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Bank Deposit Insurance and Business Cycles:

Controlling the Volatility of Risk-Based Premiums

George G. Pennacchi

Department of Finance
University of Illinois
1407 W. Gregory Drive
Urbana, Illinois 61801

Phone: (217) 244-0952
Email: gpennacc@uiuc.edu

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Abstract

Proposals to make deposit insurance risk-based need to consider how premiums would fluctuate over the business cycle. This paper derives a new deposit insurance contract that has the following three features: 1) it is fairly priced in the sense that the insurer conveys no subsidy to the bank; 2) the insurance rate can be made as stable as desired by lengthening the "average" maturity of the contract; 3) the rate can be frequently updated as new information regarding the bank's financial condition is obtained. These characteristics are achieved with a contract that is a combination of several long-term ones whose contract intervals partially overlap. Relative to a standard, short-term contract, this "moving average" contract reduces the volatility of a bank's insurance rates and avoids payment of excessively high premiums during times of financial distress.

Estimates of fair insurance rates under such a contract are presented for 42 banks based on data over the period 1987 to 1996. While lengthening the average maturity of the contract reduces the volatility of insurance rates, it also increases the average level of rates since the insurer requires a greater premium for systemic risk. The paper also finds that the distribution of fair insurance rates across banks is skewed, with most banks paying relatively low rates and a small minority of banks paying much higher ones.

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I. Introduction

Over the past decade, a number of countries began charging deposit insurance premiums that depend on the risk characteristics of individual banks.[1] Included among them is the United States, which was required to institute risk-based pricing by the Federal Deposit Insurance Corporation Improvement Act of 1991 (FDICIA). By setting a bank's insurance premium to reflect its risk of default, a risk-based premium could mimic a market default risk-premium that the bank would pay in the absence of deposit insurance. This replication of market default-risk premiums could mitigate distortions in terms of bank risk-taking and deposit issue and would reduce cross-subsidization between safe and risky banks.

Recently, the Federal Deposit Insurance Corporation (FDIC) performed a major study of the U.S. deposit insurance system.[2] While supposedly risk-based, the current system had over 90 percent of U.S. banks paying zero premiums for insurance. This was due to two flaws. First, the system specified crude risk classifications that placed almost all banks in the lowest (safest) class, thereby making them eligible for the smallest premium. Second, FDICIA and the Deposit Insurance Funds Act of 1996 mandated that premiums be used to stabilize the reserves of the FDIC's Bank Insurance Fund (BIF).[3] Premiums had to be reduced (increased) when BIF reserves exceeded (fell below) 1.25 % of insured deposits. Since the current BIF reserves to insured

[1] Garcia (2000) reports that by the year 2000, 24 out of 67 countries surveyed had deposit insurance systems that assessed risk-based premiums.
[2] This study is summarized in FDIC (2000).
[3] BIF reserves are the accumulated value of premiums previously paid by commercial banks less the value of FDIC losses from past bank failures.

deposits ratio exceeded the designated reserve ratio (DRR) of 1.25 %, premiums were eliminated for the safest banks in an attempt to return the ratio back to its target.[4]

This recent experience makes clear that premiums cannot be set to both stabilize BIF reserves and fairly price potential insurer losses from a bank's failure. BIF reserves depend on *past* losses from banking industry failures while risk-based premiums ought to reflect the likelihood of *future* losses from individual banks' failures. Recognition of this led the FDIC to recommend that it be permitted to charge risk-based premiums that are independent of fund reserves.[5] Such a reform also could reduce large swings in insurance rates since the current system requires little premiums when banking industry losses are low (and reserves are above the DRR) but potentially large premiums when industry losses are high (and reserves are below the DRR). Moreover, as argued in FDIC (2001, p.5), this volatility can harm the real economy:

> "…banks are likely to be faced with very steep deposit insurance payments when earnings are already depressed. Such premiums would divert billions of dollars out of the banking system and raise the cost of gathering deposits at a time when credit already might be tight. This, in turn, could cause a further cutback in credit, resulting in a further slowdown of economic activity at precisely the wrong time in the business cycle."

Making premiums independent of fund reserves eliminates one source of counter-cyclical movements in premiums, but risk-based pricing could create another. If a bank's financial condition worsens in economic downturns, its fair insurance premium will tend to rise.[6] Hence, a switch to true risk-based pricing may not alleviate potential credit crunches.

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[4] The FDIC also maintains a separate reserve fund for thrift institutions, known as the Savings Association Insurance Fund (SAIF). At the time, it was also above its DRR, and over 90 percent of thrifts were also paying zero insurance premiums.

[5] If maintaining an insurance fund with a stable DRR is desired, it could be done with a separate rebate/assessment scheme that would not depend on banks' current risks or their current levels of deposits. See Wilcox (2001) for an example of such a proposal.

[6] The analysis in Pennacchi (1999) confirms that premiums set to target fund reserves are positively correlated with hypothetical fair insurance premiums, and both are counter-cyclical.

One contribution of the current paper is to show how fair insurance premiums might be structured to reduce their volatility over business cycles. Two previous papers also have proposed reforming deposit insurance with an aim toward reducing the volatility of insurance rates. Konstas (1992) and Shaffer (1997) advocate similar systems in which premiums would be set to a long-term moving average of past FDIC insurance expenses (historical losses from bank failures). The proposal in the current paper is related to these, but with a significant difference. Rather than being a moving average of past FDIC losses, the moving average is forward looking: insurance rates are a moving average of the value of the FDIC's exposure to future losses. Specifically, this study presents a new model for pricing deposit insurance that has the following features:

1. A bank's insurance rate is risk-based and "fair" in the sense that it contains no subsidy. The Federal government, representing taxpayers, obtains fair compensation for providing insurance to the bank's depositors.
2. The fair insurance rate can be made as stable as desired by lengthening the "average" maturity of the insurance contract.
3. The insurance rate can be updated at regular intervals as new information on the bank's financial condition is obtained from Call Reports and/or bank examinations.

The key to making insurance rates fair, stable, yet frequently updated is to structure a bank's deposit insurance as a combination of several long-term contracts whose contract intervals partially overlap. To illustrate this idea, suppose that a deposit insurer updates a bank's insurance premium once per year, and the initial terms of the overlapping insurance contracts are n years, where n is an integer ≥ 1. Then a bank's deposit insurance can be de-composed into n insurance contracts, where each lasts n years and covers $\frac{1}{n}^{\text{th}}$ of the bank's total insured deposits. If we denote the current date as 0 and measure dates in years, then the most recently updated contract covers the interval from date 0 to date n. The contract updated one year ago covers the interval from date –1 to date n-1, while the contract updated two years ago covers the interval from date –2 to date n-2. Thus, the oldest contract, updated n-1 years ago, covers the interval from date n-1 to date 1. Figure 1 illustrates this overlapping of contracts for the case of n = 5.

If each of the n contracts assigns an initially fair annual premium to its $\frac{1}{n}^{\text{th}}$ share of the bank's deposits, the overall set of contracts provides no subsidy. At a given date, the bank's total insurance premium per deposit is the average of the n different rates. Importantly, as n increases, the bank's total premium becomes less volatile, since new information affects only a $\frac{1}{n}^{\text{th}}$ share of deposits the next time the premium is revised. However, as time passes, more of the individual contracts mature and are re-priced, so that the total premium eventually reflects changes the bank's financial condition. Still, this "moving average" of multiple overlapping contracts provides intertemporal smoothing of rates relative to a short-term contract that fully re-prices annually.[7]

A bank insured by this moving average contract is analogous to a firm with uninsured debt comprised of n different bonds, with each bond having an initial maturity of n years but having been issued at different, consecutive prior annual dates. Each year, one of the firm's bonds matures, and it rolls it over into a new n-year maturity bond. If investors price each new bond fairly based on the firm's financial risk, then the firm's interest expense, including the premium it pays for default risk, is a moving average of interest expenses from its n different bonds.

To calculate actual insurance premiums for banks under this moving average framework, values for each of the overlapping contracts must be determined. This requires specifying a risk-based insurance pricing model for these underlying contracts.[8] In this paper, we consider two related models. The first calculates premiums for each overlapping contract based on a structural

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[7] Estimates of deposit insurance rates that assume an annually re-priced contract include studies by Marcus and Shaked (1984), Ronn and Verma (1986), and Giammarino, Schwartz, and Zechner (1989).
[8] FDIC (2000,2001) discusses a variety of risk-based pricing methods.

option pricing-type model. We refer to premiums calculated in this model as "fair" in the sense that they provide no subsidy to banks and would replicate premiums charged by competitive private insurers. The second method is the same as the first except that premiums are set to cover the expected value of future deposit insurance losses for each overlapping contract.[9] These "expected value" premiums differ from the first method's "fair premiums" in that they do not provide compensation for the insurer's exposure to systemic risk. Since bank failures tend to be counter-cyclical, increasing during recessions and declining during expansions, a fair deposit insurance rate includes a positive market risk premium that expected value insurance rates lack. The paper's empirical work shows that the size of this systemic risk premium increases with a bank's probability of default and the length, n, of the overlapping contract.

The plan of the paper is as follows. The next section details the specific assumptions for valuing insurance, derives fair and expected value deposit insurance premiums, and describes how these premiums can be calculated. Section III presents empirical results for a sample of 42 commercial banks. Conclusions are given in section IV.

II. The Insurance Valuation Model

Our method for valuing each overlapping contract is similar to Cooperstein, Pennacchi, and Redburn (1995) and Pennacchi (1999) but allows for stochastic interest rates and an exogenous loss rate by the FDIC following a bank's failure. Recent credit risk models such as Longstaff and Schwartz (1995) and Collin-Dufresne and Goldstein (2001) also assume an exogenous loss or write-down rate by a bankrupt firm's creditors.[10] These papers justify this assumption by noting that during bankruptcy a firm's assets are rarely allocated according to

[9] Kuritzkes, Schuermann, and Weiner (2001) provide another method for computing deposit insurance premiums that equal the expected value of losses.

[10] In these papers, default occurs when a firm's assets reach a specified lower threshold. Bondholders then recover $(1-\omega)$ times the value of a default-free bond, where ω is the exogenous write-down or loss rate. As does the current paper's model, Collin-Dufresne and Goldstein (2001) permit a firm's leverage to be mean-reverting. Our empirical evidence, as well as that in Ashcraft (2001), supports the existence of mean-reversion in banks' capital ratios.

absolute priority rules. Rather, creditor recoveries are often the outcome of a complex bargaining process. As we discuss in more detail below, assuming an exogenous loss rate for the FDIC is attractive due to the increasing complexity of bank liabilities.

The insurance valuation model makes the following five assumptions:

A.1 ***Default-free bond price process***: *Define $P_t(\tau)$ as the date t price of a default-free zero-coupon bond that pays* \$1 *at date $t+\tau$. The value of this bond follows the process*

$$dP_t(\tau)/P_t(\tau) = \alpha_p(t,\tau)dt + \sigma_p(\tau)dq \tag{1}$$

where dq is a Brownian motion process, $\alpha_p(t,\tau)$ is the bond's expected rate of return, and $\sigma_p(\tau)$ is the standard deviation of the bond's rate of return. $\sigma_p(\tau)$ is an increasing function of the bond's time until maturity, τ, and $\lim_{\tau \downarrow 0} \sigma_p(\tau) = 0$.

This specification of bond price dynamics is assumed in Merton (1973), Vasicek (1977), and Hull and White (1990). From (1) we can define the instantaneous maturity (short-term) default-free interest rate as $r_t \equiv \lim_{\tau \downarrow 0} \alpha_p(t,\tau)$.[11]

A.2 ***Bank asset return generating process***: *Let V_t be the date t market value of a bank's assets, where assets are broadly construed to include off-balance sheet contracts and "charter" value associated with market power in lending or deposit issue. The rate of return on bank assets satisfies*

$$dV_t/V_t = \alpha_v(t)dt + \sigma_v dz \tag{2}$$

where dz is another Brownian motion process that is correlated with dq such that $dzdq = \rho dt$, ρ being the processes' instantaneous correlation coefficient. α_v is the expected rate of return on

[11] In equilibrium term structure models, $\alpha_p(t,\tau) = r_t + \lambda\sigma_p(\tau)$ where λ is the market price of interest rate risk associated with dq. For example, the Vasicek (1977) model assumes $dr = \kappa(\theta - r)dt - \sigma dq$ and results in bond prices equal to $P_t(\tau)=A(\tau)e^{-B(\tau)r}$ where $A(\tau) \equiv \exp\{(B(\tau)-\tau)[\theta+\lambda\sigma/\kappa - ½(\sigma/\kappa)^2 - (\sigma B(\tau))^2/(4\kappa)]\}$ and $B(\tau) \equiv (1-e^{-\kappa\tau})/\kappa$.

bank assets, and σ_v is the standard deviation of the rate of return on bank assets, which is constant over each yearly interval.[12]

A.3 *Liability return generating process*: *A bank's total non-ownership liabilities are assumed to earn a market rate of return satisfying*

$$dD_t / D_t = \alpha_d(t)dt + \sigma_d dq \tag{3}$$

Since a bank's liabilities are a portfolio of fixed-income securities, their value depends on the same source of risk as other bond-like instruments. Hence, the bond and bank liability processes of (1) and (3) are both driven by the same Brownian motion process, dq. We follow Pennacchi (1987a,b) by assuming that the sensitivity of the bank's total liabilities to changes in interest rates is constant, that is, σ_d is fixed. This implies that the bank maintains a constant duration or "effective maturity" for its liabilities.[13] Consistent with A.1, σ_d is an increasing function of the duration of the bank's liabilities, and for the special case of a zero duration (all liabilities re-price instantaneously), $\sigma_d = 0$ and $\alpha_d(t) = r_t$.

Equations (2) and (3) determine the primary sources of uncertainty affecting the rate of return on bank assets and liabilities. As a special case, if a bank's assets consist entirely of a portfolio of default-free fixed income securities, such as Treasury bonds, default-free mortgages, or mortgage-backed securities, this would correspond to $\rho = 1$ and σ_v would measure the sensitivity of bank assets to interest rate changes. The difference between σ_v and σ_d would reflect the bank's mismatch in the duration of its assets and liabilities and would measure of the interest

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[12] σ_v could be allowed to change from year to year as a function of the bank's end-of-year asset/liability ratio. Our empirical work assumes it is constant.

[13] Cox, Ingersoll, and Ross (1979) define the duration of a fixed-income portfolio as the maturity of the zero-coupon bond that has the same interest rate risk as this portfolio. Thus, if $\sigma_d = \sigma_d^*$, then the duration of bank liabilities is defined as the maturity, τ^*, of the zero-coupon bond that has the same risk, that is, $\sigma_p(\tau^*) = \sigma_d^*$. In the case of the Vasicek (1977) model where $\sigma_p(\tau) = \sigma(1-e^{-\kappa\tau})/\kappa$; this implies $\tau^* = -(1/\kappa)\ln(1-\kappa\sigma_d^*/\sigma)$.

rate risk of the bank's net worth. For the general case of imperfect correlation between bank assets and liabilities, $|\rho| < 1$, the bank's assets are exposed to additional sources of risk, such as credit risk or risk from changes in the market value of derivative positions.

A.4 *Behavior of bank regulators*: *Define a bank's asset/liability ratio as* $x_t \equiv V_t/D_t$. *The bank is audited at the end of each year and, if at that time* $x_t < \phi$, *it is closed.*[14] *When a bank of type b is closed, the deposit insurer incurs an expense for resolving the failed bank that is assumed to equal a given proportion,* f_b, *of the failed bank's liabilities. Thus, if the bank fails at date T, the insurer experiences a loss equal to*

$$F_T = f_b D_T \tag{4}$$

Unlike previous deposit insurance pricing models that relate the FDIC's loss to the failed bank's assets and various classes of liabilities, (4) follows the spirit of Longstaff and Schwartz (1995) in assuming an FDIC loss rate that is the same for all banks of a particular type.[15] This simplification is motivated by the difficulty of specifying FDIC losses in terms of the assets, deposits, and other senior and junior liabilities of the failed bank. As with non-banking firms, absolute priority of liabilities effectively is violated when a bank fails because many uninsured liabilities can withdraw or secure their claims shortly before the bank is closed. Such incentives probably have been amplified since national depositor preference legislation was adopted in 1993. This law raised domestic depositors' claims on a failed bank's assets above those of foreign depositors and general creditors. Its effect on the level of FDIC losses has been subject to debate, a debate that has yet to be resolved by experience, since only a few small banks have

[14] ϕ is assumed to be close to 1. Its actual value will depend on how quickly regulators act to close weak banks. While legislation mandates closure when a bank's book value capital ratio equals 2 percent, its contemporaneous market value capital ratio, $x_t - 1$, typically could be less.

[15] Exogenous loss rates also are assumed in "reduced-form" models which specify default as a Poisson process with a stochastic default intensity or hazard rate. An example is Duffie and Singleton (1999).

failed since the law's passage.[16] Specifying the appropriate loss rate, f_b, for a particular bank type, b, is left for future research.[17]

A.5 ***Other activities of banks***: *Immediately following regulators' audit of the bank at the end of each year*, *if the bank is allowed to remain in operation*, *then the following three discrete adjustments occur*: 1) *Liabilities grow discretely at the rate* g_d:

$$D_{t^+} = (1 + g_d) D_{t^-} \tag{5}$$

where D_{t-} *denotes the value of the bank's liabilities just prior to their growth at date t while* D_{t+} *denotes the value of bank liabilities just after date t*; 2) *A deposit insurance premium equal to* H_t D_{t+} *is paid*;[18] 3) *The bank adjusts its asset / liability ratio, either by issuing new equity repurchasing stock, and/or paying dividends so as to move partially toward its target capital/asset ratio*. *Specifically*, *if* $x_{t-} = V_{t-}/D_{t+}$ *is the bank's asset/liability ratio just prior to the adjustment*, x^* *is the bank's target ratio, and* $x_{t+} = V_{t+}/D_{t+}$ *is the bank's asset/liability ratio following the adjustment, then the end-of-period asset/liability ratio satisfies*[19]

$$x_{t^+} = x_{t^-} + \kappa\left(x^* - x_{t^-}\right) \tag{6}$$

[16] Marino and Bennett (1999) review this issue and related empirical findings. Ceteris paribus, the higher priority of the FDIC's insured deposit claim should lower its losses. However, the FDIC's losses could increase if uninsured liability holders react by shortening their claims' maturities or switching to secured (collateralized) liabilities.

[17] A bank's type could depend on its proportions of insured deposits, uninsured domestic and foreign deposits, senior non-deposit liabilities, junior (subordinated) non-deposit liabilities, and other characteristics such as the bank's size and location. The loss rate for each type can be estimated from historical FDIC experience, adjusted, perhaps, for changes in depositor preference and regulations such as the prompt corrective action mandates contained in the 1991 FDIC Improvement Act. Our empirical work specifies f_b based on the FDIC's historical loss rates for banks categorized by size. If future loss rates are similar to those of the past, our less complicated modeling may give reasonably accurate estimates of the FDIC's liability.

[18] H_t is the premium as a proportion of total bank liabilities. The premium as a proportion of total domestic deposits would equal H_t times the ratio of the bank's total liabilities to domestic deposits. Note that $\mathrm{H}_t D_t$ is the actual premium paid by the bank, which may differ from the fair premium calculated below.

[19] V_{t-} is the value of the bank's assets prior to paying its insurance premium while V_{t+} is the bank's assets after having paid its insurance premium and making its adjustments to capital. Thus the implicit assumption in the mean-reverting process (6) is that the bank raises sufficient (additional) capital to cover

Equations (2) and (3) characterize the rates of return on the existing stocks of bank assets and liabilities, but the value of assets and liabilities can change due to inflows and outflows. Specifically, dividend payments, equity (capital) share issues and repurchases, payment of bank deposit insurance premiums, and net new deposit growth will change the total quantity of a bank's assets and/or liabilities. For analytical simplicity, we assume that these sources and uses of funds take place at a single point in time and lead to the adjustments given in (5) and (6).

In summary, the following sequence of events is assumed to occur each year:

1. Starting from their beginning-of-year values, the market values of bank assets and deposits change stochastically during the year following the rate of return processes given in equations (2) and (3).
2. At the end of the year, regulators audit the bank and determine whether it should be closed. If the bank is closed, the deposit insurer's payment required to resolve the failure equals the expression in (4).
3. If regulators allow the bank to continue operating, then end-of-year liabilities grow discretely according to equation (5), a deposit insurance premium is paid, and bank assets change due to share purchases and/or dividend payments so as to adjust the bank's capital/asset ratio according to (6). Starting again at 1., the events are repeated for the following year.

Given the previous assumptions, we can now derive an insurer's liability for guaranteeing the deposits of a particular bank for a period of *n* years. We next determine the annual insurance premium that the bank would need to pay to cover this *n*-year liability. Lastly, we derive this bank's required insurance premium when its insurance plan is a moving average of *n* overlapping contracts.

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payment of its insurance premium. This assumption simplifies our analysis because changes in bank capital are independent of the size of insurance premiums.

Denote the current date as 0 and define l_{0n} as the insurer's liability for the possible failure of the bank occurring at only date n, which currently is exactly n years in the future.[20] This liability, l_{0n}, is a contingent claim whose value depends on the bank's assets and liabilities. Recognizing this allows us to apply standard asset pricing theory. The premise of this theory is that the equilibrium values of all assets and liabilities should not permit arbitrage opportunities, or, equivalently, that assets having the same risk should possess the same premium for risk.

Let us first consider a hypothetical bond mutual fund that invests in default-free bonds having the same duration as that of the bank's total liabilities, and denote the fund's date t share price as B_t. Because this mutual fund's duration equals that of the bank's liabilities, its rate of return process is the same as that of D_t given in equation (3). If, with no loss of generality, we assume that $B_0 = D_0$, then the only difference between the values of B_t and D_t is that total liabilities, D_t, grow discretely at rate g_d at the end of each year that the bank has not been closed. This implies that at some beginning-of-year date, t =1, 2, …, for which the bank is still in operation, $D_t = B_t(1+g_d)^{t-1}$.

Next, let us normalize (deflate) the value of the insurer's liability by this bond fund's share price, B_t.[21] It can be shown that the absence of arbitrage opportunities in the original non-normalized price system implies an absence of arbitrage in this normalized price system and, further, that a probability measure exists for which the normalized value process, l_{tn}/B_t, is a martingale:

$$\frac{l_{0n}}{B_0} = E_0^Q\left[\frac{l_{nn}}{B_n}\right] \tag{7}$$

where E_0^Q denotes the date 0 expectation operator under the equivalent martingale probability measure Q, also known as the "risk-neutral" probability measure. Equation (7) can be simplified

[20] Recall the assumption that banks are audited, and possibly closed, at the end of each year.

[21] The idea for such a normalization technique can be traced to Merton (1973) and Margrabe (1978). Lewis and Pennacchi (1999) perform a similar normalization in the context of valuing guarantees of pension benefits.

because assumption A.4 states that if the bank fails at date n, then the insurer's loss would equal $f_b D_n$. Otherwise, its loss at date n is zero. Failure at date n would occur if $x_t \geq \phi$ for $t = 1, \ldots, n$-1, but $x_n < \phi$.

Define p_{0n} as the date 0 probability under measure Q that this set of events occurs, namely, $x_t \geq \phi$ for $t = 0, 1, \ldots, n$-1, but $x_n < \phi$. Shortly, we will discuss how this risk-neutral failure probability can be computed, but for now, we emphasize that p_{0n} differs from the true probability of failure because it accounts for a risk premium. Given this definition of p_{0n}, equation (7) can be re-written as

$$\begin{aligned} \frac{l_{0n}}{B_0} &= \frac{f_b D_n}{B_n} p_{0n} = f_b \frac{B_n \left(1+g_d\right)^{n-1}}{B_n} p_{0n} \\ &= f_b \left(1+g_d\right)^{n-1} p_{0n} \end{aligned} \tag{8}$$

Since $B_0 = D_0$, equation (8) implies

$$l_{0n} = f_b \left(1+g_d\right)^{n-1} D_0 \, p_{0n} \tag{9}$$

Next, if we define L_{0n} as the value of an insurance contract that extends from the current date up until and including date n, then this n-period contract has a value that is simply the sum of the values of the single-date contracts.

$$L_{0n} = \sum_{i=1}^{n} l_{0i} = f_b D_0 \sum_{i=1}^{n} \left(1+g_d\right)^{i-1} p_{0i} \tag{10}$$

Consistent with A.5, suppose that the bank is charged annual insurance premiums to cover this n-period contract. Conditional on the bank having not failed beforehand, it would pay a premium at date t equal to $h_{0n} D_t$, t=0, 1, …, n-1. The value of these contingent premium payments can be derived in a manner similar that of the insurer's liability. Defining v_{0t} as the value of the single premium that the bank promises to pay at date t, it equals

$$v_{0t} = h_{0n} \left(1+g_d\right)^{t} D_0 \prod_{i=0}^{t} \left(1-p_{0i}\right) \tag{11}$$

where, assuming the bank is currently in operation, $p_{00} = 0$. Hence, the value of the sum of the annual promised premiums from dates 0 to n-1 is given by

$$V_{0n} = \sum_{t=0}^{n-1} v_{0t} = h_{0n} D_0 \sum_{t=0}^{n-1} \left(1+g_d\right)^t \prod_{i=0}^{t} \left(1-p_{0i}\right) \tag{12}$$

To determine the fair annual insurance premium that would set the insurer's net liability to zero for this n-year contract, we equate the value of the insurer's gross liability, L_{0n}, in equation (10) to the value of premium revenue, V_{0n}, in equation (12) and solve for h_{0n} to obtain

$$h_{0n} = f_b \frac{\sum_{i=1}^{n} \left(1+g_d\right)^{i-1} p_{0i}}{\sum_{t=0}^{n-1} \left(1+g_d\right)^t \prod_{i=0}^{t} \left(1-p_{0i}\right)} \tag{13}$$

Finally, the total premium for an n-year moving average insurance contract, that is, a contract composed of n overlapping contracts, each covering $\frac{1}{n}$ th of losses, can be calculated. Denoting this premium as H_{0n}, it equals

$$H_{0n} = \frac{1}{n} \sum_{k=0}^{n-1} h_{(0-k)(n-k)} \tag{14}$$

To complete this derivation of a moving average insurance premium, a bank's risk-neutral failure probabilities, p_{0i}, $i = 1, \ldots, n$, in equation (13) need to be specified. As a prelude, we discuss how the bank's actual or "physical" probabilities of failure can be computed. Computing a bank's risk-neutral failure probabilities are done in a similar manner. While the risk-neutral probabilities are required for valuing the insurer's liability, the physical probabilities may be of interest in their own right. They may be helpful in calibrating the model's closure point, ϕ, to make the model's implied frequency of bank failures match an historical failure rate. Also, if one substitutes the physical probabilities for the risk-neutral probabilities in equations (13) and (14), the resulting insurance premiums equal the expected loss of the deposit insurer discounted at a riskless rate. While such premiums allow the government insurer to "break-even" on average, they fail to incorporate a premium for the systemic risk to which taxpayers are exposed. Bazelon and Smetters (1999) discuss the distortions that arise when government projects are discounted by a rate that fails to account for systemic risk.

A bank's failure probabilities are determined by the joint distribution of its end-of-year asset liability ratios, x_1, x_2, …, x_{n-1}, and x_n, which are generated by the processes (2), (3), and (6). Except for times when x_t changes discretely according to (6), (2) and (3) imply that $x_t \equiv V_t/D_t$ follows the process[22]

$$\begin{aligned} dx/x &= \left(\alpha_v - \alpha_d + \sigma_d^2 - \sigma_{vd}\right)dt + \sigma_v dz - \sigma_d dq \\ &= \alpha_x dt + \sigma_x dw \end{aligned} \tag{15}$$

where $\sigma_{vd} \equiv \rho\sigma_v\sigma_d$, $\alpha_x \equiv \alpha_v\text{-}\alpha_d\text{+}\sigma_d^2\text{-}\sigma_{vd}$, $\sigma_x^2 \equiv \sigma_v^2 + \sigma_d^2 - 2\sigma_{vd}$, and dw is a standard Brownian motion process equal to $(\sigma_v dz\text{-}\sigma_d dq)/\sigma_x$. Note from equation (15) that if the bank's liabilities are of short duration, then $\sigma_d \approx 0$, $\sigma_{vd} \approx 0$, and $\alpha_d \approx r_t$. In this case, the expected rate of change in the bank's asset-liability ratio, α_x, equals the risk-premium on bank assets, $\alpha_v(t)\text{-}r_t$.

Given estimates for α_v, α_d, σ_v, σ_d, and σ_{vd}, equations (15) and (6) could be used to calculate the bank's actual probability of failure for each future date. If a model such as Vasicek (1977) is assumed to hold, then α_x and σ_x are constants and beginning-to-end-of-year changes in x_t are lognormally distributed. Starting from an initial asset-liability ratio, x_0, a random number generator can be used to calculate an end-of-year value, x_1, and, if $x_1 \geq \phi$, it would then change according to (6) and another lognormal random number would be used to generate a value for the end of the next year, x_2. This procedure would be repeated for all future years as long as $x_t \geq \phi$. If $x_t < \phi$ at some future date t, this would be noted as a failure at that date and the sequence would end. By starting from the same x_0 and simulating another path x_1, x_2, …, x_t, … multiple times, the proportion of these sequences for which failure occurs at a particular date, t, can be calculated. For a sufficiently large number of sequences, this proportion becomes an accurate measure of the true probability of failure at date t.

Calculating a bank's "risk-neutral" probability of failure, that is, the probability under the Q measure, is similar to that of calculating the true or "physical" failure probability, but with one important difference. The process used to simulate future asset-liability ratios, x_t, is given by equation (15) but with $\alpha_x = 0$, rather than $\alpha_x = \alpha_v - \alpha_d + \sigma_d^2 - \sigma_{vd}$. Beginning-to-end-of-year changes in x_t continue to be lognormally distributed, but the expected rate of change is now zero rather than equal to the risk premium on bank assets relative to liabilities, $\alpha_v - \alpha_d + \sigma_d^2 - \sigma_{vd}$.[23] Assuming that $\alpha_v - \alpha_d + \sigma_d^2 - \sigma_{vd} > 0$, the simulated risk-neutral distributions for $x_1, x_2, \ldots, x_n$ will tend have greater probability mass in smaller values of the x_t's relative to the simulated physical distributions for $x_1, x_2, \ldots, x_n$. Hence, the risk-neutral probability of avoiding failure (survival probability) over any given horizon, $\prod_{i=1}^{n}(1-p_{0i})$, is less than the corresponding physical probability.

The logic for setting $\alpha_x = 0$ when calculating the p_{0i}'s is that in a risk-neutral world, the expected rates of return on all assets would be the same and equal to the risk-free return. If the prices of assets and liabilities are normalized by the price of the bond mutual fund, B_t, as we did for the insurer's liability in equation (7), then the bond fund's normalized share price, B_t/B_t, is a constant equal to 1. In this pricing system, the normalized bond fund is the risk-free asset, and its rate of return is zero. Hence, the normalized value of bank assets, V_t/B_t, also has an expected rate of return of zero under the risk-neutral Q measure. Since the bond mutual fund earns a return identical to that of the bank's deposits (their durations are identical), the expected rate of return on normalized bank assets also equals $\alpha_x = \alpha_v - \alpha_d + \sigma_d^2 - \sigma_{vd}$, which under the risk-neutral Q measure must then be zero.

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[22] Equation (15) is the result of applying Itô's lemma.

[23] Therefore, calculating the probability of failure under the risk-neutral Q measure does not require an estimate of the relative risk premium. Compared to calculating true failure probabilities, less information and/or assumptions are needed.

III. Empirical Results

Estimates of actual and risk-neutral annual failure probabilities, and fair and expected value-based insurance rates, were computed using time series – cross section data on individual banking institutions. The data consist of 42 commercial banks and bank holding companies that had publicly-traded shareholders' equity and that were listed continuously on both CRSP and Compustat databases over the 10 year period, January 1987 through December 1996.[24] No adjustments were made to account for the potential effects of mergers during this period.[25] Summary statistics for these banks are given in Table 1 at the end of the paper. Column one of the table shows that these banks are relatively large in size, with the mean and median of year-end 1996 total liabilities of $34,083 million ($34 billion) and $12,104 million, respectively.[26] The second column gives the proportion of 1996 total liabilities that are in the form of domestic deposits.[27]

An empirical technique similar to Marcus and Shaked (1984) was used to calculate each bank's market value of assets to liabilities, x_t, for every month during the sample period and each bank's standard deviation of its assets to liabilities ratio, σ_x. This was done using data on the market value and standard deviation of each bank's shareholders' equity, as well as the covariance of its equity's returns with changes in Treasury security rates. The procedure is outlined in the Appendix. Table 1 summarizes the results, with column 3 giving the average monthly value of each bank's net worth to liability ratio, $x_t - 1$, and with column 4 giving each bank's estimated value of σ_x.

[24] Estimates for banks that do not have publicly-traded equity can be obtained using the method of Falkenheim and Pennacchi (2001).
[25] Because the sample banks are the survivors of any mergers during this period, they would tend to be the larger merger participants and be less affected. Since all of our banks' risk characteristics are normalized by total liabilities, any effect of mergers on failure probabilities and insurance premiums would need to result from a change in a bank's asset/liability ratio (x), target asset/liability ratio (x^*), or standard deviation of its asset/liability ratio (σ_x). It is not clear that mergers have any systematic effect on these risk variables.
[26] Total liabilities includes all non-ownership liabilities, such as deposits and subordinated debt, but excludes preferred and common stock.

The estimated net worth or capital, $x_t - 1$, for these banks varied substantially over the 1987 to 1996 period, a time when the commercial banking industry experienced an increasing number of failures followed by a strong recovery. The mean and median estimated capital levels, as a percent of total liabilities, for the 42 banks over this 10-year period were 11.81 % and 11.32 %, respectively. The mean and median volatilities (annual standard deviations) of changes in capital across the 42 banks were 3.14 % and 3.13 %, respectively. Banks with a higher volatility of capital tended to maintain, on average, a higher level of capital. The correlation between a bank's volatility of capital and its average level of capital over the period was 0.3256. This positive correlation is consistent with the notion that banks having riskier assets choose higher levels of capital, either voluntarily or due to regulatory requirements such as risk-based capital standards.[28]

These monthly estimates of the 42 banks' market values of capital were used to analyze the extent of mean reversion in capital ratios. Consistent with equation (6), a time series – cross-section autoregressive process of capital ratios was estimated (42 banks times 120 months = 5040 observations). Because of the evidence that higher volatility banks tend to maintain higher average capital, when performing this regression each individual bank's "target" capital ratio was set equal to its sample average over the 10-year period. The resulting estimate for the mean reversion parameter κ was 0.1766 and statistically significant at the 99 % confidence level. The implication is that if a bank's beginning-of-year capital ratio deviated from its target, then by the end of the year it would be expected to revert 17.66 % back to its target. This mean reversion parameter, along with each bank's target capital ratio, were used in simulating the capital processes required for computing insurance premiums.

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[27] Our estimates of fair and expected value insurance premiums are stated as a proportion of a bank's total liabilities. Because the current FDIC practice is to set premiums as a proportion of total domestic deposits, information on domestic deposits is included for this purpose.

[28] Flannery and Rangan (2002) also find that banks with greater portfolio risk tend to hold greater equity capital. Their findings, as well as those of Ashcraft (2001), suggest that market incentives, rather than regulatory requirements, influenced banks' choice of capital.

Using each bank's capital and volatility estimates at the end of each year during 1987-1996, 1 to 5 year failure probabilities were calculated, where the i^{th} year failure probability is the probability that the bank's net worth is negative at the end of *i* years. Both risk-neutral probabilities and actual probabilities of default were estimated. Recall that the risk-neutral probabilities are calculated by assuming the expected rate of return on bank assets and liabilities are the same, equal to the short-term, risk-free interest rate. In contrast, the estimated actual probabilities assume that the expected rate of return on bank assets exceeds that of liabilities by 0.985 % each year. This bank asset risk premium of 98.5 basis points was estimated from the market returns on bank stocks, relative to the 30-day Treasury bill rate, over the period 1926 to 1996.[29]

In addition to computing failure probabilities for the 1987 to 1996 period, we also calculated each bank's 1 to 5 year steady state failure probabilities. This was done by simulating for each bank a 1,000 year time-series of its asset/liability ratio (one plus its capital ratio), x_t. The simulation assumes that a bank's initial capital equals its individual target level, x^*, and then evolves randomly according to the processes given in (15) and (6).[30] Then, just as was done previously for the 10-year period, 1987 to 1996, 1 to 5 year risk-neutral and actual failure probabilities were calculated for each year during the 1,000-year simulation period.

Table 2 summarizes the results from calculating failure probabilities based on the 1987 to 1996 period as well as for the 1,000-year (steady state) period. The table gives the mean and median failure probabilities across both banks and time. As expected, one can see that the risk-neutral probabilities are always larger than the corresponding actual or physical probabilities. The risk-neutral probabilities are higher because the effect of a bank asset risk-premium is taken out. This is the correct probability to use for insurance valuation purposes, if one wishes to

[29] See Pennacchi (1999 p.161) for details.
[30] The simulation generates a 1,000-year time-series for each of the 42 banks. Each bank's value of x^* and σ_x are those estimated from the 1987 to 1996 period. Each bank's risk premium on bank assets is assumed to be 98.5 basis points.

properly compensate the insurer for its exposure to systemic risk. In contrast, the actual probabilities could be relevant if one wishes to calibrate some of the model's parameters to match historical bank failure rates. Table 2 also gives an indication of a skewed distribution for failure probabilities. The mean (simple average) failure probabilities are much higher than the median ones. Further, the 1987 to 1996 decade appears to be a relatively risky period for banks, since the failure probabilities during this period are generally higher than for the steady state.

Figures 1A and 1B, which graph the average risk-neutral and actual first year and fifth year failure probabilities from year-end 1987 to 1996, show that failure probabilities peaked at the beginning of 1991 and then declined during the latter half of the period. Figures 2A and 2B show the risk-neutral first, third, and fifth year failure probabilities for two individual banks: one whose average first year failure probability ranked it at the median of all banks and one whose average first year failure probability ranked it at the 75th percentile. From these figures it is clear that failure probabilities change more slowly for years farther into the future.

The next step is to calculate fair and expected-value insurance premiums using these failure probabilities and the formulas in equations (3) and (4) above. To do so, one needs to specify a bank's expected growth in liabilities in excess of the risk-free rate, g_d, and the FDIC's loss per bank liability should the bank fail, f_b. Our calculations assume that each bank's expected liability growth equals the risk-free rate, that is, $g_d = 0$.[31] The FDIC's loss rate is assumed to depend on a bank's size. As reported in Table 3 of Oshinsky (1999), the FDIC's average loss rate for failures of top 50 banks during the period 1934-1997 was 3.2 % of failed bank assets, while its average loss rate for failures of banks ranked 51-100 in size was 6.6 %. Thus, we assumed that if

[31] This is slightly higher than the actual growth in aggregate bank liabilities over the sample period. From 1987-1996, total bank liabilities grew by 4.2 % while the return on a three-month Treasury bill investment was 5.5 %. For simplicity, we have assumed that deposit growth rates are constant. However, the model and the contract design can be modified to allow deposit growth to vary across time and to have the overlapping insurance contracts cover different proportions (rather than each cover $1/n^{th}$) of total deposits. As each new *n*-year insurance contract replaces a maturing one, the incremental amount of deposits would be covered by the new *n*-year contract. Such a rule would result in new deposits being insured at a rate reflecting the bank's current risk, thereby reducing moral hazard incentives.

a bank holding company had 1996 total liabilities exceeding $15 billion, which placed it among the top 50 for that year, then the FDIC would experience a loss equal to f_b = 3.2 % of the bank's total liabilities at the time of failure. For all other bank holding companies in our sample, the FDIC's loss was assumed to equal 6.6 % of a bank's liabilities at the time of failure.

Table 3 gives the (simple) average fair and expected value insurance premiums for all banks over the 1987 to 1996 period and during the steady state for moving average contracts having n = 1 to 5 years. It shows that the average expected value premiums, which equal the FDIC's expected losses for the overlapping contracts, are over twice as high during the 1987-1996 period as during a steady state. Recall that these expected value premiums were calculated using the actual, rather than risk-neutral, default probabilities. There is a slight decline in the size of these premiums as the number of overlapping contracts, n, increases. This could be due to the effect of the bank asset risk-premium (98.5 basis points), which gives bank capital an upward drift and tends to reduce the likelihood of failure over the longer-term contracts.[32]

In contrast, one sees that the average fair premiums are higher than their expected value counterparts and rise as n increases. This is what one would expect from theory. The fair premiums use the previously computed (higher) risk-neutral probabilities of failure, which adjust for the insurer's (taxpayers') exposure to systemic risk. Interestingly, the size of the deposit insurance risk-premium, which is approximately the difference between the fair premium and its corresponding expected value premium, increases with n. For the 1987-1996 period, the difference is 4.2 cents per $100 of liabilities when n = 1 and 8.9 cents per $100 of liabilities when n = 5. For the steady state, this premium equals 1.4 cents when n = 1 and 3.5 cents when n = 5.

The intuition for why the fair insurance risk-premium rises with the number and length of the overlapping contracts, n, can be developed by comparing the volatility of fair and expected

[32] In contrast to the risk-neutral distribution where both assets and liabilities have an expected rate of change equal to the risk-free rate, for the actual probability distribution the expected rate of return on bank assets exceeds liabilities by 98.5 basis points. This implies that, on average, capital will be above its

value premiums. For contracts $n = 1$ to 5, the annual standard deviations of each bank's fair and expected value insurance premiums were computed for 1987-1996 and for a steady state. Table 4 shows the averages across the 42 banks of these standard deviations.

For both the fair and expected value premiums, the annual standard deviations decline as n increases. This is the effect of a longer moving average. As stated earlier, as n increases, a bank's total premium becomes less volatile, since new information affects only a $\frac{1}{n}^{\text{th}}$ share of the total premium. This decrease in volatility reduces the variability of premiums paid by banks, but it also makes the difference between premiums received and losses paid out by the FDIC more volatile. In other words, the variance of the net revenue received by the FDIC for providing deposit insurance (premiums minus losses) increases with n. Under a fair premium structure, the FDIC (taxpayers) must be compensated for this additional risk, and that is why the size of the risk premium increases as n becomes larger.

The previous tables reported averages across the 42 banks. We now consider means and standard deviations of premiums for the individual banks. Tables 5 and 6 report the average 1987-1996 fair and expected value premiums for each of the 42 banks. In both of these tables, banks are ranked by the size of their average one-year ($n = 1$) premiums. The relative ranking of the banks based on fair premiums does not differ significantly from that based on expected value premiums. In both cases, the distribution is skewed, with a few high-risk banks paying substantial premiums. However, it is clear that fair premiums are always at least as high as expected value premiums for any given bank. These results are confirmed by Figures 3A and 3B, which graph the fair 1-, 3-, and 5-year contract premiums for the median and 75$^{\text{th}}$ percentile bank, and by Figures 4A and 4B, which graph the expected value 1-, 3-, and 5-year contract premiums for the median and 75$^{\text{th}}$ percentile bank.

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current level in the future. While the bank will tend to adjust capital downward if it is above target, the adjustment is only partial.

In Tables 7 and 8, similar statistics are reported but for the average steady state fair and expected value premiums. Again, the banks are ranked by the size of their average one-year premiums. In general, the steady state premiums are lower than the 1987-1996 period, but skewness still is apparent. Further, those banks that were relatively risky during the 1987 to 1996 period continue to be relatively risky based on their steady state premiums. It is also noteworthy that, as in the Table 3 averages, each bank's average expected value premiums generally decline with the length of its overlapping contract, n. However, also consistent with Table 3's averages, each bank's average fair premiums increase with the contract length.

The last two tables, Tables 9 and 10, report each bank's standard deviations of fair and expected value premiums computed over the steady state. In each of these tables, banks are ordered from lowest to highest in terms of the standard deviation of their one-year (n = 1) premiums. Not surprisingly, banks that pay high premiums, on average, also have high standard deviations of premiums. However, with only a very few exceptions, a bank's standard deviation of premiums declines monotonically with the length of the overlapping contract, n. This verifies that our moving average approach acts to stabilize premiums. The lower volatility of premiums for longer contract lengths is also evident from Figures 3A, 3B, 4A, and 4B.

IV. Conclusion

This study shows that fair insurance premiums can be estimated that are stable yet subject to frequent updating. The methodology involves treating the insurance guarantee as a moving average of several long-term insurance contracts. This proposed system satisfies a number of desirable features expressed by bankers and regulators and should also be attractive to policy makers that wish to avoid providing deposit insurance subsidies.

The system provides intertemporal smoothing a bank's fair insurance premium, thereby insuring the bank against paying high rates during times of financial distress. However, this intertemporal insurance comes at a cost. The fair risk premium needed to compensate taxpayers for their exposure to systemic risk is higher the longer the average maturity of the insurance contract. Essentially, more stable deposit insurance premiums result in more volatile net revenues for the FDIC (and taxpayers): premiums will not rapidly rise to cover higher losses from bank failures during financial crises. The result is that under a stable system of premiums, more taxes need to be raised to cover FDIC losses during downturns in the banking industry. The undesirability of raising taxes during a recession is what results in a higher required risk premium.

In principle, an individual bank could choose the length of its moving average insurance contract, trading-off a higher average fair insurance premium for greater rate stability. Bank regulators, however, may wish to place an upper limit on the contract's length, since a bank's incentive for moral hazard could worsen if insurance rates adjust too slowly to changes in its risk. Such a policy would mimic how an uninsured firm chooses the maturity structure of its debt, a choice limited by the discipline of market investors.

Appendix

This Appendix describes how market value asset-liability ratios, x_t, and their volatility, σ_x, are estimated for each of the 42 banks in our sample. The method is an extension of Marcus and Shaked (1984) that incorporates interest rate risk. Note that to compute $\sigma_x^2 \equiv \sigma_v^2 + \sigma_d^2 - 2\rho\sigma_v\sigma_d$, estimates of the parameters σ_v, σ_d, and ρ are required. First, the parameter σ_d was estimated using the technique described in Appendix B of Pennacchi (1987b). This procedure analyzes changes in a bank's total interest expense to estimate the proportions of its liabilities that are of particular maturity classes. Specifically, it starts by estimating the effective proportions of liabilities that are of 3-, 6-, 12-, and 36-month maturities by analyzing how a bank's total interest expense varied with yields on 3-, 6-, 12-, and 36-month Treasury securities. From these estimated maturity or duration proportions, the standard deviation of the rate of return on total bank liabilities, σ_d, is computed using the Vasicek (1977) model of the term structure of interest rates. This was done for each of the 42 banks using interest expense data from Call Reports over the period 1987 to 1996.

Given an estimate for σ_d, the variable x_t and the parameters σ_v and ρ can be estimated in a manner similar to Marcus and Shaked (1984) and Pennacchi (1987b) using observations of a bank's market value of shareholders' equity, its equity's return standard deviation, and the covariance between its equity's return and changes in market interest rates. Define S_t as the current market value the bank's shareholders' equity, σ_s as the standard deviation of its equity's return, and σ_{sr} as the covariance between its equity's return and changes in the short-term interest rate, r_t. Also let $s_t \equiv S_t/D_t$ be the value of the bank's equity per dollar of bank deposit. By matching empirical estimates of s_t, σ_s, and σ_{sr} to their theoretical values, the parameters x_t, σ_v, and ρ are estimated. Approximating the value of bank equity as a one-year call option on the firm's assets leads to the equations[33]

$$s_t = x_t N\left(d_{1,t}\right) - N\left(d_{2,t}\right) \tag{A1}$$

$$\sigma_s^2 = \left(N\left(d_{1,t}\right)\frac{x_t}{s_t}\sigma_v \right)^2 + \left(\left[1 - N\left(d_{1,t}\right)\frac{x_t}{s_t}\right]\sigma_d \right)^2 + 2N\left(d_{1,t}\right)\left[1 - N\left(d_{1,t}\right)\frac{x_t}{s_t}\right]\frac{x_t}{s_t}\rho\sigma_v\sigma_d \tag{A2}$$

$$\sigma_{sr} = -N\left(d_{1,t}\right)\frac{x_t}{s_t}\rho\sigma_v\sigma - \left[1 - N\left(d_{1,t}\right)\frac{x_t}{s_t}\right]\sigma_d\sigma \tag{A3}$$

where $d_{1,t} = \left\{\ln\left[x_t\right] + \tfrac{1}{2}\sigma_x^2\right\}/\sigma_x$ and $d_{2,t} = d_{1,t} - \sigma_x$.

The standard deviation of equity returns, σ_s, and the covariance of equity returns with changes in the short-term (3-month Treasury bill) interest rate, σ_{sr}, were estimated using weekly

[33] The implicit assumption of this approximation for equity is that only the first year cost of the deposit might be unfairly priced. In other words, the current value of equity reflects future insurance premiums that equal the cost of insurance for each year following the first. The approximation error in pricing bank equity is probably modest, and even smaller errors in valuing σ_s and σ_{sr} are likely. The reason is that for banks that are currently in strong financial condition, the value of deposit insurance, for both the current and future years, is likely to be small or moderate. In contrast, for banks that are currently in weak financial condition, the value of deposit insurance for the first year is likely to represent the largest part of the total cost of insurance.

CRSP data for the year 1996. Also using Treasury bill data over the period 1968 to 1996, the standard deviation of the short-term interest rate was estimated to be $\sigma = 0.0224$. From Bank Compustat, the year-end 1996 value of the market value of equity to total liabilities ratio, s_t, was obtained for each bank. Then inserting the values s_t, σ_s, σ_{sr}, σ, and σ_d into (A.1) to (A.3), these three non-linear equations were solved to obtain each bank's year-end 1996 value of x_t and its parameters σ_v and ρ. From these estimates, each bank's value of $\sigma_x^2 \equiv \sigma_v^2 + \sigma_d^2 - 2\rho\sigma_v\sigma_d$ was determined. Lastly, CRSP and Compustat data were used to create a time series of monthly market value of equity to liability ratios, s_t, for each bank over the period 1987 through 1996. Inserting each bank's σ_x and s_t into (A1) then allowed us to solve for the bank's corresponding time series of monthly x_t values.

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Table 1

Summary Statistics for Sample Banks

Bank	1996 Liabilities ($ millions)	Proportion Domestic Deposits	Average Capital Ratio	Standard Deviation Capital Ratio
Sterling Bancorp, NY	784	0.729	0.0975	0.0301
Mid America Bancorp, KY	1280	0.645	0.1418	0.0159
Westamerica Bankcorporation, CA	2310	0.901	0.1123	0.0295
Hubco Inc, NJ	2913	0.890	0.1183	0.0331
Cullen Frost Bankers Inc, TX	4509	0.941	0.0697	0.0439
Trustmark Corp, MS	4670	0.770	0.1029	0.0374
Firstmerit Corp, OH	4704	0.894	0.1447	0.0352
Riggs National Corp, DC	4709	0.780	0.0530	0.0337
Wilmington Trust Corp, DE	5100	0.767	0.2206	0.0324
Deposit Guaranty Corp, MS	5802	0.883	0.0959	0.0261
Mercantile Bankshares Corp, MD	5807	0.920	0.1876	0.0393
Zions Bancorp, UT	5978	0.742	0.1028	0.0401
First Virginia Banks Inc, VA	7365	0.956	0.1549	0.0248
First Citizens Bancshares Inc, NC	7440	0.935	0.0824	0.0264
Hibernia Corp, LA	8370	0.926	0.1167	0.0392
First Commerce Corp New Orleans, LA	8466	0.861	0.0940	0.0231
Commerce Bancshares Inc, MO	8774	0.931	0.1108	0.0276
Star Banc Corp, OH	9239	0.849	0.1413	0.0321
First American Corp, TN	9531	0.808	0.0974	0.0260
Old Kent Financial Corp, MI	11653	0.863	0.1172	0.0225
First Tennessee National Corp, TN	12104	0.746	0.1098	0.0379
Marshall & Ilsley Corp, WI	13502	0.802	0.1485	0.0325
First Security Corp, UT	13567	0.696	0.1073	0.0268
Union Planters Corp, TN	13870	0.828	0.0920	0.0352
Regions Financial Corp, AL	17331	0.833	0.1419	0.0226
Fifth Third Bancorp, OH	18405	0.774	0.2553	0.0570
Huntington Bancshares Inc, OH	19340	0.671	0.1187	0.0192
Northern Trust Corp, IL	20064	0.492	0.1237	0.0316
First of America Bank Corp, MI	20278	0.871	0.0896	0.0233
Crestar Financial Corp, VA	21082	0.608	0.0985	0.0264
Southtrust Corp, AL	24488	0.707	0.0982	0.0292
Comerica Inc, MI	31591	0.699	0.1101	0.0310
Mellon Bank Corp, PA	38850	0.739	0.0956	0.0398
Corestates Financial Corp, PA	41799	0.766	0.1361	0.0432
Wachovia Corp, NC	43143	0.604	0.1518	0.0378
National City Corp, OH	46424	0.756	0.1228	0.0321
Suntrust Banks Inc, GA	47588	0.775	0.1380	0.0311
First Chicago NBD Corp, IL	95612	0.552	0.1113	0.0391
First Union Corp, NC	130119	0.714	0.0995	0.0263
Nationsbank Corp, NC	172037	0.633	0.0890	0.0365
JP Morgan & Co. Inc, NY	210594	0.041	0.0961	0.0144
Citicorp, NY	260296	0.212	0.0661	0.0293

Table 2

Mean and Median Failure Probabilities for 42 Banks During 1987 – 1996 and During a Steady-State

	Horizon				
	1 Year	2 Years	3 Years	4 Years	5 Years
Risk-Neutral Probability					
Mean, 1987-1996	0.02159	0.01937	0.01801	0.01712	0.01643
Mean, Steady State	0.00834	0.00759	0.00834	0.00924	0.01007
Median, 1987-1996	0.00032	0.00390	0.00708	0.00953	0.01016
Median, Steady State	0.00180	0.00222	0.00294	0.00368	0.00439
Actual Probability					
Mean, 1987-1996	0.01402	0.00913	0.00686	0.00572	0.00481
Mean, Steady State	0.00583	0.00364	0.00319	0.00299	0.00287
Median, 1987-1996	0.00009	0.00100	0.00150	0.00165	0.00161
Median, Steady State	0.00097	0.00074	0.00076	0.00078	0.00075

Table 3

Average Fair and Expected Value Insurance Premiums per $100 of Total Liabilities for 42 Banks During 1987 – 1996 and During a Steady State

	Overlapping Contract Period				
	$n = 1$	$n = 2$	$n = 3$	$n = 4$	$n = 5$
Fair Premium, 1987-1996	0.121	0.137	0.147	0.155	0.160
Fair Premium, Steady State	0.047	0.052	0.056	0.059	0.062
Expected Value Premium, 1987-1996	0.079	0.078	0.075	0.073	0.071
Expected Value Premium, Steady State	0.033	0.031	0.029	0.028	0.027

Table 4

Annual Standard Deviations of Fair and Expected Value Premiums Average across the 42 Banks for 1987-1996 and a Steady State

	Overlapping Contract Period				
	$n = 1$	$n = 2$	$n = 3$	$n = 4$	$n = 5$
Fair Premium, 1987-1996	0.180	0.140	0.111	0.090	0.073
Fair Premium, Steady State	0.166	0.144	0.126	0.113	0.102
Expected Value Premium, 1987-1996	0.123	0.084	0.062	0.047	0.037
Expected Value Premium, Steady State	0.130	0.100	0.081	0.067	0.058

Table 5

Fair Insurance Premiums per $100 Total Liabilities
Averages from 1987 to 1996

Bank	Overlapping Contract Period				
	$n = 1$	$n = 2$	$n = 3$	$n = 4$	$n = 5$
Mid America Bancorp, KY	0.000	0.000	0.000	0.000	0.000
JP Morgan & Co. Inc, NY	0.000	0.000	0.000	0.000	0.000
Wilmington Trust Corp, DE	0.000	0.000	0.000	0.000	0.000
Regions Financial Corp, AL	0.000	0.000	0.000	0.000	0.001
First Virginia Banks Inc, VA	0.000	0.000	0.001	0.001	0.002
Huntington Bancshares Inc, OH	0.001	0.001	0.002	0.002	0.002
Mercantile Bankshares Corp, MD	0.001	0.005	0.008	0.013	0.016
Fifth Third Bancorp, OH	0.001	0.006	0.010	0.013	0.016
Old Kent Financial Corp, MI	0.002	0.006	0.009	0.012	0.013
Suntrust Banks Inc, GA	0.002	0.007	0.011	0.014	0.016
Wachovia Corp, NC	0.004	0.011	0.017	0.022	0.026
National City Corp, OH	0.004	0.012	0.018	0.023	0.027
Star Banc Corp, OH	0.006	0.015	0.022	0.026	0.030
Marshall & Ilsley Corp, WI	0.007	0.015	0.021	0.025	0.028
Firstmerit Corp, OH	0.008	0.021	0.031	0.038	0.043
First of America Bank Corp, MI	0.009	0.019	0.026	0.031	0.034
Northern Trust Corp, IL	0.011	0.021	0.028	0.033	0.037
Comerica Inc, MI	0.016	0.030	0.040	0.046	0.050
Southtrust Corp, AL	0.018	0.029	0.037	0.042	0.046
Commerce Bancshares Inc, MO	0.019	0.037	0.051	0.062	0.068
First Union Corp, NC	0.020	0.025	0.029	0.032	0.034
First Chicago NBD Corp, IL	0.027	0.055	0.073	0.084	0.092
Corestates Financial Corp, PA	0.030	0.051	0.065	0.073	0.079
First Security Corp, UT	0.037	0.059	0.071	0.078	0.085
Crestar Financial Corp, VA	0.041	0.047	0.049	0.050	0.052
Sterling Bancorp, NY	0.042	0.076	0.098	0.109	0.115
Westamerica Bankcorporation, CA	0.051	0.078	0.096	0.109	0.120
First Commerce Corp New Orleans, LA	0.071	0.083	0.091	0.095	0.098
First Citizens Bancshares Inc, NC	0.086	0.107	0.121	0.126	0.128
Deposit Guaranty Corp, MS	0.099	0.104	0.106	0.107	0.108
Nationsbank Corp, NC	0.108	0.141	0.160	0.171	0.180
Hubco Inc, NJ	0.124	0.120	0.117	0.115	0.112
Trustmark Corp, MS	0.150	0.192	0.217	0.231	0.242
First American Corp, TN	0.150	0.135	0.127	0.124	0.123
First Tennessee National Corp, TN	0.165	0.212	0.239	0.256	0.269
Union Planters Corp, TN	0.218	0.266	0.296	0.313	0.324
Citicorp, NY	0.258	0.274	0.283	0.287	0.291
Mellon Bank Corp, PA	0.316	0.330	0.344	0.357	0.368
Zions Bancorp, UT	0.345	0.399	0.432	0.456	0.471
Hibernia Corp, LA	0.456	0.417	0.395	0.379	0.369
Riggs National Corp, DC	0.963	1.034	1.057	1.071	1.078
Cullen Frost Bankers Inc, TX	1.197	1.309	1.396	1.468	1.543

Table 6

Expected Value Insurance Premiums per $100 Total Liabilities
Averages from 1987 to 1996

Bank	Overlapping Contract Period $n = 1$	$n = 2$	$n = 3$	$n = 4$	$n = 5$
Mid America Bancorp, KY	0.000	0.000	0.000	0.000	0.000
JP Morgan & Co. Inc, NY	0.000	0.000	0.000	0.000	0.000
Wilmington Trust Corp, DE	0.000	0.000	0.000	0.000	0.000
Regions Financial Corp, AL	0.000	0.000	0.000	0.000	0.000
First Virginia Banks Inc, VA	0.000	0.000	0.000	0.000	0.000
Huntington Bancshares Inc, OH	0.000	0.000	0.000	0.000	0.000
Old Kent Financial Corp, MI	0.000	0.001	0.001	0.001	0.001
Mercantile Bankshares Corp, MD	0.000	0.002	0.003	0.003	0.004
Fifth Third Bancorp, OH	0.001	0.003	0.004	0.005	0.006
Suntrust Banks Inc, GA	0.001	0.002	0.003	0.003	0.003
National City Corp, OH	0.001	0.004	0.005	0.006	0.006
Wachovia Corp, NC	0.002	0.004	0.006	0.007	0.007
Star Banc Corp, OH	0.002	0.004	0.006	0.006	0.006
Marshall & Ilsley Corp, WI	0.002	0.005	0.006	0.007	0.007
First of America Bank Corp, MI	0.003	0.004	0.005	0.005	0.005
Firstmerit Corp, OH	0.004	0.007	0.009	0.011	0.012
Northern Trust Corp, IL	0.005	0.008	0.009	0.009	0.010
Comerica Inc, MI	0.007	0.011	0.013	0.014	0.014
Commerce Bancshares Inc, MO	0.007	0.011	0.012	0.014	0.014
Southtrust Corp, AL	0.008	0.010	0.011	0.011	0.011
First Union Corp, NC	0.008	0.009	0.008	0.008	0.007
First Chicago NBD Corp, IL	0.014	0.026	0.032	0.035	0.036
First Security Corp, UT	0.014	0.019	0.020	0.020	0.020
Corestates Financial Corp, PA	0.017	0.026	0.031	0.033	0.034
Sterling Bancorp, NY	0.018	0.025	0.029	0.030	0.029
Crestar Financial Corp, VA	0.018	0.016	0.014	0.013	0.012
Westamerica Bankcorporation, CA	0.022	0.029	0.032	0.034	0.034
First Commerce Corp New Orleans, LA	0.026	0.025	0.023	0.021	0.020
First Citizens Bancshares Inc, NC	0.038	0.038	0.036	0.033	0.031
Deposit Guaranty Corp, MS	0.046	0.039	0.034	0.030	0.027
Nationsbank Corp, NC	0.065	0.073	0.076	0.076	0.075
Hubco Inc, NJ	0.071	0.058	0.050	0.045	0.040
First American Corp, TN	0.082	0.060	0.049	0.041	0.036
Trustmark Corp, MS	0.086	0.098	0.099	0.099	0.096
First Tennessee National Corp, TN	0.095	0.107	0.112	0.114	0.112
Union Planters Corp, TN	0.128	0.134	0.132	0.130	0.127
Citicorp, NY	0.150	0.137	0.126	0.118	0.111
Zions Bancorp, UT	0.222	0.234	0.235	0.232	0.228
Mellon Bank Corp, PA	0.222	0.210	0.202	0.196	0.191
Hibernia Corp, LA	0.339	0.271	0.231	0.205	0.187
Riggs National Corp, DC	0.674	0.630	0.580	0.541	0.510
Cullen Frost Bankers Inc, TX	0.935	0.919	0.910	0.901	0.895

Table 7

Fair Insurance Premiums per $100 Total Liabilities
Averages from Steady State

Bank	Overlapping Contract Period				
	n = 1	*n* = 2	*n* = 3	*n* = 4	*n* = 5
Mid America Bancorp, KY	0.000	0.000	0.000	0.000	0.000
JP Morgan & Co. Inc, NY	0.000	0.000	0.000	0.000	0.000
Huntington Bancshares Inc, OH	0.000	0.000	0.000	0.000	0.000
First Virginia Banks Inc, VA	0.000	0.000	0.000	0.000	0.000
Regions Financial Corp, AL	0.000	0.000	0.000	0.000	0.000
Wilmington Trust Corp, DE	0.000	0.000	0.000	0.000	0.000
Old Kent Financial Corp, MI	0.000	0.000	0.001	0.001	0.001
First Commerce Corp New Orleans, LA	0.001	0.002	0.003	0.005	0.006
Commerce Bancshares Inc, MO	0.001	0.003	0.006	0.008	0.010
First of America Bank Corp, MI	0.002	0.002	0.003	0.004	0.005
Crestar Financial Corp, VA	0.002	0.004	0.005	0.007	0.008
Northern Trust Corp, IL	0.002	0.004	0.006	0.007	0.009
Suntrust Banks Inc, GA	0.003	0.003	0.004	0.004	0.004
First American Corp, TN	0.003	0.005	0.008	0.011	0.013
Star Banc Corp, OH	0.003	0.004	0.005	0.006	0.008
First Union Corp, NC	0.004	0.005	0.007	0.008	0.009
Deposit Guaranty Corp, MS	0.004	0.007	0.010	0.014	0.017
Wachovia Corp, NC	0.006	0.007	0.008	0.009	0.010
Comerica Inc, MI	0.006	0.008	0.010	0.012	0.014
Westamerica Bankcorporation, CA	0.006	0.009	0.012	0.014	0.017
Marshall & Ilsley Corp, WI	0.007	0.007	0.007	0.008	0.008
National City Corp, OH	0.008	0.009	0.010	0.012	0.013
First Security Corp, UT	0.008	0.011	0.013	0.015	0.017
Southtrust Corp, AL	0.010	0.012	0.014	0.016	0.018
Fifth Third Bancorp, OH	0.011	0.012	0.012	0.013	0.013
Mercantile Bankshares Corp, MD	0.015	0.014	0.014	0.014	0.014
Hubco Inc, NJ	0.016	0.022	0.027	0.032	0.036
Sterling Bancorp, NY	0.027	0.032	0.038	0.043	0.048
Corestates Financial Corp, PA	0.028	0.031	0.034	0.036	0.039
Firstmerit Corp, OH	0.028	0.028	0.028	0.028	0.029
First Citizens Bancshares Inc, NC	0.049	0.054	0.058	0.062	0.067
First Chicago NBD Corp, IL	0.052	0.054	0.057	0.060	0.062
Mellon Bank Corp, PA	0.055	0.066	0.073	0.079	0.084
Hibernia Corp, LA	0.064	0.076	0.085	0.092	0.098
Nationsbank Corp, NC	0.067	0.074	0.079	0.083	0.087
Citicorp, NY	0.073	0.081	0.087	0.092	0.097
First Tennessee National Corp, TN	0.098	0.108	0.115	0.122	0.127
Trustmark Corp, MS	0.111	0.119	0.126	0.132	0.137
Union Planters Corp, TN	0.117	0.128	0.136	0.144	0.151
Zions Bancorp, UT	0.166	0.173	0.178	0.184	0.189
Riggs National Corp, DC	0.362	0.410	0.439	0.463	0.484
Cullen Frost Bankers Inc, TX	0.548	0.594	0.617	0.634	0.648

Table 8

Expected Value Insurance Premiums per $100 Total Liabilities
Averages from Steady State

Bank	Overlapping Contract Period				
	n = 1	*n* = 2	*n* = 3	*n* = 4	*n* = 5
Mid America Bancorp, KY	0.000	0.000	0.000	0.000	0.000
JP Morgan & Co. Inc, NY	0.000	0.000	0.000	0.000	0.000
Huntington Bancshares Inc, OH	0.000	0.000	0.000	0.000	0.000
First Virginia Banks Inc, VA	0.000	0.000	0.000	0.000	0.000
Regions Financial Corp, AL	0.000	0.000	0.000	0.000	0.000
Old Kent Financial Corp, MI	0.000	0.000	0.000	0.000	0.000
Wilmington Trust Corp, DE	0.000	0.000	0.000	0.000	0.000
First Commerce Corp New Orleans, LA	0.000	0.000	0.000	0.001	0.001
Commerce Bancshares Inc, MO	0.000	0.001	0.001	0.001	0.001
First of America Bank Corp, MI	0.001	0.001	0.001	0.001	0.001
Crestar Financial Corp, VA	0.001	0.001	0.001	0.001	0.001
First American Corp, TN	0.001	0.001	0.002	0.002	0.002
Northern Trust Corp, IL	0.001	0.001	0.002	0.002	0.002
Suntrust Banks Inc, GA	0.001	0.001	0.001	0.001	0.001
First Union Corp, NC	0.001	0.002	0.002	0.002	0.002
Star Banc Corp, OH	0.001	0.001	0.002	0.002	0.002
Deposit Guaranty Corp, MS	0.002	0.002	0.002	0.002	0.002
Westamerica Bankcorporation, CA	0.003	0.003	0.003	0.003	0.003
Comerica Inc, MI	0.003	0.003	0.003	0.003	0.003
Wachovia Corp, NC	0.003	0.003	0.003	0.003	0.003
First Security Corp, UT	0.004	0.004	0.003	0.003	0.003
Marshall & Ilsley Corp, WI	0.004	0.003	0.003	0.002	0.002
National City Corp, OH	0.004	0.004	0.004	0.004	0.003
Southtrust Corp, AL	0.005	0.005	0.005	0.004	0.004
Fifth Third Bancorp, OH	0.008	0.007	0.007	0.007	0.007
Hubco Inc, NJ	0.008	0.009	0.009	0.010	0.010
Mercantile Bankshares Corp, MD	0.011	0.009	0.008	0.007	0.006
Sterling Bancorp, NY	0.016	0.015	0.014	0.013	0.013
Firstmerit Corp, OH	0.018	0.015	0.013	0.011	0.010
Corestates Financial Corp, PA	0.019	0.018	0.018	0.017	0.017
First Citizens Bancshares Inc, NC	0.032	0.027	0.024	0.022	0.020
First Chicago NBD Corp, IL	0.036	0.033	0.030	0.029	0.027
Mellon Bank Corp, PA	0.037	0.038	0.038	0.037	0.037
Hibernia Corp, LA	0.043	0.042	0.041	0.040	0.039
Nationsbank Corp, NC	0.046	0.043	0.040	0.038	0.036
Citicorp, NY	0.047	0.043	0.040	0.037	0.035
First Tennessee National Corp, TN	0.068	0.064	0.060	0.057	0.054
Trustmark Corp, MS	0.077	0.069	0.064	0.060	0.057
Union Planters Corp, TN	0.078	0.071	0.066	0.063	0.060
Zions Bancorp, UT	0.121	0.109	0.100	0.094	0.089
Riggs National Corp, DC	0.258	0.248	0.237	0.227	0.218
Cullen Frost Bankers Inc, TX	0.429	0.413	0.394	0.377	0.363

Table 9

Standard Deviations of Fair Insurance Premiums per $100 Total Liabilities Computed from Steady State

Bank	Overlapping Contract Period				
	$n = 1$	$n = 2$	$n = 3$	$n = 4$	$n = 5$
Mid America Bancorp, KY	0.000	0.000	0.000	0.000	0.000
JP Morgan & Co. Inc, NY	0.000	0.000	0.000	0.000	0.000
Huntington Bancshares Inc, OH	0.000	0.000	0.000	0.000	0.000
First Virginia Banks Inc, VA	0.001	0.001	0.000	0.000	0.000
Regions Financial Corp, AL	0.001	0.001	0.000	0.000	0.000
Wilmington Trust Corp, DE	0.005	0.003	0.002	0.001	0.001
Old Kent Financial Corp, MI	0.006	0.004	0.003	0.003	0.003
Commerce Bancshares Inc, MO	0.008	0.011	0.013	0.013	0.013
First Commerce Corp New Orleans, LA	0.009	0.008	0.009	0.009	0.010
Crestar Financial Corp, VA	0.015	0.013	0.013	0.012	0.011
Northern Trust Corp, IL	0.018	0.015	0.013	0.012	0.011
First Union Corp, NC	0.021	0.018	0.017	0.015	0.014
First American Corp, TN	0.024	0.022	0.021	0.020	0.019
Suntrust Banks Inc, GA	0.027	0.019	0.015	0.013	0.011
Star Banc Corp, OH	0.028	0.023	0.020	0.017	0.015
First of America Bank Corp, MI	0.029	0.021	0.016	0.013	0.011
Wachovia Corp, NC	0.039	0.028	0.023	0.019	0.016
Comerica Inc, MI	0.039	0.029	0.024	0.021	0.019
Deposit Guaranty Corp, MS	0.047	0.033	0.029	0.027	0.025
National City Corp, OH	0.052	0.037	0.030	0.026	0.022
Southtrust Corp, AL	0.053	0.041	0.035	0.031	0.028
Westamerica Bankcorporation, CA	0.055	0.042	0.035	0.031	0.028
Fifth Third Bancorp, OH	0.063	0.046	0.036	0.029	0.025
First Security Corp, UT	0.069	0.051	0.039	0.032	0.027
Hubco Inc, NJ	0.078	0.064	0.055	0.048	0.043
Marshall & Ilsley Corp, WI	0.087	0.061	0.047	0.038	0.032
Corestates Financial Corp, PA	0.125	0.101	0.085	0.073	0.065
Sterling Bancorp, NY	0.191	0.147	0.119	0.101	0.087
Mellon Bank Corp, PA	0.192	0.171	0.152	0.136	0.123
Mercantile Bankshares Corp, MD	0.203	0.158	0.122	0.097	0.079
Firstmerit Corp, OH	0.203	0.147	0.114	0.092	0.077
First Chicago NBD Corp, IL	0.216	0.176	0.148	0.128	0.112
Nationsbank Corp, NC	0.237	0.200	0.172	0.151	0.135
Citicorp, NY	0.269	0.248	0.227	0.208	0.191
Hibernia Corp, LA	0.304	0.249	0.209	0.179	0.157
First Citizens Bancshares Inc, NC	0.364	0.332	0.297	0.264	0.235
First Tennessee National Corp, TN	0.435	0.392	0.351	0.318	0.287
Trustmark Corp, MS	0.448	0.364	0.304	0.263	0.230
Union Planters Corp, TN	0.450	0.368	0.310	0.266	0.232
Zions Bancorp, UT	0.582	0.491	0.422	0.367	0.324
Riggs National Corp, DC	0.902	0.874	0.826	0.778	0.732
Cullen Frost Bankers Inc, TX	1.097	1.033	0.955	0.883	0.820

Table 10

Standard Deviations of Expected Value Insurance Premiums per $100 Total Liabilities Computed from Steady State

	Overlapping Contract Period				
Bank	$n = 1$	$n = 2$	$n = 3$	$n = 4$	$n = 5$
Mid America Bancorp, KY	0.000	0.000	0.000	0.000	0.000
JP Morgan & Co. Inc, NY	0.000	0.000	0.000	0.000	0.000
Huntington Bancshares Inc, OH	0.000	0.000	0.000	0.000	0.000
First Virginia Banks Inc, VA	0.000	0.000	0.000	0.000	0.000
Regions Financial Corp, AL	0.000	0.000	0.000	0.000	0.000
Old Kent Financial Corp, MI	0.002	0.001	0.001	0.001	0.000
Wilmington Trust Corp, DE	0.002	0.001	0.001	0.000	0.000
First Commerce Corp New Orleans, LA	0.003	0.002	0.002	0.001	0.001
Commerce Bancshares Inc, MO	0.003	0.003	0.003	0.003	0.003
Crestar Financial Corp, VA	0.007	0.005	0.004	0.003	0.003
First Union Corp, NC	0.009	0.006	0.005	0.004	0.003
Northern Trust Corp, IL	0.009	0.007	0.005	0.004	0.003
First American Corp, TN	0.010	0.007	0.006	0.005	0.004
Star Banc Corp, OH	0.014	0.010	0.008	0.006	0.005
First of America Bank Corp, MI	0.015	0.009	0.006	0.004	0.003
Suntrust Banks Inc, GA	0.015	0.009	0.006	0.005	0.004
Comerica Inc, MI	0.023	0.014	0.010	0.008	0.007
Deposit Guaranty Corp, MS	0.024	0.013	0.010	0.008	0.006
Wachovia Corp, NC	0.025	0.016	0.012	0.009	0.007
Southtrust Corp, AL	0.029	0.019	0.014	0.011	0.009
Westamerica Bankcorporation, CA	0.031	0.019	0.014	0.011	0.009
National City Corp, OH	0.033	0.020	0.014	0.011	0.009
First Security Corp, UT	0.037	0.023	0.015	0.011	0.008
Hubco Inc, NJ	0.045	0.031	0.024	0.019	0.016
Fifth Third Bancorp, OH	0.050	0.033	0.024	0.019	0.016
Marshall & Ilsley Corp, WI	0.056	0.034	0.024	0.018	0.015
Corestates Financial Corp, PA	0.095	0.069	0.054	0.044	0.037
Sterling Bancorp, NY	0.135	0.089	0.063	0.049	0.039
Firstmerit Corp, OH	0.149	0.095	0.067	0.050	0.040
Mellon Bank Corp, PA	0.154	0.122	0.102	0.085	0.073
Mercantile Bankshares Corp, MD	0.168	0.117	0.084	0.063	0.050
First Chicago NBD Corp, IL	0.171	0.123	0.095	0.077	0.064
Nationsbank Corp, NC	0.184	0.136	0.107	0.088	0.074
Citicorp, NY	0.209	0.172	0.146	0.125	0.108
Hibernia Corp, LA	0.239	0.173	0.132	0.106	0.088
First Citizens Bancshares Inc, NC	0.286	0.224	0.179	0.146	0.121
Union Planters Corp, TN	0.346	0.245	0.187	0.149	0.122
Trustmark Corp, MS	0.349	0.249	0.190	0.153	0.127
First Tennessee National Corp, TN	0.357	0.294	0.246	0.209	0.179
Zions Bancorp, UT	0.471	0.353	0.279	0.228	0.191
Riggs National Corp, DC	0.744	0.643	0.558	0.489	0.431
Cullen Frost Bankers Inc, TX	0.945	0.809	0.699	0.613	0.544

Figure 1

An Example of Five Overlapping Contracts

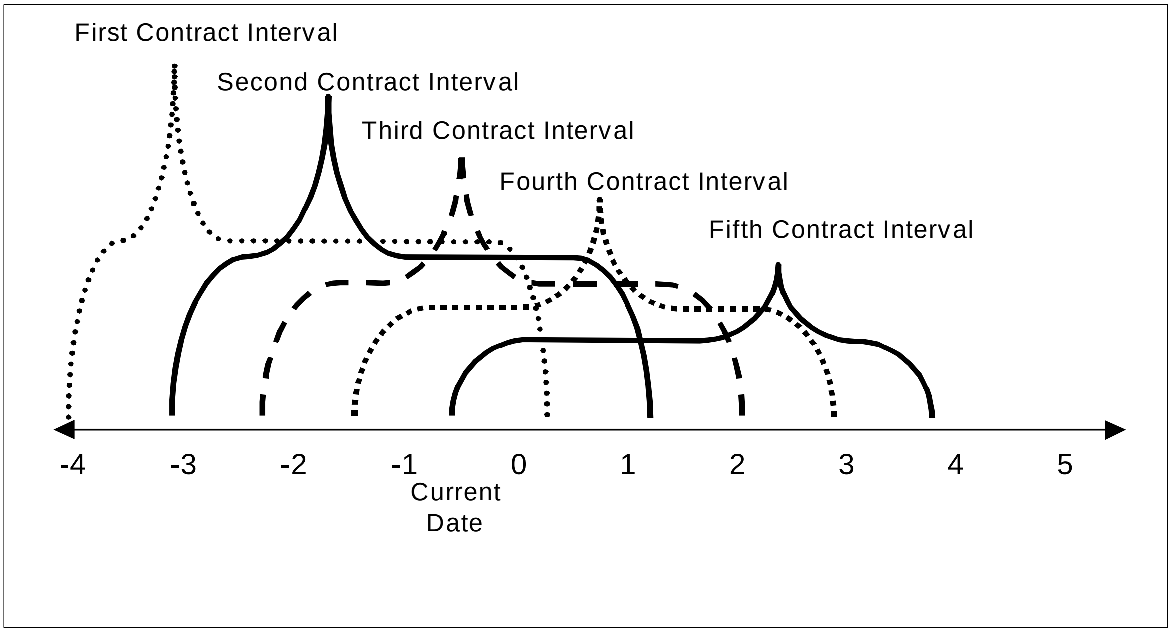

Figure 1A
Average Risk Neutral and Actual First Year Failure Probabilities

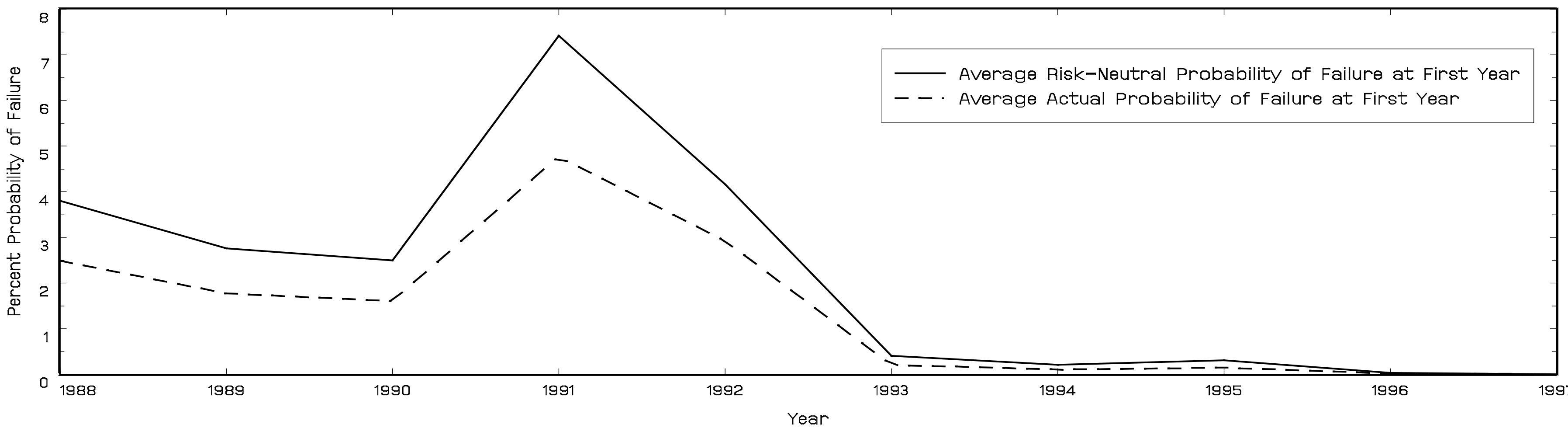

Figure 1B
Average Risk-Neutral and Actual Fifth Year Failure Probabilities

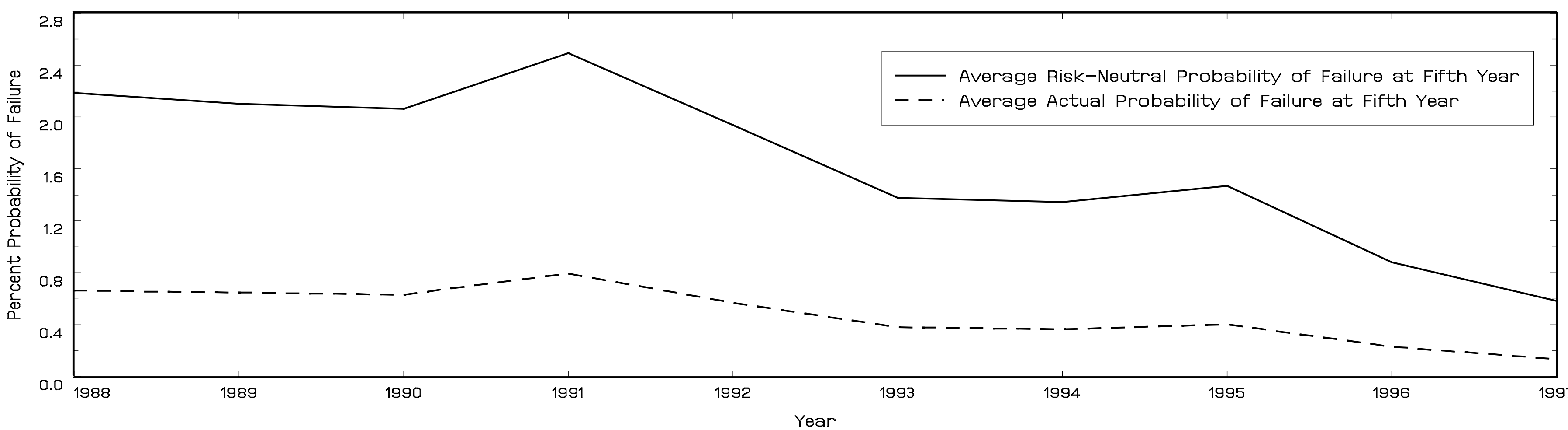

Figure 2A
Risk Neutral Failure Probabilities for Median Bank

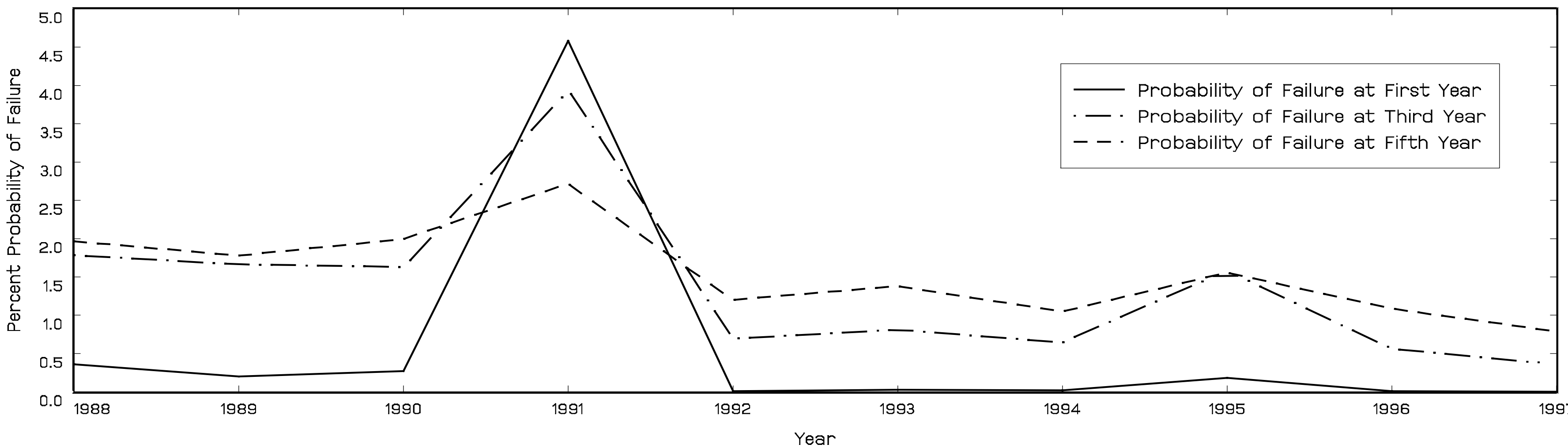

Figure 2B
Risk Neutral Failure Probabilities for 75th Percentile Bank

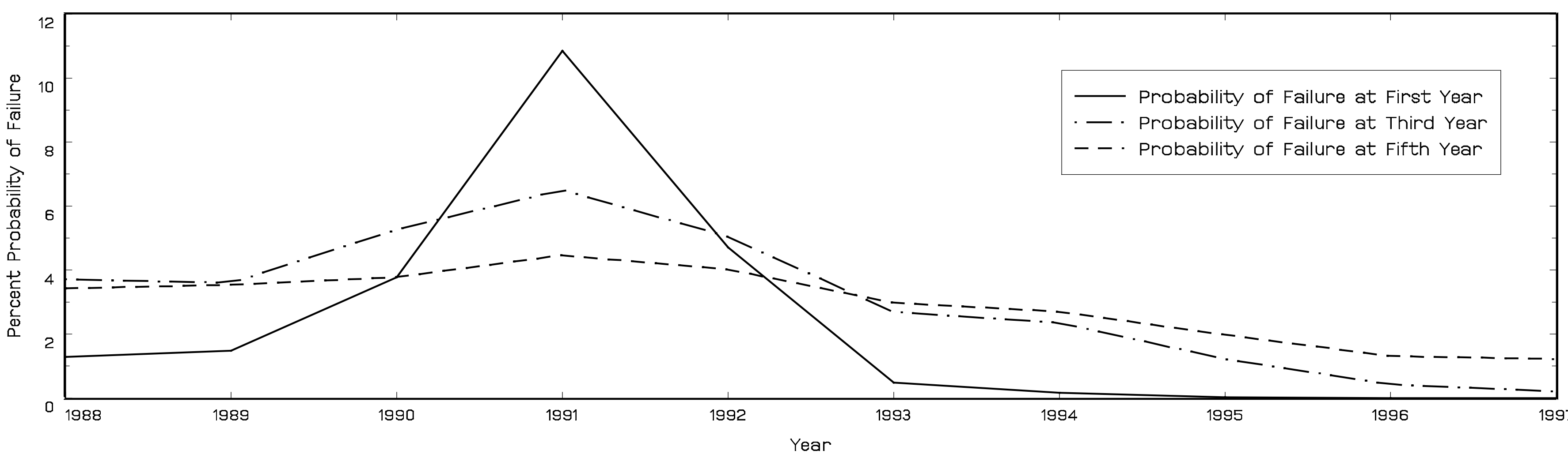

Figure 3A
Fair Premiums for Median Bank

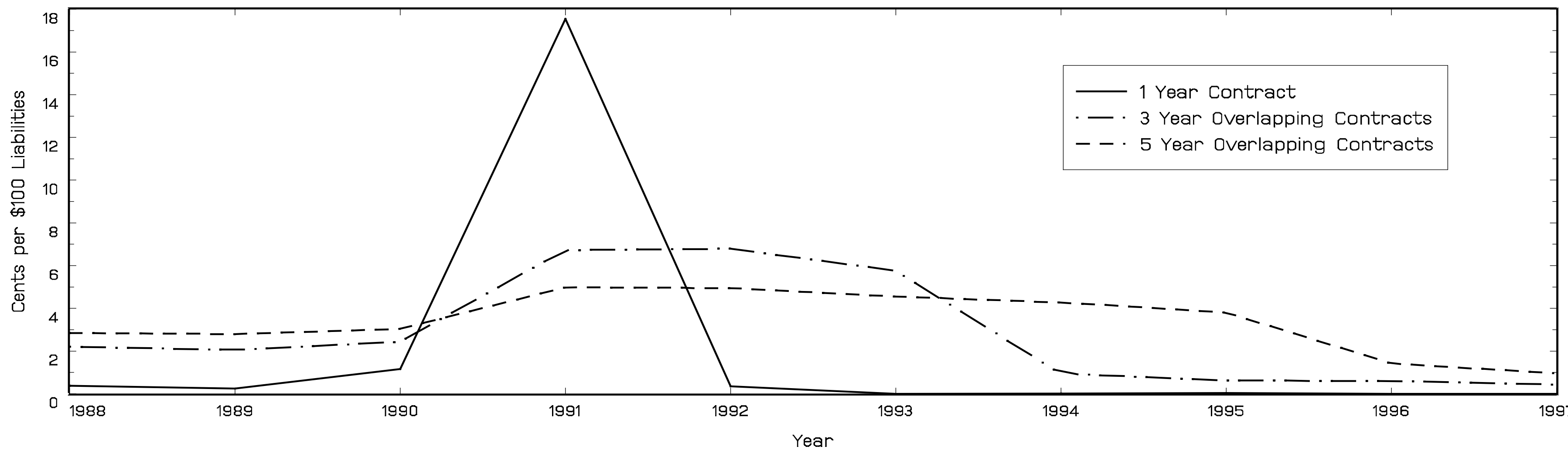

Figure 3B
Fair Premiums for 75th Percentile Bank

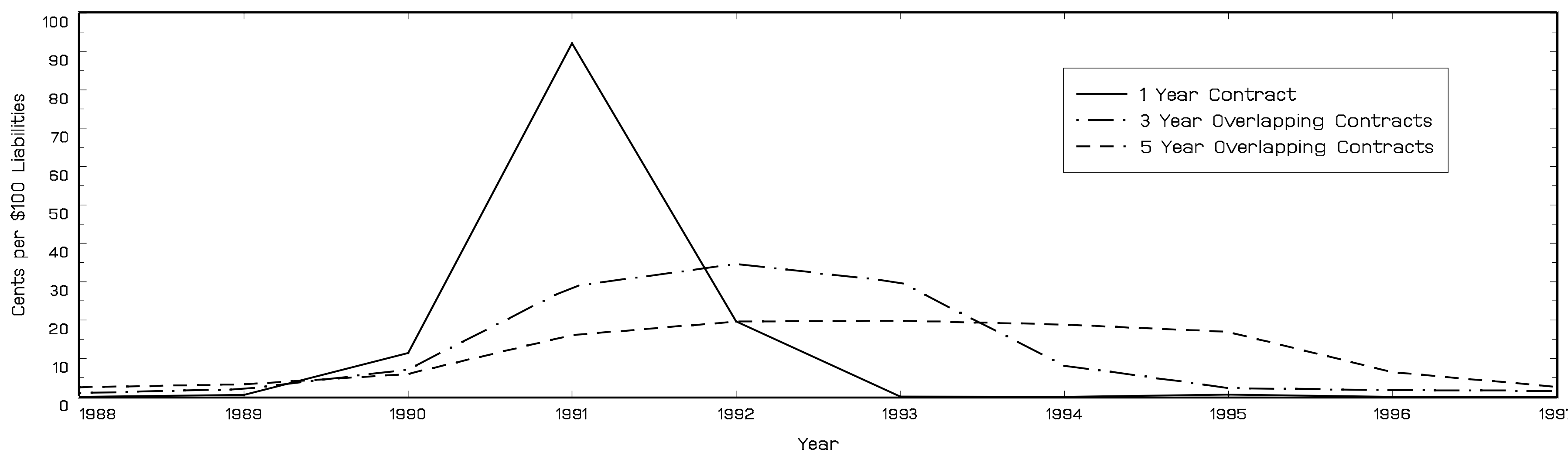

Figure 4A
Expected Value Premiums for Median Bank

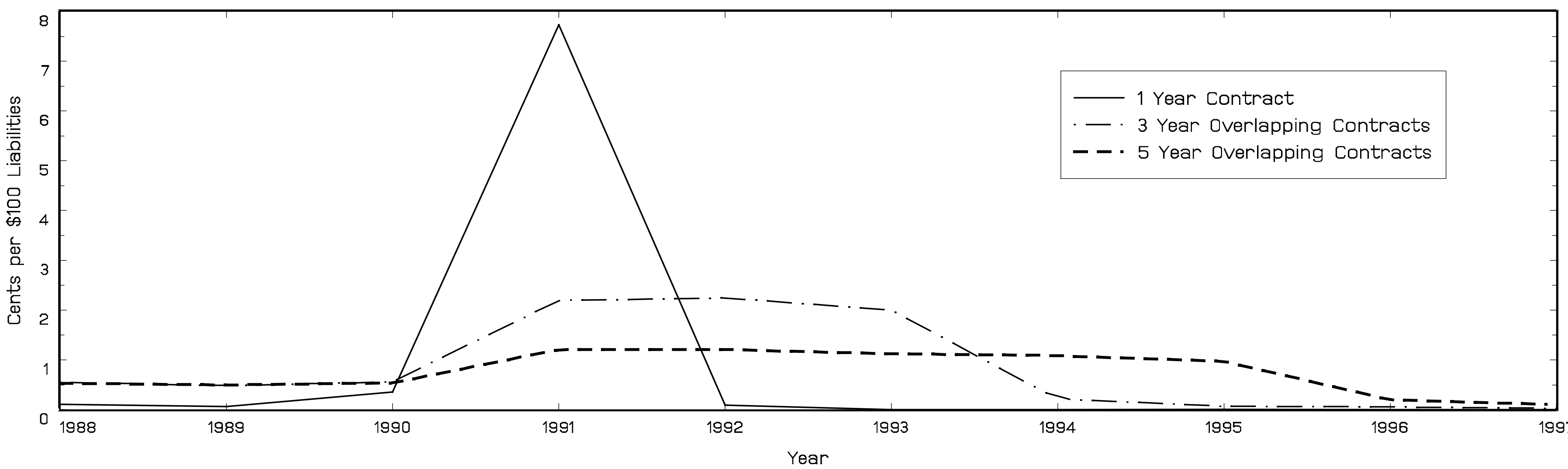

Figure 4B
Expected Value Premiums for 75th Percentile Bank