Market Discipline and Regulatory Oversight: Evidence on Bank Risk and Liability Choices from 1986 to 2013

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June 2014

Abstract

We develop a theoretical model which shows that under risky lending and deposit insurance the asset and liability choices of a bank are interrelated through its probability of insolvency. Changes in the riskiness of a bank's asset portfolio imply changes in the pricing and structure of its assets and liabilities. We empirically test the implications of the model using U.S. bank holding company data for the September 1986 to December 2013 period. We find that interest rates on uninsured deposits are more sensitive to risk than those on insured deposits. We identify some sub-periods in which banks take advantage of this pricing difference and increase reliance on insured deposits relative to total liabilities to weaken market discipline. However, such regulatory arbitrage is not present in sub-samples of problem institutions, suggesting regulators may have prevented troubled banks from increasing their relative use of insured deposits to weaken market discipline. In addition, we find strong evidence that greater deposit risk premium is associated with a decrease in future insolvency risk for troubled institutions, supporting the view that depositors exert *ex post* influence on problem banks. The *ex post* influence becomes more evident after various regulations requiring more bank disclosure and increasing capital requirement went into effect since 2002.

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1. Introduction

Regulators, bank managers, and academic researchers are increasingly interested in understanding the ability of market investors and government regulators to discipline institution risk taking. The recent capital regulations for banking institutions (Basel II and Basel III) stress the importance of the role of market discipline in regulating banking firms. As Bliss and Flannery (2002) point out, market discipline manifests itself in two forms: monitoring and influence. Monitoring refers to the ability of investors to appraise a firm's condition and to incorporate their assessments into its security prices. Influence occurs when information from market monitoring is used to change managerial actions to improve firm condition. Flannery (2012) further categorizes influence as either *ex ante* or *ex post*. *Ex ante* discipline occurs if bank managers take into account the potential effect of risk changes on their firms' cost of capital when making new financial decisions. *Ex post* discipline happens if debtholders and other stakeholders put pressure on an excessively risky institution to take measures to reduce its risk exposure. Furthermore, information from a depository institution's debt and equity prices may supplement regulators' information set, leading to regulator-induced corrective actions if the institution does not conduct its business in a safe and sound manner.

Although numerous studies have examined the monitoring function of debtholders by assessing the accuracy of the yields of deposits and subordinated debt in reflecting the changing default risk of depository institutions, research on the *ex post* influence of debtholders on managers of depository institutions is relatively sparse. Bliss and Flannery (2002) examine the influencing roles of stocks and bonds for U.S. bank holding companies. However, there has been no study that empirically examines debtholders' monitoring function and their *ex post* influence at the same time. This paper fills this gap by investigating whether the monitoring function of depositors leads to an effective reduction of banks' incentives to take excessive risk. Because regulators also provide risk-control discipline, a related issue we examine is the relative roles of depositor discipline and regulatory oversight in influencing the behavior of banking firms. In addition, we study whether banks change their liability structure to respond to disciplinary actions of market investors and regulators. We examine these issues by developing a theoretical model on the interaction of a bank's asset and liability choices under risky lending and insurance deposit and performing empirical tests with quarterly data on the price and quantity of bank liabilities for a sample of U.S. bank holding companies. We examine the changing characteristics of market discipline and regulatory oversight from September 1986 to December 2013, a period that covers two banking crises and various changes of regulatory environment. The theoretical model and empirical findings from our paper shed light on how market and regulatory discipline have evolved over distinct banking eras.

In summary, we find evidence that depositors engage in *ex ante* monitoring of a bank's risk taking, as well as, they exert *ex post* influence on it. The interest rates on both insured and uninsured deposits contain a risk premium that increases with bank insolvency risk. Moreover, interest rates on uninsured deposits are more risk sensitive than those on insured deposits. We identify some sub-periods when banks increase the relative usage of insured deposits to weaken market discipline. However, this kind of regulatory arbitrage is absent from a sub-sample comprised solely of troubled institutions. Furthermore, there is strong evidence that greater deposit risk premium is negatively related to future changes in insolvency risk for troubled institutions. The *ex post* influence becomes more noticeable after 2002 following the introduction of various regulations that require more bank disclosure and increase capital requirement.

The rest of the paper is organized as follows. Section 2 develops the theoretical model and discusses its testable implications. Section 3 develops the empirical tests. Section 4 discusses the sample and data. Section 5 provides the empirical results. Section 6 concludes.

2. Theory and Testable Hypotheses

We develop a theoretical model to examine the interaction of a bank's asset and liability choices under insolvency risk and deposit insurance. Our model goes beyond the existing theoretical work (e.g., Klein,1971, and Landskroner and Paroush, 2008, and contributes to the literature by explicitly considering how the borrowers' risk affects a bank's pricing of deposits and the choice of its asset and liabilities.

2.1. The Model

Consider a one period model with a bank extending loans to a single borrower and accepting insured and uninsured deposits. The demand for loans and the supply of insured deposits and uninsured deposits denoted by *L*, *D*, and *U* are given by

$$\begin{aligned} L &= k - lr; k > 0, l > 0 \\ D &= a + bi; a \geq 0, b > 0 \\ U &= e + dj; e < 0, d > b > 0 \end{aligned} \tag{1}$$

where r, i, and j are the interest rates on loans, insured deposits and uninsured deposits, respectively. The demand for loans is a downward sloping function of the loan rate, while the supply of (insured and uninsured) deposits is an upward sloping function of the rate the bank pays; however, uninsured deposits are more sensitive to interest rate changes than insured deposits.[1] The t = 0 insurance premium P the bank pays is a percentage c of insured deposits; that is,

$$P = cD; c > 0 .$$

The bank's equity E cannot be less than the official capital requirement expressed as an exogenously fixed percentage m of its loans; i.e., $E \geq mL \geq 0$.[2] Further, the bank invests the part B of the deposits and equity not used to make loans or to pay the insurance premium in risk-free government securities which earn an interest rate g. Therefore, the bank's t = 0 balance sheet identity is

$$L + B + cD = D + U + E \quad (2)$$

And B is the slack variable.

The borrower's assets at t = 1, denoted by s, take values in the non-negative closed interval $[\underline{s}, \bar{s}]$ with a probability distribution whose density and cumulative density function is denoted by $f(s)$ and $F(s)$, respectively. The borrower repays the loan and remains solvent if $(1+r)L \leq s \leq \bar{s}$, but goes bankrupt if $\underline{s} \leq s < (1+r)L \leq \bar{s}$ and the bank captures the whole value of the borrower's assets s. The bank does not always fail when the borrower goes bankrupt; it only fails when $\underline{s} \leq s < s^*$, where $s^* \leq (1+r)L$ is the critical level of the borrower's assets for which the bank's t = 1 cash flow vanishes; i.e.,

$$s^* + (1+g)B = (1+i)D + (1+j)U .$$

Using (2) to substitute for B gives

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[1] The nonnegative intercept of D indicates the willingness of depositors to forego income for security, while the negative intercept of U suggests depositors require a minimum positive rate to bear the risk of such deposits.

[2] The Bank of International Settlement specifies capital requirement as a percentage of risk-weighted assets. Because cash and government securities can be assumed to have a zero risk weight, it is reasonable to state that the capital requirement equals a fixed percentage m of a bank's loans in the context of our model.

$$s^* = [(1+i) - (1+g)(1-c)]D + (j-g)U + (1+g)L - (1+g)E. \qquad (3)$$

The impact of *r*, *E*, j, and *i* on s^* is given by

$$\begin{aligned}
\frac{\partial s^*}{\partial r} &= -(1+g)l < 0 \\
\frac{\partial s^*}{\partial E} &= -(1+g) < 0 \\
\frac{\partial s^*}{\partial j} &= U - (g-j)d \\
\frac{\partial s^*}{\partial i} &= D - (g-i)b + (1+g)cb.
\end{aligned} \qquad (4)$$

Intuitively, *ceteris paribus*, increasing the rate *r* the bank charges on loans lowers *L*, which from (2) leads to an increase in *B*. As a result, the bank can break even for a lower level of the borrower's assets. A similar argument suggests that, all else the same, increasing equity enables the bank to break even for a lower level of the borrower's assets. An exogenous increase in the interest rate *j* the bank pays on uninsured deposits has two effects on s^*. First, it increases the interest payment on these deposits, thereby requiring a higher $s^*$for the bank to break even. Second, it increases uninsured deposits, thus impacting the amount the bank earns by investing the additional uninsured deposits in government securities. If the spread between the rate the bank earns on government securities and the rate it pays on uninsured deposits is positive (i.e., $g > j$), the bank earns more by investing the additional uninsured deposits in government securities, thus being able to break even for a lower s^*; the opposite is true if $g < j$. Depending on the relative strength of these two effects, increasing *j* may result in a higher or a lower s^*. Two similar effects are also associated with the impact of, *ceteris paribus*, an increase in i on $s^{*.}$ However, in this case there is an additional third effect. Specifically, the increase in *i* increases *D* requiring the bank to pay the premium on the additional insured deposits instead of using the money to invest in government securities; by foregoing the income it could earn by investing this additional premium in government securities, the bank breaks even at a higher s^*. Although the first and the third of these effects are positive, the second effect could be positive or negative depending on whether g is less than or exceeds i. Overall, the impact of $i$on s^* depends on the relative strength of these three effects.

The above discussion suggests that the same critical level s^* can be obtained by several different quadruples of r, i, j, and E values. Assume, for example, s^* increases with i, but is inversely related with j. Then, starting with a given s^*, the bank can appropriately increase r and j, while at the same time reduce i and E in such a way that s^* remains unchanged. Essentially, the reduction in s^* induced by the higher values of r and j and the lower value of i will be balanced by the increase in s^* caused by the lower value of E. This suggests that r, i, j, and E are not independent of each other; instead, they are interrelated through s^* or, equivalently, through the bank's probability of default.[3]

The bank's t =1 cash flow is given by

$$\begin{aligned}
&X = (1+r)L + (1+g)B - (1+i)D - (1+j)U && \text{if } s \in [(1+r)L, \bar{s}] \\
&Y = s + (1+g)B - (1+i)D - (1+j)U && \text{if } s \in [s^*, (1+r)L) \\
&Z = 0 && \text{if } s \in [\underline{s}, s^*).
\end{aligned} \tag{5}$$

Equation (5) says that if the borrower is solvent at t = 1, the bank collects the full loan repayment in addition to the proceeds from the investment in government securities and it returns insured and uninsured deposits with interest. On the other hand, if the borrower defaults but the bank

[3] However, r, i, j, and E may not be interrelated only through s^*. If income taxes are considered in the analysis, there is a different critical level of the borrower's assets, denoted with s^{**}, at which the bank's taxable income vanishes (i.e., $s^{**} + gB = iD + jU$) such that $s^* < s^{**} < (1+r)L$ with the bank paying income taxes only if the borrower's assets exceed s^{**}. Following reasoning similar to that for s^*, it follows that the bank's choices are interrelated through s^{**}. Hence, in the presence of taxes, the bank's decisions interact via the bank's probability of default and the bank's probability of paying income taxes. Although it adds to the complexity of the model, the introduction of taxes does not contribute much to the idea that r, i, j, and E are not independent of each other.

remains solvent, the bank possesses all the assets of the borrower along with the proceeds from the investment in government securities and repays insured and uninsured depositors with interest. Finally, if the borrower and the bank fail, the bank's cash flow vanishes.[4]

Assuming risk-neutrality, the bank's $t = 1$ net value V is given by

$$V = \int_{(1+r)L}^{\bar{s}} Xf(s)ds + \int_{s*}^{(1+r)L} Yf(s)ds - (1+g)E ,$$

which, using (2) and (5), reduces to

$$V = (r-g)L + (g-i)D + (g-j)U - \int_{s*}^{(1+r)L} F(s)ds - (1+g)cD . \qquad (6)$$

Intuitively, (6) says the end-of-period value of the bank is equal to the income from loans net of the opportunity cost of investing in government securities, plus the net income earned from the investment of insured deposits in government securities, plus the net income earned from the investment of uninsured deposits in government securities, minus the net loss incurred when the borrower defaults,[5] minus the insurance premium cost of insured deposits.

The bank's problem is to choose r, i, j, and E to

$$\begin{aligned} & Maximize\, V \\ s.t.\quad & mL - E \le 0 \\ & \underline{s} - s^* \le 0 \\ & s^* - (1+r)L \le 0 \\ & (1+r)L - \bar{s} \le 0 \\ & r \ge 0, i \ge 0, j \ge 0, E \ge 0 \end{aligned} \qquad (7)$$

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[4] It is implicitly assumed that bankruptcy of the borrower or the bank is costless.

[5] Denoting with M the bank's expected cash flow when the borrower defaults but the bank survives and with N the expected loss of the full repayment cash flow X the bank incurs when the borrower defaults, it follows that

$$M \equiv \int_{s*}^{(1+r)L} YdF(s) = X \cdot F((1+r)L) - \int_{s*}^{(1+r)L} F(s)ds \equiv N - \int_{s*}^{(1+r)L} F(s)ds$$

implying

$$\int_{s*}^{(1+r)L} F(s)ds = N - M$$

which is the net loss incurred when the borrower defaults.

where V is given by (6), the first constraint is the bank's capital requirement constraint, the second constraint requires that the minimum level s^* of the borrower's assets for which the bank remains solvent is greater than the lower limit of s, the third constraint requires that the critical level s^* of the borrower's assets does not exceed the borrower's loan repayment, the fourth constrain requires that loan repayment does not exceed the borrower's upper limit of assets, and the rest are the non-negativity constraints for the bank's choices. From (6), the bank's value depends on the s^*, the critical value of the borrower's assets. As indicated earlier, the bank's choices of r, i, j, and E are interrelated through s^*. It then follows that the optimal r, i, j, and E which maximize the bank's value are not chosen independently of each other but, instead, they are determined simultaneously.

The problem in (7) is a nonlinear maximization problem and its Lagrangean function is

$$\Lambda = V + \lambda_1 (E - mL) + \lambda_2 (\mathrm{s}^* - \underline{s}) + \lambda_3 [(1+\mathrm{r})L - \mathrm{s}^*] + \lambda_4 [\bar{s} - (1+r)L],$$

where λ_i, i = 1, 2, 3, 4 are the Lagrange multipliers. In general, obtaining a closed form solution for the bank's maximization problem is difficult. Even so, the problem's optimal solution must satisfy the following Kuhn-Tucker conditions for a maximum

$$\frac{\partial \Lambda}{\partial r}=\frac{\partial V}{\partial r}-\lambda_1 m\frac{\partial L}{\partial r}+(\lambda_2-\lambda_3)\frac{\partial s^*}{\partial r}+(\lambda_3-\lambda_4)\left[L+(1+r)\frac{\partial L}{\partial r}\right] \le 0 \quad r\ge 0 \quad and \quad r\frac{\partial \Lambda}{\partial r}=0$$

$$\frac{\partial \Lambda}{\partial i}=\frac{\partial V}{\partial i}+(\lambda_2-\lambda_3)\frac{\partial s^*}{\partial i} \le 0 \quad i\ge 0 \quad and \quad i\frac{\partial \Lambda}{\partial i}=0$$

$$\frac{\partial \Lambda}{\partial j}=\frac{\partial V}{\partial j}+(\lambda_2-\lambda_3)\frac{\partial s^*}{\partial j} \le 0 \quad j\ge 0 \quad and \quad j\frac{\partial \Lambda}{\partial j}=0$$

$$\frac{\partial \Lambda}{\partial E}=\frac{\partial V}{\partial E}+\lambda_1+(\lambda_2-\lambda_3)\frac{\partial s^*}{\partial E} \le 0 \quad E\ge 0 \quad and \quad E\frac{\partial \Lambda}{\partial E}=0$$

$$\frac{\partial \Lambda}{\partial \lambda_1}=E-mL \ge 0 \quad \lambda_1\ge 0 \quad and \quad \lambda_1\frac{\partial \Lambda}{\partial \lambda_1}=0$$

$$\frac{\partial \Lambda}{\partial \lambda_2}=s^*-\underline{s} \ge 0 \quad \lambda_2\ge 0 \quad and \quad \lambda_2\frac{\partial \Lambda}{\partial \lambda_2}=0$$

$$\frac{\partial \Lambda}{\partial \lambda_3}=(1+r)L-s^* \ge 0 \quad \lambda_3\ge 0 \quad and \quad \lambda_3\frac{\partial \Lambda}{\partial \lambda_3}=0$$

$$\frac{\partial \Lambda}{\partial \lambda_4}=\bar{s}-(1+r)L \ge 0 \quad \lambda_4\ge 0 \quad and \quad \lambda_4\frac{\partial \Lambda}{\partial \lambda_4}=0$$

As indicated earlier, the borrower's assets take values in the closed interval $[\underline{s},\bar{s}]$. The width of this interval is indicative of the borrower's riskiness. If, for instance, the upper bound of this interval remains the same but the lower bound increases, the upside potential for the borrower's assets remains the same but now their value cannot drop as low as before; hence, the riskiness of the borrower is reduced. This may cause the bank to reassess the rate it charges on its loans to the borrower. However, since the bank's choices (i.e., *r, i, j,* and *E*) are interrelated through s^* it follows that not only the rate on loans but also equity, the rates on both types of deposits, as well as the borrower's critical level of assets may change as a result of the borrower's reduced risk. Despite the lack of closed form solution to the bank's problem, it is possible to demonstrate the existence of an optimal solution to the bank's problem and assess the impact of a change in the borrower's riskiness on the optimal solution through a numerical example.

An Example

Table 1 provides the specifics of such an example. Part A of the table gives the assumed values of the different parameters. In line with existing empirical literature, the intercept and the slope of the insured deposits are positive (Amel and Hannan 1999); for uninsured deposits the intercept is negative while the slope is positive (Billet et al. 1998) and, as indicated in connection with (1), greater than the slope of the insured deposits. For loans the intercept is positive and the slope negative. The official capital requirement is eight percent of the loans. The portion of insured deposits the bank pays as premium is five and a half percent. The upper limit of the distribution of s, the borrower's assets, is one, while the lower limit is initially equal to zero and it is assumed that s is uniformly distributed. *Mathematica* is used to solve the bank's maximization problem. To be realistic, the rate on government securities is set equal to 5.6 percent, the average 6-month T-bill rate during 1982-2009, and *Mathematica* is instructed to choose rates in the $.03 \leq r \leq .2$, $.056 \leq i \leq .2$, and $.056 \leq j \leq .2$ intervals, representative of the rates that prevailed during the same period for loans, insured deposits, and uninsured deposits, respectively. Further, equity is required to be non-negative and no less than the required official capital requirement mL. In addition, as suggested in the model, the solution obtained by *Mathematica* must result in a critical level s^* of the borrower's assets that lies between the lower and upper limit of s and it must be at most equal to the loan repayment which, in turn, cannot exceed the upper limit of the borrower's assets. All these constraints along with the non-negativity constraints for the bank's choice variables r, i, j, and E are reported in Part B of the table. Finally, unlike the model presented earlier, the example also requires that the rates paid on insured and uninsured deposits exceed the 6-month T-bill rate and investment in government securities is non-negative.

Using these parameter values, the optimal solution obtained by *Mathematica* is reported in the first row of Part C of Table 1. Clearly, $r, i, j, E > 0$, and the bank just satisfies the minimum capital requirement. Further, the optimal value of the bank is positive and all the constraints in Part B of the table are satisfied. Finally, the next to the last column of the table gives $N - M$ which, as indicated in footnote 5, is the net loss the bank suffers when the borrower defaults.

Recalling that $s \in [0,1]$, the lower bound is now gradually increased by one percent of the original interval's width (i.e., by .01) and the results are reported in the remainder of Part C of Table 1. As the lower bound increases, the risk of the borrower declines. However, in this example the rate on loans and insured deposits do not change as risk is reduced. On the other hand, the rate on uninsured deposits eventually drifts lower. Loans and insured deposits remain unchanged, while after a while uninsured deposits decline and remain at a lower level. As the risk of the borrower declines, the bank's equity increases but its investment in government securities is practically always equal to zero. Further, as the borrower becomes less risky the value of the bank increases while the net loss it suffers when the borrower defaults increases. Finally, all the constraints in Part B of the table are satisfied.

2.2. Empirical implications from the theoretical model

The example in the previous section demonstrates the implications of our theoretical model regarding the possible impact the riskiness of assets may have on the pricing and composition of a bank's assets and liabilities. Specifically, exogenously changing risk (i.e., changing the lower bound of the domain of the distribution of the borrower's assets) results in the reevaluation of the critical level s^* of the borrower's assets for which the bank's cash flow vanishes; equivalently, it changes the probability the bank will be solvent or bankrupt upon loan maturity. This change may be attained via an adjustment in the levels of the determinants of the critical level s^* which are the prices of loans (r) and deposits (i and j), as well as the level of the bank's equity. The change in their pricing necessitates adjustments in the bank's level of loans, secured and unsecured deposits and, by default, government securities. Based on the above implications of the model, our empirical work examines how a bank's risk affects its liability choices and the interest rates on its deposits during different banking eras. Our findings shed light on how market discipline and regulatory oversight evolve over different banking and regulatory regimes.

2.2.1. Do depositors monitor bank risk taking?

We examine bank depositors' monitoring ability by examining whether interest rates on insured and uninsured deposits increase with bank risk. The numerical example in Table 1 suggests that the interest rates of insured deposits and uninsured deposits respond differently to changes in bank risk. For the set of parameters assumed, Table 1 shows that interest rates on uninsured depositors are more risk sensitive than those on insured deposits. The empirical work in this paper examines interest rates on insured deposits and uninsured deposits separately to ascertain differences in the way the two types of depositors monitor banking firms. The existence of a positive relation between deposit rates and bank risk suggests that depositors can monitor the financial condition of banking firms.

2.2.2. Does the monitoring function of depositors lead to an effective reduction of banks' incentives to take excessive risk?

If depositors can monitor bank risk taking, and interest rates on insured or uninsured deposits contain a risk premium that increases with the probability of bank insolvency, then depositors may exert *ex ante* and/or *ex post* influence on banks' managerial behavior. Our study focuses on investigating the relation between the monitoring function of depositors and their *ex post* influence on managers of excessively risky banks to take actions to reduce bank risk. The *ex post* influence may come from depositors directly, or from regulators that use deposit price and quantity information to identify banks that may require corrective action. If *ex-post* influence on excessively risky banks is effective, we expect future bank risk to be negatively related to the current risk premium contained in the deposit rates of these institutions. On the other hand, we expect *ex post* depositor influence to be ineffective if the negative relation between the risk premium and bank future insolvency risk is absent.

2.2.3. Do banks replace uninsured with insured deposits to weaken depositor influence?

Previous research has examined the changes in the liability composition of depository institutions around particular discrete events that indicate changes of institution risk. Billett et al. (1998) suggests that, if the costs of insured deposits are less sensitive to risk increases than the costs of other uninsured liabilities, a troubled bank could soften market discipline by expanding its usage of insured deposits relative to other uninsured liabilities. They provide evidence that banks can reduce the burden of market discipline by increasing (decreasing) their reliance on insured deposits after the announcement of Moody's downgrade (upgrade). Goldberg and Hudgins (2002) examine how thrifts that face impending insolvency resolution change their deposit composition. They find that failed thrifts exhibit declining proportions of uninsured deposits-to-total deposits prior to failure. However, Goldberg and Hudgins (2002) find mixed results on whether failing thrifts have lower uninsured deposits-to-total deposits ratio prior to failure relative to solvent institutions.

While Billet et al. (1998) and Goldberg and Hudgins (2002) study depositor discipline under extreme cases, how banks' liability composition responds to institution risk taking has not been formally analyzed under more general and less dramatic situations. Neither has this issue been examined for periods of financial crisis. Our paper seeks to compile evidence on the relation between an institution's liability composition and its risk changes over distinct banking eras. We develop a measure of banks' insolvency risk and examine whether banks lessened the weight of depositor discipline by substituting insured deposits for uninsured deposits when their risk increased. Our numerical example in Table 1 shows that as bank risk increases (i.e., $\underline{s}$ decreases), the bank increases its usage of uninsured deposits over some interval of $\underline{s}$ (from 0.01 to 0.10 in Table 1). While insured deposits remain mostly unchanged, the percentage of uninsured deposits over total liabilities in general increases as the bank becomes riskier. This suggests that greater risk sensitivity of uninsured deposits relative to insured deposits may not necessarily lead to increased reliance on insured deposits to reduce market discipline.

2.2.4. The relation between depositor discipline and regulatory oversight

Evidence from Prowse (1997) suggests that there exists a substitution relation between discipline from insiders on the board of directors and large shareholders and discipline from regulators in corporate control markets.[6] Goyal (2005) finds that the incentives of subordinated debtholders to discipline excessive risk taking of banking firms are stronger in a less regulated

[6] Prowse (1997) finds that the likelihood of regulatory intervention in a BHC decreases with the equity stakes of insiders that are on the board of directors and with the equity stakes of large shareholders for a sample of U.S. BHCs from 1987 to 1992.

environment. However, the relation between depositor discipline and regulatory oversight has not been directly examined by previous empirical research. Whether the relation is a substitutionary or complementary one is still an empirical question. We plan to fill the void by first identifying key regulatory changes from 1986 to 2013 and dividing the entire period into sub-periods according to their extent of regulatory stringency. Then, we examine how the sensitivity of a bank's deposit interest rate to changes in its risk is related to the stringency of regulatory discipline.

3. Empirical Design

This section develops the econometric model we use to perform our empirical tests. We perform several tests to capture the comparative statics of our theoretical model. First, we assess the impact of a bank's insolvency risk on the pricing of its insured and uninsured deposits using the following reduced-form regressions:

$$i_{mt} = \alpha_0 + \alpha_1 RISK_{mt} + \alpha_2' X_{mt} + \eta_{1mt}, \tag{8}$$

$$j_{mt} = \beta_0 + \beta_1 RISK_{mt} + \beta_2' X_{mt} + \eta_{2mt}, \tag{9}$$

where i_{mt} and j_{mt} are the interest rates on bank *m*'s insured deposits and uninsured deposits at time *t*, respectively; α_0, a_1, β_0, and β_1 are the corresponding coefficients; α_2 and β_2 are vectors of coefficients; η_{1mt} and η_{2mt} are random error terms; $RISK_{mt}$ is bank *m*'s probability of being in financial distress at time *t*; and X_{mt} is a vector of control variables.

Second, we study the effect of insolvency risk has on a bank's level of insured and uninsured deposits using the following reduced-form equations for *D* and *U*:

$$Ln(D_{mt}) = \delta_0 + \delta_1 RISK_{mt} + \delta_2' X_{mt} + \mu_{1mt}, \tag{10}$$

$$Ln(U_{mt}) = \gamma_0 + \gamma_1 RISK_{mt} + \gamma_2' X_{mt} + \mu_{2mt}, \tag{11}$$

where $Ln(Dmt)$ and $Ln(Umt)$ are the natural logarithm of insured deposits and uninsured deposits for bank *m* at time *t*, respectively; δ_0, δ_1, γ_0, and γ_1 are the corresponding coefficients; δ_2 and γ_2 are vectors of coefficients; and μ_{1mt} and μ_{2mt} are random error terms. We use the natural logarithm of insured deposits and uninsured deposits to alleviate the potential problem of extreme observations on the dependent variables.

Third, to test whether banks increase their reliance on insured deposits relative to total liabilities to weaken market discipline, we also perform the following reduced-form regression:

$$\frac{D_{mt}}{Liability_{mt}} = \lambda_0 + \lambda_1 RISK_{mt} + \lambda_2' X_{mt} + \mu_{3mt}, \qquad (12)$$

where λ_0 and λ_1 are the corresponding coefficients, λ_2 is a vector of coefficients, and μ_{3mt} is a random error term.

We measure $RISK_{\mathrm{mt}}$ in equations (8) - (12) as the probability that bank *m* is a problem institution in quarter *t*, i.e., $Pr(Problem\ Bank)_{mt}$. Ashcraft (2008) uses the 85th percentile of the ratio of problem loans to regulatory capital as a cut-off point to classify problem banks. He documents that problem banks identified this way resembles closely the CAMEL rating of 3/4/5, used by U.S. regulators to define a problem bank. Because data on problem loans are available publicly only from March 2001, this variable is missing for a substantial number of bank holding companies in our sample; hence, we use the ratio of allowance for loan and lease losses to regulatory capital to classify problem banks. As in Ashcraft (2008), regulatory capital is estimated as the sum of the BHC equity capital[7] and subordinated debt. We classify a bank as a problem institution if its ratio of allowance for loan and lease losses is over the 85th percentile of

[7] Bank holding company capital includes the following items from the FR Y-9C reports: (1) perpetual preferred stock and related surplus, (2) common stock (par value), (3) surplus (exclude all surplus related to preferred stock), (4) retained earnings, (5) accumulated other comprehensive income, and (6) other equity capital components.

all observations. For banks that have information on both allowance for loan and lease losses to capital and problem loans to capital, the correlation between the two ratios is 0.79. Given this high correlation, we expect our classification of problem banks to be similar to the one in Ashcraft (2008). In general, it is expected that a bank becomes a problem institution, and also increases the loss exposure of the FDIC, as a result of excessive risk taking.

We estimate $Pr(Problem\ Bank)_{mt}$ synthetically following a procedure similar to that in Guo (2003). This procedure mimics the process by which market investors may estimate the probability of an institution to be a problem bank. It is assumed that, before estimating bank *m*'s probability of being a problem bank at quarter *t*, investors first ascertain the determinants of being a problem bank from historical data. This could be done through a logit regression. The binary dependent variable $f_{,m,t\text{-}1}$ in this regression equals 1 if bank *m* is a problem bank in the previous quarter (*t*-1), and 0 otherwise. The logit regression is specified as

$$f_{m,t-1} = b' Z_{m,t-2} + \varepsilon_{m,t-1}, \qquad (13)$$

where *b* is a vector of parameters, *Z* is a vector of explanatory variables, and ε is a random-error term. Data for the explanatory variables for this logit regression come from bank call reports for quarter (*t*-2). Previous insolvency-prediction studies (Sinkey, 1975; Altman, 1977; Thomson, 1991; Cole, 1993; and others) include in *Z* variables that proxy for deposit institutions' capital adequacy, credit quality, management efficiency, earnings power and liquidity to estimate their insolvency probability. In line with that, we use bank holding company equity capital to assets, provision of loan losses to assets, operating expenses to assets, return on assets, cash and securities to assets and the natural logarithm of total assets as explanatory variables in the logit regression. Given the coefficient vector *b* estimated from the logit regression, market investors could then infer bank *m*'s probability of being a problem bank for quarter *t*, $\Pr(Problem\ Bank)_{mt}$ using its financial-statement data from the most recent quarter (*t*-1), i.e.,

$$\Pr(Problem\ Bank)_{mt} = \frac{\exp(b' Z_{m,t-1})}{1 + \exp(b' Z_{m,t-2})} \qquad (14)$$

Finally, to ascertain the existence of *ex post* influence from depositors, we estimate bank m's risk premium at time t (denoted as $PREMIUM_{mt}$) for its insured and uninsured deposits as $\alpha_1 RISK_{mt}$ and $\beta_1 RISK_{mt}$ respectively; where α_1, β_1 and $RISK_{mt}$ are estimated from equations (8), (9) and (14), respectively. We test whether greater risk premiums embedded in deposit interest rates result in greater constraints against excessive risk taking. These constraints may come from depositors directly, or from bank regulators and other stakeholders that utilize the information revealed by the risk premiums. We estimate the logit model in equation (15) on the likelihood of improvement in insolvency risk.

$$Dimprove_{m,t+1} = \theta_0 + \theta_1 Premium_{mt} + \theta_3 Ln(Assets) + \varepsilon_{m,t+1}, \qquad (15)$$

where the dependent variable *Dimprove* equals one if a BHC's probability of being a problem bank in the next period is less than that of the current period, and zero otherwise; θ_0, θ_1 and θ_2 are the corresponding coefficients; and $\varepsilon_{m,t+1}$ is a random error term. Intuitively, regression (15) enables us assess whether changes in the risk premium embedded in the current rates on insured and uninsured deposits impacts the bank's riskiness in the following period. If greater risk premiums result in greater influence to deter excessive risk taking, we expect θ_1 to be positive. We include *Ln*(*Assets*) in equation (15) to control for the size effect.

<u>*Tests of Interest*</u>

We first examine whether a bank's deposit interest rate contains a risk premium. The presence of a risk premium is consistent with a positive coefficient on bank insolvency risk (*RISK*) in equations (8) and (9), i.e.,

$\alpha_1 > 0$, and $\beta_1 > 0$.

Next, we analyze how these coefficients change over time. The objective is to examine whether the risk premium changes across various banking eras. In addition, we examine whether the cost of insured deposits is less risk sensitive than the cost of uninsured deposits, i.e., whether

$\beta_1 - \alpha_1 > 0$.

Furthermore, we test for the signs of the *RISK* coefficients δ_1 and γ_1 in (10) and (11) to determine how the levels of insured and uninsured deposits are affected by changes in the bank's risk. More importantly however, we are interested in how a bank's relative reliance on uninsured deposits is impacted by changes in its risk. If banks increase the proportion of insured deposits (uninsured deposits) relative to total liabilities to soften (strengthen) depositor discipline, we expect $\lambda_1<0$ ($\lambda_1>0$) in equation (12).

Moreover, if bank depositors exert *ex post* influence on problem institutions, we expect banks are more likely to reduce their future insolvency risk when the current risk premium contained in their deposit rates is higher, i.e., $\theta_1>0$ in equation (15).

In addition, we plan to analyze the relation between market discipline and regulatory discipline by examining how the coefficients on $RISK_{mt}$ in equations (8) - (12) vary with the changing regulatory environment.

4. Data and Sample

The sample in this paper includes all the U.S. bank holding companies (BHCs) for the period of September 1986 to December 2013. Our sample period starts in the third quarter of 1986 because it is the earliest time the quarterly data on the Consolidated Report of Condition and Income (the call reports) are publically available from the website of the Federal Reserve

Bank of Chicago. The 27-year period covers the banking crisis in the 1980s, the most recent financial crisis since 2007, and various regulatory regime changes in the banking industry. This allows us to examine how the changing regulatory and economic environment affects the relation between the riskiness of the banks and the compositions of their assets and liabilities.

We obtain the quarterly call reports (Y-9C) data from the third quarter of 1986 to the end of 2013 from the website of the Federal Reserve Bank of Chicago. Table 2 reports the definition and summary statistics of the variables used in the empirical analysis. The control variable vector *X* in equations (8) - (12) includes the (1) FDIC reserve ratio, (2) natural logarithm of bank assets, *Ln(Assets)*, (3) 6-month T-Bill rate, (4) natural logarithm of state personal income, *Ln(STATEINC)*, (5) statewide Herfindahl-Hirschman Index for banks, *HHIB*, (6) state population density (*DENSITY*), and (7) quarter dummy variables. The FDIC reserve ratio is the FDIC's Bank Insurance Fund balance as a percent of the insured deposits of all the insured U.S. commercial banks. We include it to measure the constraint on FDIC's liquidation capacity and the likelihood of bank closure with an incomplete FDIC payoff. Because depositors view T-bills and bank deposits as substitutes, the level of T-bill rate should affect deposit supply. It is expected that deposit rates move in accordance with the similar-maturity risk-free rate (Guo 2003).

Ln(Assets) is used to control for bank size. It also measures the cross-regional competition among large banks for subsidized borrowing and lending opportunities. If larger banks are more aggressive in obtaining deposit insurance subsidies, then *Ln(Assets)* should be positively related to banks' deposit interest rates. However, *Ln(Assets)* could also capture a bank's monopoly power and depositors' assessment of the likelihood of closure with an incomplete FDIC payoff. If banks with greater monopoly power pay lower deposit rates, or if larger institutions are thought to be protected by a "too-big-to-fail" policy (Park and Peristiani, 1998), increases in the size of an institution should decrease the deposit rates it would offer. Whether deposit rates increase with *Ln(Assets)* depends on whether the moral-hazard effect dominates the impacts of monopoly power and the too-big-to-fail policy (Guo, 2003). We use *Ln(STATEINC)*, to control for the effects of regional economic condition on deposit supply (Berger and Hannan, 1989 and others). Statewide Herfindahl-Hirschman Index for banks (*HHIB*) is calculated by summing the squared market share of each firm's deposits in its state. We expect higher *HHIB* to be associated with greater market concentration and less competition in the deposit market. Thus interest rates on deposits should be negatively related to *HHIB* (Berger and Hannan, 1989).[8] As in Park and Peristiani (1998), *DENSITY* is also included to control for deposit market variation due to different population densities. *DENSITY* is defined as the number of inhabitants per square mile in a state. We expect greater *DENSITY* to be associated with greater deposit supply and lower interest rate on deposits.

Variables *ASSETS*, bank holding company equity capital, provision of loan losses, operating expenses, return on assets, cash and securities are computed using data from the call reports of the bank holding companies. *HHIB* is calculated using the Summary of Deposits data as of June 30 in each year from the FDIC.[9] The 6-month T-bill rates are extracted from the Federal Reserve Board's website. State population density (*DENSITY*) is calculated based on the data the U.S. Census Bureau. State personal income (*STATEINC*) comes from the U.S.

[8] An alternative measure of market concentration used by Hannan and Hanweck (1988) and Berger and Hannan (1989) is the three-firm concentration ratio. Because they find the results are not affected by the choice of the Herfindahl-Hirschman Index or the three-firm concentration ratio, our paper limits the proxy for market concentration to *HHIB*.

[9] The Summary of Deposits data are available only on an annual basis.

Department of Commerce, Bureau of Economic Analysis' Regional Economic Information System. The FDIC's fiscal year-end reserve balance and reserve ratio are extracted from the website of the FDIC.

We obtain the FR Y-9C reports for all the BHCs that filed them between the third quarter of 1986 and the end of 2013. BHCs with total consolidated assets of $500 million or more are required to file FR Y-9C reports. We obtain total asset data from the Federal Reserve Bank of Chicago's Holding Company database for 4768 BHCs in our sample. After deleting BHCs that have missing observations for the variables used to estimate the regressions in equations (10) to (12), we have 4603 and 4190 BHCs to estimate the regressions on the quantities of insured and uninsured deposits, respectively. Because actual deposit interest rate data are not available, we follow Amel and Hannan (1999) in estimating these rates by dividing deposit interest expenses by the amount of deposits held. Interest expenses data for insured deposits and uninsured deposits are reported separately starting March 1997; therefore, we estimate our deposit interest rates regressions in (8) and (9) over the period following March 1997. As a result, we have 3471 and 3447 BHCs with complete information to estimate the regressions of interest rates on insured deposits and uninsured deposits, respectively.

Table 2 reports that the total assets of the bank holding companies range from $6.45 million to $2.46 trillion, insured deposits and uninsured deposits account for 76.07% and 13.96% of banks' total liabilities, respectively. To alleviate the effect of possibly spurious outliers, we winsorize extreme (1^{st} and 99^{th}) percentiles of the interest rates on insured and uninsured deposits.

5. Empirical Findings

To examine how the sensitivities of a bank's deposit interest rate and quantity to changes in its risk are related to the stringency of regulatory discipline, we divide our sample period into nine sub-periods according to the key regulatory changes that may have affected the extent of regulatory stringency. Table 3 lists the sub-periods and the key regulatory changes that occurred with the period. From the third quarter of 1986 (1986Q3) to the end of 2013 (2013Q4), we have identified two U.S. banking crises and several key banking acts that were designed to change the regulatory environment of banking firms. The two banking crises are the 1980s crisis and the more recent crisis that started in 2007. The banking acts include the Financial Institutions Reform, Recovery, and Enforcement Act (FIRREA) of 1989, Federal Deposit Insurance Corporation Improvement Act (FDICIA) of 1991, Riegle-Neal Interstate Banking and Branching Efficiency Act (IBBEA) of 1994, Gramm-Leach-Bliley Act (GLB Act) of 1999, Sarbanes-Oxley Act (SOX) of 2002, Basel II capital requirement that was initially published in 2004, Dodd-Frank Act of 2010, and Basel III capital requirement that was initially issued in 2010.

Tables 4 to 6 present the results from the random-effects generalized least squares (GLS) panel-data regressions of the interest rates of insured and uninsured deposits in equations (8) and (9), respectively. The error terms are clustered at the BHC level. We estimate each regression using the whole sample period and various sub-periods as specified in the tables.

Table 4 reports the GLS panel-data regressions of the interest rates on insured deposits of 3471 [10] BHCs for different sub-periods. For most of the sub-periods, the coefficient on Pr(*Problem Bank*) is significantly positive at the 1% level. Only in the 2002Q2-2004Q2 pre-Basel II sub-period is the coefficient on Pr(*Problem Bank*) insignificant. This suggests that in

[10] Each sub-period regression in Table 4 has fewer than 3471 BHCs because many BHCs do not have data for all the quarters between 1997Q1 and 2013Q4.

general, interest rates on insured deposits increase with the likelihood of bank insolvency. The coefficient on *FDIC Reserve Ratio* is significantly negative for 3 out the 6 sub-periods. These findings indicate that, even insured depositors monitor bank risk taking due to their concern about bank insolvency and an incomplete depositor payoff.

The results on the control variables in Table 4 are interesting as well. The coefficient on *Ln(Assets)* is significantly negative in four out of the six sub-periods. This is consistent with the view that larger banks with greater monopoly power pay lower deposit rates. It is also consistent with the scenario that larger banks are more likely to be protected by a "too-big-to-fail" policy (Park and Peristiani, 1998) and their depositors are content with a smaller risk premium. However, the coefficient on *Ln(Assets)* is insignificant for the post Basel II period (2004Q3-2007Q3) and the post Dodd-Frank, post Basel III period (2010Q3-2013Q4). In addition, Table 4 also shows that the coefficient on *T-Bill Rate* is significantly positive in four out of the six sub-periods, indicating that bank deposit interest rates move in the same direction as the risk-free rate. However, the significantly negative coefficient on *T-Bill Rate* for the 1997Q1-1999Q3 and the 2010Q3-2013Q2 sub-period is puzzling. Moreover, at least one of the coefficients on *HHIB*, *DENSITY* and *Ln*(*STATEINC*) is significantly negative for each sub-period, consistent with the view that banks pay lower rates in states with more market concentration and greater supply of funds.

Table 5 presents the regressions on interest rate of uninsured deposits of 3447 BHCs of different sub-periods. The coefficient on Pr(*Problem Bank*) is significantly positive for all the sub-periods. This suggests that the interest rate on uninsured deposits also contains a risk premium that increases with the bank’s insolvency risk. The coefficients of other control variables show similar pattern as those in Table 4.

To compare how the rates on insured and uninsured deposits respond to bank risk, Panel A of Table 6 reports only the coefficients on Pr(*Problem Bank*) and their z-statistics for the interest rate regressions in Tables 4 and 5 for all sub-periods in our sample. As expected, the coefficient of Pr(*Problem Bank*) is much larger for uninsured deposits than that for insured deposits, indicating that the interest rate of uninsured deposits is much more risk sensitive than that of insured deposits. The contrast in risk sensitivity between rates on insured and uninsured deposits suggests that uninsured depositors monitor bank risk more intensively than insured depositors. Panel B of Table 6 reports the coefficients on Pr(*Problem Bank*) for the deposit interest rates regressions for problem BHCs only. It appears that the coefficients of Pr(*Problem Bank*) for the problem BHC sub-sample are mostly greater than those for the whole sample for both insured and uninsured deposits. This suggests that in general, depositors exert greater market discipline on troubled institutions. However, for the 2010Q3-2013Q4 post Dodd-Frank period, the coefficient on Pr(*Problem Bank*) ceases to be significant for the sub-sample of problem BHCs. This is consistent with the scenario that increased regulatory discipline for troubled BHCs may have substituted depositors' incentive to monitor troubled banks during that post-crisis period.

Tables 7 and 8 report how Ln(*Insured Deposits*) and Ln(*Uninsured Deposits*) respond to Pr(*Problem Bank*), respectively. Table 7 shows that for the regressions of Ln(*Insured Deposits*), the coefficient on Pr(*Problem Bank*) is significantly positive for five out of the nine sub-periods, and insignificant for the other four sub-periods. This suggests that banks often increase their insured deposits amount when their insolvency risk increases. Interestingly, Table 8 reports that the coefficient on Pr(*Problem Bank*) is also significantly positive for six out of the nine sub-periods for the regression of Ln(*Uninsured Deposits*). Moreover, for sub-periods 1991Q4-

1994Q3 and 1999Q4-2002Q2 the coefficient on Pr(*Problem Bank*) is significantly positive for both Ln(*Insured Deposits*) and Ln(*Uninsured Deposits*) regressions. However, it is unknown from these results whether banks increase their usage of insured deposits to weaken market discipline.

To ascertain whether banks change the composition of their liabilities to soften depositor discipline, Table 9 reports the coefficient on Pr(*Problem Bank*) for the regressions of the ratios of insured deposits to total liabilities (*Insured Deposits/Liab*) and uninsured deposits to total liabilities (*Uninsured Deposits/Liab*) along with the regressions of Ln(*Insured Deposits*) and Ln(*Uninsured Deposits*). Panel A of Table 9 presents the results for regressions using all the BHCs in each sub-period. Interestingly, for two of the nine sub-periods (1989Q3-1991Q3 and 2007Q4-2010Q2), banks significantly increase their insured deposits relative to total liabilities when their insolvency risk increases, showing evidence that banks soften the market discipline by increasing their relative usage of insured deposits. However, for three subperiods (2002Q3-2004Q2, 2004Q3-2007Q3 and 2010Q3-2013Q4), banks significantly increased their uninsured deposits relative to total liabilities, suggesting they were subject to more market discipline against excessive risk taking.

Panel B of Table 9 reports the coefficient on Pr(*Problem Bank*) for the same four regressions as in Panel A using problem BHCs only. In none of the sub-periods is this coefficient significantly positive for the regression of *Insured Deposits/Liab*. In two sub-periods (2004Q3-2007Q3 and 2010Q3-2013Q4), problem BHCs significantly reduce the ratio of insured deposits while increasing the relative usage of uninsured deposits. This suggests that regulators may have prevented troubled banks from increasing their relative use of insured deposits to weaken market discipline.

To examine whether depositors exert *ex post* influence on problem institutions, we estimate the logit model specified in equation (15) for the sub-sample of problem BHCs and report the results in Table 10. The error terms of the regressions are clustered at the BHC level. Because it may take time for any depositor influence to take effect, we estimate equation (15) using the one-, two-, three- and four-quarter change in the likelihood of being a problem bank to define the dependent variable *Dimprove*. To conserve space, Table 10 only reports the results from the regressions using the one-quarter change of insolvency risk to generate the dependent variables. *D*improve equals one if a BHC's probability of being a problem bank in the next quarter is less than that of the current quarter, and zero otherwise. Results from the regressions using the two-, three- and four-quarter changes of insolvency risk are qualitatively similar. Logit regressions in Panels A and B of Table 10 use *Insured Deposit Risk Premium* and *Uninsured Deposit Risk Premium* as the key explanatory variables, respectively. In Panel A, the coefficients on *Insured Deposit Risk Premium* are significantly positive in all the sub-periods except for the post-Dodd-Frank Act/Basel III period. In Panel B, the coefficients on *Uninsured Deposit Risk Premium* are significantly positive for all the sub-periods. Overall, both coefficients become greater after 2002. These findings support the hypothesis that depositors exert *ex post* influence on troubled banks, and this trend becomes more evident after regulations requiring greater bank disclosure and/or increasing capital requirement went into effect since 2002.

However, the significantly negative coefficient on *Insured Deposit Risk Premium* for the 2010Q3-2013Q4 sub-period indicates an absence of influence from insured depositors in the post Dodd-Frank Act/Basel III period. This result complements that of the insignificant coefficient on Pr(*Problem Bank*) in the regression of insured deposit interest rates for the problem banks during the post Dodd-Frank Act/Basel III period (see Panel B of Table 6). This again suggests that the more stringent regulatory environment towards troubled banks in the post Dodd-Frank Act/Basel III period may have substituted for the discipline from insured depositors.

6. Conclusions

In this paper we develop a theoretical model that examines the interaction of a bank's asset and liability choices under risky lending and deposit insurance. The model shows that the bank's liability and asset choices interact through its probability of insolvency. This implies that changes in the risk of the bank's asset portfolio lead to changes in the pricing and structure of its assets and liabilities. In addition, the paper empirically tests the implications of the model using U.S. bank holding company data for the September 1986 to December 2013 period. We find that interest rates on both insured and insured deposits contain a risk premium that increases with bank insolvency risk. Nevertheless, the interest rate of uninsured deposits is more risk sensitive than that of insured deposits. Moreover, we identify some sub-periods (1989Q3-1991Q3 Post-FIRREA period and 2007Q4-2010Q2 Banking Crisis) in which banks on average take advantage of this pricing difference and increase reliance on insured deposits relative to total liabilities to weaken market discipline. However, this pattern does not persist in sub-samples comprised solely of problem institutions. This suggests that regulators may have prevented troubled banks from increasing their relative use of insured deposits to undermine market discipline. In addition, we find strong evidence that an increase in the risk premium embedded in the current interest rates on deposits is more likely to lead to a decrease in future insolvency risk for troubled institutions, supporting the view that depositors exert *ex post* influence on problem banks. This *ex post* influence is more evident after regulations that require more bank disclosure and/or increase capital requirement went into effect since 2002. We also find evidence of a substitution relation between insured depositor discipline and regulatory influence on problem bank risk taking during the post Dodd-Frank Act/Basel III period.

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Table 1.

Part A: Parameters									
$k=0.45$	$l=1.3$	$a=0.1$	$b=0.2$	$e=-0.1$	$d=0.9$	$c=0.055$	$m=0.08$	$g=0.056$	$\bar{s}=1$

Part B: Constraints						
$0.03\le r\le 0.2$	$0.056\le i\le 0.2$	$0.056\le j\le 0.2$	$0\le mL\le E$	$\underline{s}\le s^*\le 1$	$s^*\le(1+r)L\le 1$	$0\le L,D,U,B$

Part C: Comparative Statics

$\underline{s}$	*r (%)*	*i (%)*	*j (%)*	*L*	*D*	*U*	*E*	*B*	*V*	*s**	*(1+r)L*	*N – M*	*E-mL*
0.00	19.99999	5.6000148	18.8573417	0.190000	0.1112000297	0.069716076	0.015200054	8.7483258E-08	0.00572497817	0.200290	0.228000	0.00593401	4.88E-08
0.01	20.00000	5.6000114	18.8573374	0.190000	0.1112000227	0.069716036	0.015200062	6.4476222E-08	0.00594494932	0.200290	0.228000	0.00593401	5.73E-08
0.02	19.99988	5.6004623	18.8560581	0.190002	0.1112009246	0.069704523	0.015213966	1.8306464E-08	0.00616817410	0.200275	0.228002	0.00593737	1.38E-05
0.03	20.00000	5.6000048	18.8573143	0.190000	0.1112000096	0.069715829	0.015200196	1.7866209E-08	0.00639849498	0.200290	0.228000	0.00593405	1.95E-07
0.04	19.99999	5.6000388	18.8572848	0.190000	0.1112000776	0.069715563	0.015200644	1.5210700E-07	0.00663228075	0.200289	0.228000	0.00593415	6.34E-07
0.05	20.00000	5.6000020	15.4448352	0.190000	0.1112000039	0.039003516	0.045912492	6.2138558E-09	0.00704170513	0.162455	0.228000	0.01279623	0.030712
0.06	19.99994	5.6002069	13.1364998	0.190001	0.1112004137	0.018228498	0.066689222	1.2926596E-06	0.00775482336	0.138050	0.228001	0.01646335	0.051489
0.07	19.99999	5.6000197	11.3534713	0.190000	0.1112000394	0.002181241	0.082735211	3.7508462E-07	0.00869079866	0.119856	0.228000	0.01880933	0.067535
0.08	20.00000	5.6000001	11.1113706	0.190000	0.1112000003	0.000002335	0.084913676	9.8842178E-09	0.00975843405	0.117430	0.228000	0.01909712	0.069714
0.09	20.00000	5.6000004	11.1111899	0.190000	0.1112000009	0.000000709	0.084915306	1.3124864E-08	0.01085107588	0.117418	0.228000	0.01909851	0.069715
0.10	19.99998	5.6000281	11.1112989	0.190000	0.1112000561	0.000001690	0.084915809	1.3382216E-06	0.01196785867	0.117428	0.228000	0.01909741	0.069716

Table 2

Summary statistics of selected variables for the 110-quarter period of September 1986 to December 2013.

Variable	No. of Obs.	Mean	Std. Dev.	Min	Max
Assets ($ millions)	163423	6264.8080	63200	6.454	2460000
Loans ($ millions)	163422	3166.3750	27400	0	1020000
Insured Deposits ($ millions)	154997	2526.8140	21400	0	1010000
Insured Deposits/Total Liabilities	154996	0.7607	0.1341	0.2024	0.9562
Uninsured Deposits ($ millions)	122524	1190.8810	14300	0	612000
Uninsured Deposits / Liabilities	122523	0.1396	0.0823	0.0140	0.4479
Interest Rate on Insured Deposits (%) (1997Q1 to 2013Q3)	98433	2.1150	1.1693	0.1464	4.6809
Interest Rate on Uninsured Deposits (%) (1997Q1 to 2013Q3)	95227	2.8400	1.8493	0.0993	7.2142
Interest Premium (over 6-month T-Bill rate) on insured Deposits (%)	98433	-0.7312	1.5033	-3.9110	2.2551
Interest Premium (over 6-month T-Bill rate) on uninsured Deposits (%)	95227	0.0503	2.0678	-5.3430	4.4535
ROA (Return on Assets, %)	163416	0.5465	0.5869	-2.1819	2.1172
ROE (Return on Equity ROE, %)	162640	6.2480	7.8449	-38.7320	23.9587
FDIC Reserve Balance ($ billions)	163423	27.8608	19.0922	-20.9000	52.4000
FDIC Reserve Ratio (FDIC Reserve/Insured Deposits of All Banks, %)	163423	0.8789	0.5484	-0.3900	1.3840
Pr(Problem Bank) (Probability of being a problem bank)	156649	0.1829	0.2657	0.0000	1
T-Bill Rate (6-month T-Bill Rate in %)	163423	3.9724	2.4891	0.0406	9.6118
DENSITY (State Population / State Land Area)	162354	218.2289	490.5729	0.9429	10528.4900
HHIB (Statewide Herfindahl-Hirschman Index for Banks)	162917	679.1503	495.7238	61.5200	6400.8980
STATEINC (State Personal Income, $ billions)	162354	281	283	6.7273	1850

Table 3 Sub-periods and major regulatory changes during each sub-period.

Sub-period	Major Events
1986Q3 - 1989Q2 (Banking Crisis)	Banking crisis
1989Q3-1991Q3 (Post FIRREA)	Financial Institutions Reform, Recovery, and Enforcement Act (FIRREA) was signed into law on August 9, 1989. It was designed to reform, recapitalize, and consolidate the Federal deposit insurance system, to enhance the regulatory and enforcement powers of Federal financial institutions regulatory agencies. The Savings Association Insurance Fund (SAIF) replaced the Federal Savings and Loans Insurance Fund (FSLIC), and the FDIC started to oversea both the SAIF and the Bank Insurance Fund (BIF).
1991Q4-1994Q3 (Post FDICIA)	Federal Deposit Insurance Corporation Improvement Act (FDICIA) was effective on Dec. 19, 1991. The act contains provisions that improve the capitalization of the Federal Deposit Insurance Corporation (FDIC), demand more stringent capital requirements, intervene early in the affairs of troubled or undercapitalized banks, provide prompt failure resolution, and implement risk-based deposit insurance premiums. FDICIA indicates a shift from regulatory forbearance to prompt corrective action for undercapitalized banks.
1994Q4-1999Q3 (Post IBBEA)	Riegle-Neal Interstate Banking and Branching Efficiency Act (IBBEA) was signed into law on September 29, 1994. It paves the way for bank holding companies to acquire a bank in any state, subject to certain conditions, and consolidate their interstate banks into a branch network. It also permits free-standing banks to merge with other banks across state lines.
1999Q4-2002Q2 (Post GLB)	Gramm-Leach-Bliley Act (GLB Act) was enacted on November 12, 1999. It repealed part of the Glass–Steagall Act of 1933, removing barriers in the market among banking companies, securities companies and insurance companies that prohibited any one institution from acting as any combination of an investment bank, a commercial bank, and an insurance company. With the passage of the Gramm–Leach–Bliley Act, commercial banks, investment banks, securities firms, and insurance companies were allowed to consolidate.
2002Q3-2004Q2 (Post SOX)	Sarbanes-Oxley Act (SOX) became effective on July 30, 2002. It increased corporate financial transparency through improved disclosures and improving oversight through strengthening corporate governance.
2004Q3-2007Q3 (Post Basel II)	Basel II was initially published in June 2004. It uses a "three pillars" concept – (1) minimum capital requirements (addressing risk), (2) supervisory review and (3) market discipline. It attemps to ensure that capital allocation is more risk sensitive, to enhance disclosure requirements which allow market participants to assess the capital adequacy of an institution, and to ensure that credit risk, operational risk and market risk are quantified based on data and formal techniques. It attempts to reduce the scope for regulatory arbitrage.
2007Q4-2010Q2 (Banking Crisis)	Banking crisis started in December 2007.
2010Q3-2013Q4 (Post Dodd-Frank Act and Basel III)	Dodd-Frank Act was signed into law on July 21, 2010. It requires comprehensive regulation of financial markets, including increased transparency of derivatives, consumer protection reforms and strengthened investor protection. Basel III capital requirement was initially issued in December 2010. It aims to improve the banking sector's ability to absorb shocks arising from financial and economic stress, to improve risk management and governance, and to strengthen banks' transparency and disclosures.

Table 4

Random-effects generalized least squares estimates of the panel data regressions of the interest rate on insured deposits for samples of U.S. bank holding companies, March 1997 to December 2013. The error terms are clustered at the BHC level. Numbers in brackets are z-statistics of the coefficients.

	Dependent variable: Interest Rate on Insured Deposits					
Explanatory Variables	1997Q1-1999Q3 (Post FDICIA, Pre GLB Act)	1999Q4-2002Q2 (Post GLB, Pre-SOX)	2002Q3-2004Q2 (Post SOX & Pre Basel II)	2004Q3-2007Q3 (Post Basel II)	2007Q4-2010Q2 (Banking Crisis, Pre Dodd-Frank Act, Pre Basel III)	2010Q3-2013Q4 (Post Dodd-Frank Act, Post Basel III)
Pr(Problem Bank)	0.0912	0.1011	0.0282	0.0885	0.0739	0.0752
	[3.87]***	[4.44]***	[1.60]	[3.84]***	[4.57]***	[5.88]***
FDIC Reserve Ratio	-40.8806	4.9823	1.7661	0.4529	-1.3822	-0.9222
	[12.23]***	[16.10]***	[5.90]***	[2.30]**	[36.72]***	[51.98]***
Ln(Assets)	-0.0648	-0.1112	-0.0838	0.0114	-0.0933	-0.01
	[2.36]**	[6.61]***	[2.58]***	[0.89]	[5.46]***	[0.37]
T-Bill Rate	-0.4638	0.1377	1.3318	0.7197	1.1042	-0.1226
	[6.19]***	[15.79]***	[109.07]***	[69.29]***	[60.40]***	[4.50]***
HHIB × 10^{-5}	-8.5900	-12.0800	-2.1700	-1.4100	-0.6520	-1.1300
	[2.22]**	[4.11]***	[2.64]***	[0.81]	[0.36]	[0.95]
Density × 10^{-5}	-9.65	-11.10	-5.06	-6.91	8.96	7.17
	[3.28]***	[3.98]***	[2.02]**	[4.83]***	[1.35]	[1.65]*
Ln(STATEINC)	-0.1217	-0.1571	-0.0685	-0.0468	-0.0363	-0.0299
	[6.06]***	[8.68]***	[5.43]***	[3.64]***	[1.77]*	[2.41]**
Quarter Dummies	yes	yes	yes	Yes	yes	yes
Intercept	65.3482	omitted	omitted	omitted	2.7622	1.6555
	[13.48]***				[6.27]***	[4.58]***
Overall R^2	0.1280	0.4056	0.2797	0.4996	0.4415	0.3139
No. of BHCs	1979	2127	2337	2435	1149	1272
No. of Obs.	16414	18608	16338	20403	10731	12919

*, **, *** Significantly different from zero at the 10%, 5%, and 1% levels respectively, using a two-tailed tests.

Table 5

Random-effects generalized least squares estimates of the panel data regressions of the interest rate on uninsured deposits for samples of U.S. bank holding companies, March 1997 to December 2013. The error terms are clustered at the BHC level. Numbers in brackets are z-statistics of the coefficients.

Dependent variable: Interest Rate on Uninsured Deposits

Explanatory Variables	1997Q1-1999Q3 (Post FDICIA, Pre GLB Act)	1999Q4-2002Q2 (Post GLB, Pre-SOX)	2002Q3-2004Q2 (Post SOX & Pre Basel II)	2004Q3-2007Q3 (Post Basel II)	2007Q4-2010Q2 (Banking Crisis, Pre Dodd-Frank Act, Pre Basel III)	2010Q3-2013Q4 (Post Dodd-Frank Act, Post Basel III)
Pr(Problem Bank)	0.279	0.2585	0.1329	0.1346	0.1589	0.1351
	[3.79]***	[4.90]***	[3.40]***	[2.59]***	[4.89]***	[5.51]***
FDIC Reserve Ratio	230.1069	3.0637	-1.8933	0.4312	-2.6098	-1.2756
	[19.52]***	[14.33]***	[10.24]***	[2.77]***	[30.41]***	[32.93]***
Ln(Assets)	0.0307	0.0108	-0.0683	-0.004	-0.0826	-0.0605
	[2.79]***	[1.00]	[7.86]***	[0.49]	[6.00]***	[4.13]***
T-Bill Rate	-3.4369	0.1663	4.6296	1.1229	1.9543	-0.1479
	[12.28]***	[17.86]***	[129.79]***	[76.27]***	[49.22]***	[1.57]
HHIB × 10^{-5}	-3.72	-9.79	-2.84	-1.5	-3.57	-1.31
	[1.00]	[3.99]***	[1.88]*	[0.67]	[1.19]	[0.80]
Density × 10^{-5}	-7.04	-7.25	-3.5	-5.46	-8.28	8.84
	[3.39]***	[5.37]***	[1.52]	[3.72]***	[1.36]	[3.84]***
Ln(STATEINC)	-0.0307	-0.0332	-0.0403	-0.0202	-0.0204	-0.0504
	[2.43]**	[2.77]***	[3.39]***	[1.84]*	[0.96]	[3.42]***
Quarter Dummies	yes	yes	Yes	yes	yes	Yes
Intercept	-295.8863	omitted	Omitted	omitted	2.9663	3.6436
	[16.72]***				[7.04]***	[10.45]***
Overall R^2	0.8345	0.8220	0.7018	0.7241	0.7283	0.5419
No. of BHCs	1912	2113	2334	2433	1149	1269
No. of Obs.	14468	17873	16126	20371	10708	12811

*, **, *** Significantly different from zero at the 10%, 5%, and 1% levels respectively, using a two-tailed tests.

Table 6

The coefficients on Prob(Problem Bank) for random-effects generalized least squares estimates of the panel data regressions for samples of U.S. bank holding companies, March 1997 to December 2013. Dependent variables include interest rate on insured deposits and interest rate on uninsured deposits. The error terms are clustered at the BHC level. Numbers in brackets are z-statistics of the coefficients.

Dependent Variable	1997Q1-1999Q3 (Post FDICIA, Pre GLB Act)	1999Q4-2002Q2 (Post GLB, Pre-SOX)	2002Q3-2004Q2 (Post SOX & Pre Basel II)	2004Q3-2007Q3 (Post Basel II)	2007Q4-2010Q2 (Banking Crisis, Pre Dodd-Frank Act, Pre Basel III)	2010Q3-2013Q4 (Post Dodd-Frank Act, Post Basel III)
	Panel A: Coefficient on Pr(Problem Bank) for Interest Rate Regressions (All the BHCs)					
Interest Rate on Insured Deposits	0.0912	0.1011	0.0282	0.0885	0.0739	0.0752
	[3.87]***	[4.44]***	[1.60]	[3.84]***	[4.57]***	[5.88]***
Interest Rate on Uninsured Deposits	0.279	0.2585	0.1329	0.1346	0.1589	0.1351
	[3.79]***	[4.90]***	[3.40]***	[2.59]***	[4.89]***	[5.51]***
	Panel B: Coefficient on Pr(Problem Bank) for Interest Rate Regressions (Problem-BHCs only)					
Interest Rate on Insured Deposits	0.1627	0.1559	0.1099	0.1085	0.0631	-0.0118
	[2.83]***	[2.31]**	[2.89]***	[2.29]**	[2.03]**	[0.41]
Interest Rate on Uninsured Deposits	0.3421	0.4635	0.2762	0.1984	0.1776	0.0762
	[2.21]**	[3.25]***	[2.38]**	[1.42]	[2.60]***	[1.34]

*, **, *** Significantly different from zero at the 10%, 5%, and 1% levels respectively, using a two-tailed tests.

Table 7
Random-effects generalized least squares estimates of the panel data regressions of the natural logarithm of insured deposits for samples of U.S. bank holding companies, September 1986 to December 2013. The error terms are clustered at the BHC level. Numbers in brackets are z-statistics of the coefficients.

Dependent Variable: Ln(Insured Deposits)

Explanatory Variables	1986Q3 - 1989Q2 (Banking Crisis)	1989Q3-1991Q3 (Post FIRREA)	1991Q4-1994Q3 (Post FDICIA)	1994Q4-1999Q3 (Post IBBEA)	1999Q4-2002Q2 (Post GLB)	2002Q3-2004Q2 (Post SOX)	2004Q3-2007Q3 (Post Basel II)	2007Q4-2010Q2 (Banking Crisis)	2010Q3-2013Q4 (Post Dodd-Frank Act and Basel III)
Pr(Problem Bank)	0.0232	0.0263	0.0159	-0.0001	0.023	0.0125	-0.0033	0.0292	0.0001
	[4.13]***	[5.38]***	[3.25]***	[0.00]	[2.22]**	[0.79]	[0.34]	[4.86]***	[0.02]
FDIC Reserve Ratio	0.0621	-0.0812	-0.0039	-0.4036	0.4398	-0.0478	0.4933	omitted	0.1349
	[2.47]**	[6.42]***	[0.56]	[1.83]*	[1.38]	[0.42]	[2.65]***		[13.82]***
Ln(Assets)	0.9423	0.9491	0.9609	0.9911	0.9253	0.9708	0.8825	0.9099	0.9707
	[77.14]***	[93.88]***	[93.81]***	[25.39]***	[30.63]***	[10.39]***	[44.24]***	[44.51]***	[62.55]***
T-Bill Rate	0.002	0.0053	-0.0224	-0.0554	-0.009	-0.0085	0.021	-0.0229	0.0847
	[0.93]	[1.12]	[7.14]***	[0.96]	[0.92]	[2.76]***	[2.21]**	[11.20]***	[3.50]***
HHIB × 10^{-5}	1.1600	-2.2300	-1.9400	-5.9600	0.4250	-0.0253	-0.9460	-1.7000	-0.8110
	[1.01]	[3.90]***	[2.31]**	[1.96]**	[0.49]	[0.06]	[1.15]	[1.49]	[1.53]
Density × 10^{-5}	-0.5760	-1.4700	0.1470	-0.7390	-0.1570	-0.3240	-2.7000	-3.6400	3.2600
	[0.81]	[2.08]**	[0.20]	[0.38]	[0.16]	[0.10]	[1.03]	[0.72]	[0.65]
Ln(STATEINC)	-0.0231	-0.0094	0.0154	0.031	-0.0005	-0.0044	0.0203	-0.0163	-0.0288
	[3.13]***	[0.86]	[1.44]	[1.42]	[0.05]	[0.18]	[1.23]	[1.16]	[1.47]
Quarter Dummies	yes	Yes	yes	yes	yes	yes	yes	yes	yes
Intercept	0.7584	0.492	0.0368	omitted	omitted	0.0994	omitted	1.1304	0.4576
	[4.49]***	[2.27]**	[0.18]			[0.15]		[3.07]***	[1.04]
Overall R^2	0.9839	0.9743	0.9463	0.9344	0.9299	0.9089	0.9040	0.9372	0.9403
No. of BHCs	1572	1705	1918	2223	2127	2337	2435	1149	1272
No. of Obs.	11396	11895	16983	28403	18608	16338	20403	10,731	12919

, **, *** Significantly different from zero at the 10%, 5%, and 1% levels respectively, using a two-tailed tests.

Table 8

Random-effects generalized least squares estimates of the panel data regressions of the natural logarithm of uninsured deposits for samples of U.S. bank holding companies, September 1986 to December 2013. The error terms are clustered at the BHC level. Numbers in brackets are z-statistics of the coefficients.

Dependent Variable: Ln(Uninsured Deposits)

Explanatory Variables	1986Q3 - 1989Q2 (Banking Crisis)	1989Q3-1991Q3 (Post FIRREA)	1991Q4-1994Q3 (Post FDICIA)	1994Q4-1999Q3 (Post IBBEA)	1999Q4-2002Q2 (Post GLB)	2002Q3-2004Q2 (Post SOX)	2004Q3-2007Q3 (Post Basel II)	2007Q4-2010Q2 (Banking Crisis)	2010Q3-2013Q4 (Post Dodd-Frank Act and Basel III)
Pr(Problem Bank)	-0.0219	0.0121	0.0422	0.0505	0.0493	0.0484	0.0926	0.0233	0.0662
	[0.76]	[0.50]	[2.05]**	[2.03]**	[2.46]**	[3.72]***	[4.06]***	[1.55]	[4.48]***
FDIC Reserve Ratio	-0.2319	-0.0565	-0.2787	-0.8032	-1.3419	-1.6204	-1.6563	Omitted	-0.3688
	[1.76]*	[0.85]	[16.69]***	[5.60]***	[3.24]***	[4.68]***	[6.55]***		[9.85]***
Ln(Assets)	1.1416	1.0659	1.051	1.044	1.0111	0.9737	0.9594	0.8951	0.8487
	[67.88]***	[86.24]***	[69.96]***	[58.98]***	[39.90]***	[35.42]***	[45.15]***	[27.45]***	[24.19]***
T-Bill Rate	0.0391	0.1183	0.0632	-0.4442	0.0145	-0.0123	0.006	-0.0113	-0.0952
	[2.93]***	[5.61]***	[5.13]***	[11.19]***	[1.25]	[0.94]	[0.41]	[2.32]**	[0.61]
HHIB $\times 10^{-5}$	1.96	3.95	4.9	2.22	2.47	-1.23	-1.14	3.88	-6.78
	[0.39]	[0.95]	[2.55]**	[0.65]	[1.51]	[1.53]	[0.52]	[1.82]*	[0.73]
Density $\times 10^{-5}$	3.52	2.29	-0.953	-8.93	-9.28	-14.66	-11.08	-41.01	-0.0001
	[1.30]	[1.16]	[0.29]	[1.96]*	[1.94]*	[1.93]*	[1.81]*	[4.14]***	[0.86]
Ln(STATEINC)	0.1104	0.0768	0.0266	0.0233	-0.0348	0.0151	0.027	0.0765	-0.0009
	[4.12]***	[3.02]***	[1.68]*	[1.41]	[1.87]*	[0.84]	[1.46]	[2.70]***	[0.03]
Quarter Dummies	yes	Yes	yes	yes	yes	yes	yes	Yes	yes
Intercept	-6.2964	-5.3454	-3.9938	omitted	omitted	omitted	omitted	-1.944	0.056
	[12.13]***	[10.38]***	[11.88]***					[3.15]***	[0.08]
Overall R^2	0.9389	0.9377	0.8788	0.8654	0.8261	0.8095	0.8175	0.7948	0.6696
No. of BHCs	600	720	1415	2115	2071	2330	2429	1145	1266
No. of Obs.	2932	3364	10066	23441	17674	16068	20362	10701	12821

*, **, *** Significantly different from zero at the 10%, 5%, and 1% levels respectively, using a two-tailed tests.

Table 9

The coefficients on Prob(Problem Bank) for random-effects generalized least squares estimates of the panel data regressions for samples of U.S. bank holding companies, September 1986 to December 2013. Dependent variables include the natural logarithm of insured deposits, natural logarithm of uninsured deposits, insured deposits to total liabilities and uninsured deposits to total liabilities. The error terms are clustered at the BHC level. Numbers in brackets are z-statistics of the coefficients.

Dependent Variable	1986Q3 - 1989Q2 (Banking Crisis)	1989Q3-1991Q3 (Post FIRREA)	1991Q4-1994Q3 (Post FDICIA)	1994Q4-1999Q3 (Post IBBEA)	1999Q4-2002Q2 (Post GLB)	2002Q3-2004Q2 (Post SOX)	2004Q3-2007Q3 (Post Basel II)	2007Q4-2010Q2 (Banking Crisis)	2010Q3-2013Q4 (Post Dodd-Frank Act and Basel III)
	Panel A: Coefficient on Pr(Problem Bank) for the Specified Regressions (All the BHCs)								
Ln(Insured Deposits)	0.0232	0.0263	0.0159	-0.0001	0.023	0.0125	-0.0033	0.0292	0.0001
	[4.13]***	[5.38]***	[3.25]***	[0.00]	[2.22]**	[0.79]	[0.34]	[4.86]***	[0.02]
Ln(Uninsured Deposits)	-0.0219	0.0121	0.0422	0.0505	0.0493	0.0484	0.0926	0.0233	0.0662
	[0.76]	[0.50]	[2.05]**	[2.03]**	[2.46]**	[3.72]***	[4.06]***	[1.55]	[4.48]***
Insured Deposits/Liab	0.0012	0.0071	0.0013	-0.0085	0.0001	-0.0032	-0.0161	0.0065	-0.0121
	[0.41]	[2.76]***	[0.50]	[1.65]*	[0.03]	[1.12]	[3.62]***	[2.31]**	[4.40]***
Uninsured Deposits/Liab	-0.0014	0.0002	-0.0002	-0.0007	0.0032	0.0069	0.0163	0.0009	0.0066
	[0.32]	[0.06]	[0.07]	[0.23]	[1.42]	[3.70]***	[4.57]***	[0.39]	[3.04]***
	Panel B: Coefficient on Pr(Problem Bank) for the Specified Regressions (Problem BHCs Only)								
Ln(Insured Deposits)	0.0284	0.0198	-0.0073	-0.0011	-0.0055	0.0121	-0.0268	0.0199	-0.0124
	[3.83]***	[2.90]***	[0.28]	[0.04]	[0.40]	[2.18]**	[1.65]*	[2.27]**	[1.51]
Ln(Uninsured Deposits)	-0.0342	0.0307	-0.017	0.0146	0.0045	0.0391	0.0948	0.031	0.1248
	[0.70]	[0.94]	[0.49]	[0.46]	[0.13]	[1.82]*	[1.87]*	[1.05]	[3.89]***
Insured Deposits/Liab	0.0058	0.0046	0.0049	0.004	-0.0043	0.0032	-0.0168	0.003	-0.0249
	[1.38]	[1.17]	[1.22]	[0.66]	[0.62]	[0.54]	[2.00]**	[0.63]	[4.60]***
Uninsured Deposits/Liab	-0.0092	0.002	-0.006	-0.0011	-0.0024	0.0059	0.0202	0.0023	0.0149
	[1.07]	[0.36]	[1.65]*	[0.28]	[0.44]	[1.52]	[2.56]**	[0.56]	[3.17]***

*, **, *** Significantly different from zero at the 10%, 5%, and 1% levels respectively, using a two-tailed tests.

Table 10

Logit model on the likelihood of improvement in insolvency risk for samples of U.S. bank holding companies, March 1997 to December 2013. The dependent variable *D*improve equals one if a BHC's probability of being a problem bank in the next quarter is less than that of the current quarter, and zero otherwise. The error terms are clustered at the BHC level. Numbers in brackets are z-statistics of the coefficients. The explanatory variables in Panel A are *Insured Deposit Risk Premium* and *Ln*(*Assets*), and the explanatory variables in Panel B are *Uninsured Deposit Risk Premium* and *Ln*(*Assets*). *Insured Deposit Risk Premium* and *Uninsured Deposit Risk Premium* are estimated with the procedure described in Section 3.

Explanatory Variables	1997Q1-1999Q3 (Post FDICIA, Pre GLB Act)	1999Q4-2002Q2 (Post GLB, Pre-SOX)	2002Q3-2004Q2 (Post SOX & Pre Basel II)	2004Q3-2007Q3 (Post Basel II)	2007Q4-2010Q2 (Banking Crisis, Pre Dodd-Frank Act, Pre Basel III)	2010Q3-2013Q4 (Post Dodd-Frank Act, Post Basel III)
	Panel A					
Insured Deposit Risk Premium	20.2244	24.8038	35.2253	33.0593	58.9035	-250.8767
	[7.68]***	[13.77]***	[11.14]***	[10.21]***	[23.73]***	[21.35]***
Ln(Assets)	0.0826	-0.0041	0.1069	-0.0428	0.1182	0.2991
	[1.60]	[0.07]	[1.56]	[0.44]	[2.99]***	[5.50]***
Intercept	-1.4901	-0.6827	-2.2888	-0.0372	-4.2141	-5.5551
	[2.11]**	[0.86]	[2.50]**	[0.03]	[7.27]***	[7.08]***
Pseudo R^2	0.1223	0.1803	0.2057	0.1392	0.2701	0.1688
No. of BHCs	209	415	324	270	519	434
No. of Observations	963	1,855	1,371	1,209	2,619	3,097

Explanatory Variables	Panel B					
Uninsured Deposit Risk Premium	9.6167	8.3441	14.0168	18.0748	20.911	38.9182
	[7.68]***	[13.77]***	[11.14]***	[10.21]***	[23.73]***	[21.35]***
Ln(Assets)	0.0826	-0.0041	0.1069	-0.0428	0.1182	0.2991
	[1.60]	[0.07]	[1.56]	[0.44]	[2.99]***	[5.50]***
Intercept	-1.4901	-0.6827	-2.2888	-0.0372	-4.2141	-5.5551
	[2.11]**	[0.86]	[2.50]**	[0.03]	[7.27]***	[7.08]***
Pseudo R^2	0.1223	0.1803	0.2057	0.1392	0.2701	0.1688
No. of BHCs	209	415	324	270	519	434
No. of Observations	963	1,855	1,371	1,209	2,619	3,097

*, **, *** Significantly different from zero at the 10%, 5%, and 1% levels respectively, using a two-tailed tests.