker loses franchise value F. From these facts, we have equation (19).

[34] Compared with the case where $D = \underline{D}_j$, the only benefit for the banker to set $D < \underline{D}_j$ is that the bank need not issue subdebt at date 1 if its project will succeed. If (20) holds, the value destroyed by the examination (c_M) exceeds the benefit ($\underline{D}_j - \alpha$), so the banker has no incentive to always trigger the examination.

that the bank can bribe the investor not to monitor by offering him a high interest rate on the subdebt. By (17) and (18), the banker has stronger incentives to do so when b is high, that is, his gain from taking the value-destroying action is attractive. Also, the banker may want to choose project R rather than project S. As shown in the following proposition, a cap on D can help remove these unwanted outcomes. By imposing an appropriate cap on D, the government can eliminate all the equilibria except those in which the subdebt investor monitors and the banker chooses the safe project.

Proposition 3. Suppose that the bank is set up at date 0, and the government imposes both capital regulation and subdebt regulation. Moreover, it requires that $D < min\{\overline{D}_S, \underline{D}_R\}$.

(a) There is no perfect Bayesian equilibrium in which the banker undertakes project R or the investor does not monitor.

(b) If

$$k \geq k_{SD} \equiv max\{0,\ k_1 - [q\ b - q\ (\underline{D}_S - \alpha) - (1 - q)\ c_M]\}, \qquad (21)$$

the only Perfect Bayesian equilibrium of the game is the one in which the banker chooses project S and sets $D = \underline{D}_S$, and the investor offered to buy the subdebt monitors.

Proposition 3 states that the banker will choose the safe project and the investor will monitor if subdebt regulation is imposed and (21) is satisfied.[35] The proposition can be explained as follows. Because $\overline{D}_S < \overline{D}_R$, requiring D to be lower than $\overline{D}_S$ makes it impossible to have an equilibrium in which the investor buys the debt without monitoring. Also, requiring D lower than $\underline{D}_R$ makes it impossible to have an equilibrium in which the banker undertakes project R. Therefore, given the cap on D specified in the proposition, the only equilibrium candidates remained are those in which the

[35] Since both players are rational, they can figure out the equilibrium and they will choose their equilibrium strategies. The subdebt investor will form his belief about the banker's project choice according to the equilibrium.

banker chooses project S and the investor monitors. Intuitively, the banker must set D sufficiently high to induce the investor to buy the subdebt without monitoring. Also, the required interest rate on subdebt must be higher if the investor knows that the banker pursues project R. By setting a ceiling on the interest rate of subdebt, the government can eliminate the equilibria in which the disciplining effects of subdebt regulation are substantially weakened.

In the literature, Calomiris (1997, 1999) suggest that there should be interest rate caps on subdebts. Proposition 3 provides a justification for these proposals. Blum (2002) worries that interest rate caps on subdebt may eliminate the investors' incentives to acquire information. In contrast to Blum's view, we show that interest rate caps may be *necessary* for inducing investors to acquire information about the issuing banks.

Proposition 3 also shows k_{SD}, the minimum amount of bank capital needed to induce the banker to choose the safe project when subdebt regulation is imposed. Compared with the case where only capital regulation is used, the subdebt requirement has three effects on the banker's risk-taking incentives. First, when the project will fail and s = L, the requirement induces a regulatory examination on the bank, thus stops the banker from absconding. Second, when the project will succeed and s = H, the requirement increases the bank's debt burden by $\underline{D}_S - \alpha$. Finally, when the bank's project will succeed and s = L, the examination reduces the bank's profit by c_M.

These three effects are expressed in the first, second, and third terms in the square bracket of (21), respectively. The first effect lowers the banker's incentives to pursue risk, while the other two increase his risk-taking incentives. If the first effect is significant enough so that

$$q\,b - q\,(\underline{D}_S - \alpha) - (1 - q)\,c_M > 0,$$

then $k_{SD} < k_1$. In other words, subdebt regulation may allow the government to lower the bank capital requirement. Note that by (21), the first effect is more significant when b, the amount

of money the banker can steal from the bank, is higher. Intuitively, managers of weak banks have more opportunities to take value-destroying actions before the banks are closed if regulatory forbearance is common in the banking industry, and/or if capital ratios cannot timely reflect the true financial health of banks. Proposition 3 implies that subdebt regulation is more likely to be valuable in these cases.

In the literature, Blum (2002) considers only the second effect stated above, so he concludes that subdebt regulation will increase rather than decrease banks' incentives to pursue risk. Proposition 3 implies that Blum's result may no longer hold if subdebt regulation has the merit of reducing the probability that banker can take value-destroying actions in the downturn.

5. Welfare Effects of Subdebt Regulation

In this section, we discuss whether imposing subdebt regulation can improve social welfare. Suppose that the government can raise funds at the risk-free interest rate and deposit insurance incurs no welfare losses. Given that both bank capital and subdebt regulations are imposed, social welfare can be written as

$$W_{SD} \equiv p_S X_S + (1 - p_S)(Y - F) - 1 - k_{SD} r_k - \{ [p_S (1 - q) + (1 - p_S) q] c_M + [p_S q + (1 - p_S)(1 - q)] \alpha r_{SD} + (1 - p_S)(1 - q)(Y - b) + c_I \}. \quad (22)$$

In equation (22), $p_S X_S + (1 - p_S)(Y - F) - 1$ is the net present value of project S assuming that it is fully financed by deposits, and $k_{SD} r_k$ is the cost of bank capital. The terms in the braces are the costs incurred when subdebt regulation is imposed.[36]

[36] In equation (22), $[p_S (1 - q) + (1 - p_S) q] c_M$ is the expected project value destroyed by the examination, $[p_S q + (1 - p_S)(1 - q)] \alpha r_{SD}$ is the return required by the subdebt investor (which is αr_{SD}) multiplied by the probability

An interesting observation from (22) is that W_{SD} is decreasing in α. In our model, an increase in α reduces welfare in two ways. First, investors require a higher rate of return on subdebt than on deposits. Second, an increase in α escalates the bank's debt burden, thus raises k_{SD}. If α can be endogenously determined, the government should keep reducing it as long as subdebt regulation still motivates the investor to monitor. By (15), the optimal α for the government is $\underline{\alpha}_S$.[37]

To see whether subdebt regulation can improve welfare, consider the case where the government will set k equal to k_1 if subdebt regulation is not implemented. The following proposition identifies the condition under which subdebt regulation can improve welfare in this case.

Proposition 4. Suppose that $\Pi_k(S, k_2) < 0$ or (8) does not hold, so the government will set k equal to k_1 if subdebt regulation is not imposed. Moreover, $\Pi_M(S, \underline{D}_S, k_{SD}) \geq 0$. In this case, subdebt regulation improves social welfare if and only if

$$c_I + [p_S (1 - q) + (1 - p_S) q]\, c_M + [p_S q + (1 - p_S)(1 - q)]\, \alpha\, r_{SD} <$$
$$(k_1 - k_{SD})\, r_k + (1 - p_S)\, q\, (Y - b). \qquad (23)$$

In equation (23), the left-hand-side items are the costs of subdebt regulation, while the right-hand-side ones are the benefits. When subdebt regulation is implemented, an investor

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that the subdebt is issued (which is $[p_S q + (1 - p_S)(1 - q)]$), $(1 - p_S)(1 - q)(Y - b)$ is the expected social loss caused by the banker's absconding, and c_I is the information acquisition cost for the investor. Note that the loss of the bank's franchise value F has been considered when we calculate the present value of project S.

[37] Technically, the government has to set α slightly higher than $\underline{\alpha}_S$. If $\alpha = \underline{\alpha}_S$, by (12) to (14), $\underline{D}_S = \overline{D}_S$, which implies the government may be unable to use the cap on D to eliminate the unwanted equilibria in which the banker sets $D = \overline{D}_S$ to avoid monitoring.

spends c_I to acquire signal s, project value will be reduced by c_M if the investor refuses to buy the debt, and the investor requires a higher rate of return on subdebt than on deposits. On the other hand, subdebt regulation may bring two benefits. First, if $k_{SD} < k_1$, the regulation lowers the amount of bank capital needed to induce the banker to choose project S by $k_1 - k_{SD}$. Second, the regulation reduces the probability that the banker will abscond by $(1 - p_S)\, q$. Subdebt regulation can be justified if (23) holds, that is, its benefits outweigh the costs.

The following numerical example demonstrates a case in which subdebt regulation is welfare improving. Assume that $p_S = 0.9$, $X_S = 1.1933$, $p_R = 0.5$, $X_R = 1.54$, $Y = 0.26$, $b = 0.08$, $r_k = 0.18$, $r_{SD} = 0.08$, $F = 0.25$, $q = 0.85$, $c_I = 0.001$, and $\alpha = \underline{\alpha}_S$. It can be shown that all the constraints of the model are satisfied if $0.0306 < c_M < 0.2633$.[38] In this case, $k_1 = 0.07$, $k_2 = 0.57$, $\underline{\alpha}_S = 0.0132$, $\Pi_k(S, k_1) > 0$, $W_1(k_1) > 0$, and $\Pi_k(S, k_2) < 0$. Moreover, when $0.0306 < c_M < 0.1012$, subdebt regulation not only reduces the required bank capital for inducing the banker to choose project S (that is, $k_{SD} < k_1$), but also improves social welfare.

Proposition 4 suggests that imposing subdebt regulation may still improve welfare even if bank capital regulation has already been in place. Although both capital and subdebt are junior to deposits and both are costly funding sources, the two regulations are different in nature. While capital regulation forces shareholders of banks to behave themselves, subdebt regulation encourages outsiders who cannot share the upside gains of the banks' risk-taking to monitor banks. In fact, the two regulations can be complements. Suppose that $0 < k_{SD} < k_1$, and the government will set $k = k_1$ if subdebt regulation is not imposed. In this case, using capital regulation to deter the banker from taking value-destroying actions is either too costly

[38] These constraints include (1), (3), (9), (15), (20), $0 < b < Y$, $0 < \alpha < 1 - k$, $Y < 1 - k - \alpha$, and $X_S \geq Max\{1 - k - \alpha + D,\ 1 - k + c_M\}$.

or infeasible. Subdebt regulation not only helps alleviate the banker's value-destroying problem, it also reduces the bank capital to choose the right project. Therefore, complementing bank capital regulation, subdebt regulation can be an effective mechanism for disciplining banks.

In the above discussion, we focus on the case where the government will set $k = k_1$ if subdebt regulation is not imposed. If the government will set $k = k_2$ without subdebt regulation, the regulation can still improve welfare if $k_2 - k_{SD}$, the reduction in capital requirement caused by subdebt regulation, is sufficiently high.

6. Discussions

This section studies two issues related to subdebt regulation. Section 6.1 discusses practical concerns for implementing subdebt regulation. It investigates how collusion between the banker and the subdebt investor and the possibility that the government may bail out the subdebt investor will affect the effectiveness of subdebt regulation. It also briefly discusses possible ways to set the interest rate ceilings of subdebt. Section 6.2 introduces proposals that require banks to issue contingent capital certificates. As will be explained, to prevent the government from bailing out subdebt investors, we propose that subdebt should convert into the issuing bank's common stock if the government takes over or provides open assistance to the bank. Because of this conversion feature, our proposal is also a contingent capital proposal, and it shares important common features with other contingent capital proposals.

6.1. Practical concerns for implementing the subdebt regulation

In Section 2, we assume that the banker and the subdebt investor cannot collude, and that

the government cannot bail out the subdebt investor. This subsection studies the cases in which these assumptions are relaxed. First consider the collusion between the banker and the subdebt investor. Suppose that the banker is allowed to invest in the subdebt issued by the bank.[39] Also, at date 1 the banker receives perfect information about the date-2 cash flow of the bank's project before he decides whether to buy the subdebt. All the other assumptions in Section 2 remain the same.

Under this setting, outside investors will not buy the subdebt due to the information disadvantage they face: the banker would offer the subdebt to an outside investor only when the return from investing in the debt is negative. If the return is positive, the banker would buy the debt himself. Since the only investor that may buy the subdebt is the banker himself, the function of subdebt in this case becomes similar to that of bank capital. This point is illustrated in the following proposition.

Proposition 5. Suppose that the banker establishes the bank at date 0, and both bank capital and subdebt regulations are imposed. The banker is allowed to invest in the subdebt, and he perfectly learns the date-2 cash flow of the bank's project when deciding whether to buy the subdebt. Also, assume that $0 < \alpha < \min\{\frac{b}{1+r_{SD}}, \frac{c_M}{r_{SD}}\}$.

(a) The banker always buys the subdebt at date 1.

(b) (i) If $k + \alpha < k_I$, the banker chooses project R, and he absconds with money when the project fails.

[39] When the banker and the subdebt investor collude, they maximize their joint welfare. The simplest way to model this situation is to assume that the banker himself is the investor. Therefore, we assume that the banker can buy the subdebt.

(ii) If $k_1 \leq k + \alpha < k_2$, the banker chooses project S, and he absconds with money when the project fails.

(iii) If $k + \alpha \geq k_2$, the banker chooses project S, and he injects funds into the bank when the project fails.

Proposition 5 discusses the case where α is not high.[40] Part (a) of the proposition states that the banker will always buy the subdebt in this case. From this result, subdebt becomes a sure funding source for the bank. If the bank's project will succeed, the banker buys the debt to avoid the costly regulatory examination. If the bank's project will fail, the banker buys the debt to preserve the opportunity to abscond. By part (b) of the proposition, α and k have the same impacts on the banker's behavior. Note that part (b) of the proposition would become equivalent to Proposition 1 if we replace all the $k + \alpha$ by k. Therefore, in case the banker and subdebt investors can collude, the subdebt requirement serves the same function as bank capital regulation if α is not high.

From the above discussions, if the purpose of subdebt regulation is to induce outside investors to monitor banks, banks and subdebt investors should not be allowed to collude. That is, parties closely related to a bank should be banned from buying the bank's subdebt.

[40] The condition $\alpha < b / (1 + r_{SD})$ implies that α is not high enough to deter the banker from absconding. To see this, suppose that the condition does not hold, so $\alpha (1+r_{SD}) > b$. When the bank's project will fail, the benefit for the banker from absconding (which is b) is less than the cost to invest in the subdebt (which is $(1 + r_{SD}) \alpha$), so the banker will not buy the debt and the bank will be examined. By this result, when the banker and the subdebt investor can collude, a sufficiently high subdebt requirement (that is, $\alpha > b / (1 + r_{SD})$) can deter the banker from taking value destroying actions. We do not discuss this case because we think that the amount of subdebt required to deter the banker from absconding may be too high in the real world. The results under the case where $\alpha > b / (1 + r_{SD})$ are available from the authors upon request. The condition $\alpha < c_M / r_{SD}$ guarantees that the banker will buy the subdebt when the bank's project will succeed. For the banker, when the project will succeed, the net cost for him to invest in the debt is $r_{SD} \alpha$, and the cost of the regulatory examination is c_M. If $\alpha < c_M / r_{SD}$, he will invest in the subdebt to avoid the regulatory examination when he learns that the project will succeed.

Also, cross-holding of subdebts between banks should be prohibited. Banks will abide by the no-collusion rules if the punishments for violating them are serious enough. On the other hand, as Proposition 5 shows, even if banks and subdebt investors can get around the no-collusion rules, subdebt regulation still has the function of bank capital regulation.

Next consider how a possible government bailout of the subdebt investor will affect the results. Suppose it is common knowledge that the government will bail out the subdebt investor with probability β when the bank's project fails, where β is a constant with $0 \le \beta \le 1$. The subdebt investor receives the full amount of D at date 2 when he is bailed out. All the other assumptions in Section 2 hold. The following proposition demonstrates that it becomes more difficult to induce the subdebt investor to monitor when the probability of a bailout is higher.

Proposition 6. Suppose that the government bails out the subdebt investor at date 2 with probability β when the bank's project fails.

(a) For i = S, B, if the subdebt investor believes that the banker chooses project i, the minimal α that can induce him to monitor is

$$\hat{\alpha}_i(\beta) \equiv \frac{c_I}{(1-p_i)(2q-1)(1+r_{SD})}\left[1+\frac{\beta}{p_i(1-\beta)}\right]. \qquad (24)$$

(b) $\hat{\alpha}_i(\beta)$ is increasing in β, and approaches infinity when β approaches 1.

The results in Proposition 6 are intuitive. As β increases, buying the debt without acquiring s becomes more attractive than monitoring to the investor. Hence, α must become larger to induce him to monitor. By part (b) of the proposition, when β is sufficiently high, the

minimum α that can induce the investor to monitor can far exceed the value of the bank's assets, which will make subdebt regulation infeasible. Proposition 6 implies that the effectiveness of subdebt regulation will be hampered if the government bails out subdebt investors too frequently.

To alleviate the problem that government bailouts may compromise the subdebt investors' incentives to monitor, we propose that subdebts issued to satisfy the subdebt requirement should have the following conversion feature: the subdebt will automatically convert into the issuing bank's common stock at a predetermined conversion price if the government takes over or provides open assistance to the bank. The conversion price is set high so that subdebt investors will suffer losses when conversion occurs. The government will have no incentive to go against the conversion to save subdebt investors because the conversion alleviates the bank's debt burden. In this way, the subdebt holders of a financially distressed bank will be punished even if the government bails out other creditors.[41] The fear of this punishment will induce subdebt holders to monitor banks. This conversion feature is not a new idea. Similar suggestions have been studied in other proposals. Please see Section 6.2 for more discussion.

Adding the conversion feature to subdebt does not change the results in our model. Because the bank's project has only two possible outcomes and the money left at the bank is insufficient to pay off the depositors when the bank's project fails, the value of the subdebt holder's converted shares is always zero at any positive conversion price.[42] As a result, the

[41] We implicitly assume that in a bank bailout, the government saves only the creditors, but not the shareholders of the bank. This assumption is reasonable. For example, according to Federal Deposit Insurance Corporation (1989), when the FDIC bailed out the Continental Illinois National Bank and Trust Company in 1984, the interests of its shareholders were eliminated.

[42] According the definition of the conversion feature stated in the paper, conversion will occur at date 2 if the bank's project fails and the government decides to bail out the bank. In this case, depositors are bailed out, while the banker and the subdebt investor are not.

players' payoffs in all the cases will not be affected by the conversion feature. However, if the model is modified so that the outcome of the bank's project becomes continuous, the value of the subdebt investor's converted shares will be positive if the government bails out the bank before the bank's equity value becomes negative. In this case, the conversion value of subdebt matters because it affects the investor's payoffs in bad states. When the conversion value is higher (that is, when the conversion price is lower), the investor's payoffs in bad states are higher, so he will require a lower yield on subdebt. This will make it easier for the bank to keep the subdebt yield below the interest rate ceiling. On the other hand, by reducing the punishment against the subdebt investor in bad states, a higher conversion value worsens the investor's incentives to monitor. Therefore, when the conversion value becomes higher, the government may have to raise the required amount of subdebt issued (that is, α) or lower the interest rate ceiling to increase the investor's monitoring incentives. The optimal conversion value of subdebt will depend on the tradeoff between these two effects.[43]

Finally, we briefly discuss how to determine the interest rate caps of subdebt. As shown in Section 4, the level of the interest rate cap must be adequate: the banker can induce the investor to buy the debt without monitoring if the cap is too high, and no investor will buy the debt if the cap is too low. In the literature, there have been some discussions on this issue. Several papers, including Calomiris (1999) and Evanoff and Wall (2001), propose that the yields on corporate bonds of a certain rating (such as BBB) are good candidates for the interest rate caps. The caps determined by this principle not only can timely reflect the changes in bond markets, but also may reduce the pro-cyclical problem of bank regulation

[43] That is, the conversion value should be higher if it is more important to make issuing subdebt a feasible choice for the bank, and should be lower if it is more important to preserve the investor's incentives to monitor.

because the risk premiums on corporate bonds of a certain rating are likely to be higher during recessions and lower during economic booms.[44] Also, the empirical results in Evanoff and Jagtiani (2004) suggest that subdebt regulation will be more effective if the corporate bonds used to set the caps have similar maturities with the subdebts. These papers provide an insightful guide for designing reasonable interest rate caps of subdebt.

6.2. Contingent capital certificates

Contingent capital certificates (CCCs thereafter) have recently been advocated as an important tool to alleviate the too-big-to-fail problem in the banking industry. For an issuing bank, CCCs are debt obligations when issued, and will convert into the bank's common stock if the bank's capital ratio falls below a predetermined value.[45] Take the proposal in Flannery (2009) for example. Flannery suggests that one alternative for a large financial firm to satisfy the capital requirement is to keep the market value of its common shares no lower than 4 percent of total assets if the firm has sufficient outstanding CCC. The face value of the CCC must be at least 4 percent of total assets, and the CCC will convert on the day after the market value of the firm's common shares falls below 4 percent of total assets. In addition, the conversion price is designed in a way that the market value of the shares that holders of the

[44] For more discussion on this point, see Evanoff and Wall (2001).

[45] There has not been a consensus on the main features of the CCC requirement. The issues under debate include whether the conversion triggers should be market-based or accounting-based measures, whether a systemic index that reflects the financial conditions of the whole banking industry should be included as a conversion trigger, whether the conversion price should be a premium price or a discounted price, and how to alleviate the potential stock price manipulation problem. For more discussion, see Albul, Jaffee, and Tchistyi (2010), Acharya et al. (2009), Duffee (2009), Flannery (2005, 2009), Hart and Zingales (2009), McDonald (2010), Pennacchi (2010), Strongin, Hindlian, and Lawson (2009), Sundaresan and Wang (2010), and Squam Lake Working Group on Financial Regulation (2009).

CCC receive is equal to the face value of the CCC on the day of the conversion.[46]

Requiring banks to issue CCCs has several merits. It lowers the issuing banks' bankruptcy probabilities if the conversions of CCCs into shares occur before banks become bankrupt. Also, by increasing the banks' risk-absorption capacities, the CCC requirement lowers the government's need to bail out banks as well as the amount of money the government has to inject into bailed-out banks. In addition, it implements market discipline by punishing bank shareholders whose banks are in weak financial conditions: their shares are diluted when CCCs are converted, and the implicit subsidy from government bailouts is substantially reduced. Another advantage of the CCC requirement is that issuing banks need not pay high interest rates on CCC bonds if the bonds are properly designed. A CCC bond is not risky if conversion always occurs before the issuing bank becomes financially distressed and the market value of the converted shares is no less than the bond's face value.

Because of the conversion feature we impose in Section 6.1, the subdebt regulation proposed in this paper is also a contingent capital proposal. As in other CCC proposals, the conversion feature of subdebt prevents the government from bailing out the creditors of distressed banks at the expense of taxpayers and enhances market discipline. The additional merit of the conversion feature in our proposal is that it preserves the subdebt investors' incentives to monitor banks, and monitoring by investors will generate valuable information for bank supervision. This implies that, if well designed, the CCC requirement may also play a positive role for enforcing prompt corrective actions in the banking industry.[47]

[46] See pages 9 to 10 in Flannery (2009).

[47] In the real world, banks' asset values may suddenly drop significantly. Therefore, CCC bonds may still be risky because the market values of the converted shares may fall below the face values of the bonds. When CCCs are not risk-free, it is possible for them to play the role of subdebt in the subdebt regulation we propose.

7. Concluding Remarks

In this paper, we demonstrate that subdebt regulation may reduce bank risk and improve social welfare. There are several directions to extend our model. One is to consider the case where bank managers do not maximize welfare of bank shareholders. In our paper, we assume that the banker owns and manages the bank. As Saunders et al. (1990) and Gorton and Rosen (1995) point out, the interests of bank managers may diverge from those of bank shareholders, and this divergence has important implications on the banks' moral hazard problems. It will be interesting to see how effective bank capital and subdebt regulations are in this case.

Another direction of extending the model is to investigate the case where bank risk is observable, so banks with higher asset risk have to pay higher interest rates on subdebt. This extension will allow us to learn more about the direct discipline effect of subdebt regulation. Finally, we can consider other regulatory mechanisms in our model. For example, Goyal (2005) shows that restrictive covenants in bank debts play an important role on mitigating bank risk taking. Esty (1998) suggests that imposing contingent liability on bank shareholders can reduce bank risk. Studying how these mechanisms affect the behavior of both bank managers and subdebt investors will be a promising topic for future study.

That is, regulators will examine banks that are unable to successfully issue CCCs, and will take corrective actions against a bank if the examination reveals that it is in a poor financial condition.

Appendix

Proof of Proposition 1.

As discussed in the text, if the bank's project fails, the banker will inject wealth to pay off the deposits if $k \geq k_2$, and will abscond otherwise. First consider the case where $k < k_2$. In this case, the banker will choose project S at date 0 if and only if

$$p_S [X_S - (1 - k)] + (1 - p_S) (b - F) \geq p_R [X_R - (1 - k)] + (1 - p_R) (b - F),$$

or equivalently $k \geq k_1$. Because $G > Y$, we know that $k_1 < k_2$.

Now consider the case where $k \geq k_2$. In this case, the banker will choose project S if and only if

$$p_S [X_S - (1 - k)] + (1 - p_S) [Y - (1 - k)] \geq p_R [X_R - (1 - k)] + (1 - p_R) [Y - (1 - k)],$$

or equivalently, $G \geq Y$, which always holds. Therefore, the banker always chooses project S if $k \geq k_2$. This completes the proof of the proposition. **Q.E.D.**

Proof of the Lemma.

By (7), $W_k(k_2) \geq W_k(k_1)$ if and only if (8) holds. Therefore, if $\Pi_k(S, k_2) \geq 0$ and (8) holds, the government should set $k = k_2$. Otherwise, it should set $k = k_1$. **Q.E.D.**

Proof of Proposition 2.

For j = S, R, define $D_{0j} \equiv (1 + r_{SD}) \alpha / p_j$. From the investor's payoffs for choosing the three alternatives, he will buy the debt without monitoring if $D \geq max\{\overline{D}_j, D_{0j}\}$, will monitor if $\underline{D}_j \leq D < \overline{D}_j$, and will neither acquire s nor buy the debt if $D < min\{\underline{D}_j, D_{0j}\}$. It can be easily shown that if $\alpha \geq \underline{\alpha}_j$, then $\overline{D}_j \geq D_{0j} \geq \underline{D}_j$. If $\alpha < \underline{\alpha}_j$, then $\overline{D}_j < D_{0j} < \underline{D}_j$. Using these facts, we can easily prove parts (a) and (b) of the proposition. For part (c), because $p_S > p_R$, it is obvious that $\underline{\alpha}_S > \underline{\alpha}_R$ by (12). Also, given $p_S > p_R$, by (13) and (14) it can be easily verified that $\overline{D}_R > \overline{D}_S$ and $\underline{D}_R > \underline{D}_S$ if $\alpha > \underline{\alpha}_S$. **Q.E.D.**

Proof of Proposition 3.

For part (a), if the banker undertakes project R in equilibrium, the equilibrium D is either

$\overline{D}_R$ or $\underline{D}_R$. If the banker induces the investor not to monitor, the equilibrium D is either $\overline{D}_R$ or $\overline{D}_S$. Therefore, under the requirement that $D < min\{\overline{D}_S, \underline{D}_R\}$, there is no perfect Bayesian equilibrium in which the investor chooses project R or buys the subdebt without monitoring. For part (b), suppose that the investor believes that the banker will choose project S. Because of the cap on D, the banker cannot induce the investor to buy the debt without monitoring. Therefore, the banker will choose project S and set $D = \underline{D}_S$ if and only if $\Pi_M(S, \underline{D}_S, k) \geq \Pi_M(R, \underline{D}_S, k)$, which is equivalent to (21). From these results, if subdebt regulation is imposed and (21) is satisfied, the only Perfect Bayesian equilibrium is the one in which the banker chooses project S and the investor monitors. This completes the proof of the proposition. **Q.E.D**.

Proof of Proposition 4.

It can be easily shown that $W_{SD} \geq W_k(k_1)$ if and only if (23) holds. This completes the proof of the proposition. **Q.E.D.**

Proof of Proposition 5.

Suppose that the banker is allowed to invest in the subdebt. As explained in the paper, he will be the only one who may buy the debt. First consider the case where he learns that the bank's project will succeed. Given $\alpha < c_M / r_{SD}$, the banker will buy the subdebt to save the cost of the regulatory examination because $c_M > \alpha\, r_{SD}$. Next consider the case where the banker learns that the bank's project will fail. In this case, he has three choices. Without considering the sunk cost $(1 + r_k)\, k$, his payoff is $Y - (1 - k - \alpha) - (1 + r_{SD})\, \alpha$ if he buys the debt and injects funds into the bank, is $b - F - (1 + r_{SD})\, \alpha$ if he buys the debt and absconds with money, and is $-F$ if he does not buy the debt. Given $\alpha < \frac{b}{1+r_{SD}}$, not buying the subdebt is strictly dominated by buying the debt and absconding. Therefore, the banker will always buy the subdebt when $0 < \alpha < \min\{\frac{b}{1+r_{SD}}, \frac{c_M}{r_{SD}}\}$. This proves part (a) of the proposition.

When the bank's project fails, injecting funds into the bank is better than absconding for

the banker if and only if $Y - (1 - k - \alpha) \geq b - F$, or equivalently, $k + \alpha \geq k_2$. Obviously, the banker will choose project S if he injects funds to the bank when the bank's project fails because he internalizes all the costs in this case. This proves part (b)(iii) of the proposition.

Finally, given the above discussions, for i = S, B, when $k + \alpha < k_2$, the banker's payoff for choosing project i is $p_i [X_i - (1 - k - \alpha) - D + D] + (1 - p_i)(b - F) - (1 + r_k) k - (1 + r_{SD}) \alpha$. It can be easily shown that he will choose project S if $k + \alpha \geq k_1$ and will choose project R otherwise. This completes the proof of the proposition. **Q.E.D.**

Proof of Proposition 6.

As in Section 4, in this case the investor offered to buy the subdebt has three choices: (i) buy the debt without acquiring s, (ii) neither acquire s nor buy the debt, and (iii) acquire s and buy the debt if and only if s = H. His payoffs for these three alternatives are

$$[p_i + (1 - p_i)\beta] D - (1 + r_{SD}) \alpha,$$

0, and

$$[p_i q + (1 - p_i)(1 - q)\beta] D - [p_i q + (1 - p_i)(1 - q)](1 + r_{SD})\alpha - c_1,$$

respectively. Applying the same logic for proving Proposition 2, it can be easily shown that the minimum α for inducing the investor to monitor is $\hat{\alpha}_i(\beta)$. This completes the proof of part (a). Part (b) is obvious from (24). **Q.E.D.**

Date 0	Date 1	Date 2
- The banker decides whether to establish a bank - If the banker establishes a bank, he puts k dollars in the bank as capital, and raises $1 - k$ dollars by issuing deposits. The banker then chooses between project S and project R.	- Deposits of α dollars mature. The bank issues subdebt to repay depositors. It announces D, the amount of money it promises to pay to the subdebt investor at date 2, and randomly picks an investor - Given D, the investor decides whether to spend c_I to acquire s. He then decides whether to buy the subdebt - If the investor refuses to buy the subdebt, the regulator examines the bank. He allows the bank to be reopened if its project will succeed, and takes over the bank if its project will fail. The reopened bank is allowed to issue deposits to pay off the maturing deposits	- The bank's project matures - If the bank is not taken over by the regulator at date 1, the banker decides whether to abscond with money, and whether to inject funds into the bank - Depositors and the subdebt investor get paid if the bank has enough money

The Figure. The Time Line of the Model.

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