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Effectiveness of Capital Regulation at U.S. Commercial Banks, 1985 to 1994

ARMEN HOVAKIMIAN and EDWARD J. KANE*

ABSTRACT

Unless priced and administered appropriately, a governmental safety net enhances risk-shifting opportunities for banks. This paper quantifies regulatory efforts to use capital requirements to control risk-shifting by U.S. banks during 1985 to 1994 and investigates how much risk-based capital requirements and other deposit-insurance reforms improved this control. We find that capital discipline did not prevent large banks from shifting risk onto the safety net. Banks with low capital and debt-to-deposits ratios overcame outside discipline better than other banks. Mandates introduced by 1991 legislation have improved but did not establish full regulatory control over bank risk-shifting incentives.

THE SAVINGS AND LOAN INSURANCE DEBACLE taught U.S. taxpayers that they cannot rely on bank or government accounting reports to signal how well or how poorly insured institutions are being supervised. To ameliorate incentive conflicts that might flow from the absence of this signal, in 1991 Congress imposed on federal regulators an obligation to control taxpayer exposure to loss from bank risk-taking in a proactive market-mimicking manner. The operational framework by which regulators strive to meet this obligation seeks to monitor and to discipline the extent to which a bank's capital position can comfortably absorb the risk exposures that the bank pursues.

Despite this pattern of monitoring and control, the nation's 100 largest banks lost almost one-fourth of their market capitalization in the third quarter of 1998 (Matthews (1998)). That bank stock could lose so much value so quickly indicates that risk-modeling systems for managing bank and taxpayer loss exposure are less effective than advertised. The root problem is that, even though bank accountants face incentives to understate risks and to overstate capital, regulators seem disinclined to constrain circumvention opportunities by enforcing market-based standards and definitions for measuring bank risk and bank capital instead of accounting-based ratios and definitions.

The academic foundations for undertaking risk-based supervision of bank capital positions lie in Merton (1977). Viewing a deposit guarantee as a put option written by the Federal Deposit Insurance Corporation (FDIC), Mer-

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ton shows that the value of deposit insurance to bank stockholders increases with asset risk and leverage. Hence, by monitoring these parameters, an insurer can measure and control its loss exposure.

For several reasons, the option-pricing perspective imparts downward bias to statistical estimates of the benefits bank stockholders derive from the federal safety net (Kane (1995)). Nevertheless, econometric research on bank risk-shifting employs the option perspective almost exclusively. The literature begins with Marcus and Shaked (1984) who use a one-year put option model to estimate a risk-adjusted “fair” value for a bank’s deposit insurance premium. FDIC insurance is overpriced on average for banks in the Marcus–Shaked sample, but the distribution of fair premiums is strongly skewed to the right. Using improved one-period models, Ronn and Verma (1986) and Duan, Moreau, and Sealey (1992) develop similar qualitative findings.

By imposing prompt option settlement, single-period models understate stockholder benefits from deposit insurance more than multiperiod models do. Pennacchi’s (1987a, 1987b) multiperiod models generate a higher fair premium by relaxing the counterfactual assumption of single-period models that, on a nearby settlement date, insurance premiums are adjusted to fair value and/or each bank is forced to raise its capital ratios to a fair level. Allen and Saunders (1993), Cooperstein, Pennacchi, and Redburn (1995), and Saunders and Wilson (1995) build on this multiperiod perspective.

This paper develops robust option-model evidence that capital regulation has failed to control risk-shifting incentives. Although values differ with bank characteristics and across time, sensitivity tests show that *qualitative* patterns of stockholder benefits are robust to a battery of sample partitions and differences in modeling assumptions. In particular, our central policy implication is insensitive to whether we model deposit insurance as a single-period or multiperiod option contract or whether we model bank access to capital forbearance as a selective or nonselective strategy.

The paper has five parts. The first sets out the regression model we estimate. This two-equation model frames capital regulation as an attempt by deposit insurers to control bank risk-shifting. Section II uses option-pricing theory to transform stock market and accounting data into the unobservable variables featured in the regression model. Section III describes our sources and sampling procedures. The fourth section carries out and interprets our hypothesis tests and sensitivity experiments, and the final section summarizes the findings and develops policy implications.

I. Empirical Design

This paper adopts and expands regressions developed by Duan et al. (1992):

$$\Delta \frac{B_{jt}}{V_{jt}} = \alpha_{0j} + \alpha_1 \Delta \sigma_{V_{jt}} + \epsilon_{jt}, \quad (1)$$

$$\Delta IPP_{jt} = \beta_{0j} + \beta_1 \Delta \sigma_{V_{jt}} + \xi_{jt}. \quad (2)$$

In equations (1) and (2), B is the face value of deposits and other debt, V is the market value of a bank's assets, σ_V is the standard deviation of asset returns, and IPP is the fair deposit insurance premium per dollar of deposits. The slope coefficients in equations (1) and (2) have the following interpretations:

$$\alpha_1 \equiv \frac{d(B/V)}{d\sigma_V}, \quad (3)$$

$$\beta_1 = \frac{dIPP}{d\sigma_V} = \frac{\partial IPP}{\partial \sigma_V} + \frac{\partial IPP}{\partial (B/V)} \alpha_1. \quad (4)$$

Hypotheses about opportunities for risk-shifting specify signs for α_1 and β_1 . Merton (1977) models the government guarantee as a single-period put option written by the government on the bank's assets. He shows that—barring market and government disciplinary responses—the value of deposit insurance increases in σ_V and B/V . Holding the bank's FDIC premium fixed, positive partial derivatives for the fair premium with respect to σ_V and B/V imply that bank stockholders can extract value from the FDIC.

Intuitively, equations (1) and (2) parametrize a struggle between would-be risk-shifting banks and wielders of outside regulatory discipline. The model ties changes in IPP to exogenous bank adjustments in asset risk σ_V , but allows the net impact of higher asset risk to be tempered by regulatory and market pressure for lower bank leverage.

Risk-sensitive capital regulation seeks to force a bank's leverage to decrease with increases in asset risk. The sign of α_1 establishes whether risk-sensitive capital regulation and complementary market pressure discipline risk at all. To be fully successful, capital regulation must also make the total differential of IPP with respect to σ_V nonpositive. β_1 measures how much a bank can benefit from increasing the volatility of its asset returns.

For market and regulatory restraints even to discipline and, more important, also to neutralize risk-shifting incentives, two hypotheses must be confirmed:

HYPOTHESIS 1: $\alpha_1 < 0$,

HYPOTHESIS 2: $\beta_1 \leq 0$.

Failing to reject Hypothesis 1 would affirm that risk restraints on leverage do to some extent discipline efforts to increase the volatility of bank returns. Even if α_1 is negative, risk-shifting incentives would exist if β_1 were positive.

II. Models of Deposit Insurance

The variables IPP , V , and σ_V in equations (1) and (2) are not directly observable. We follow Marcus and Shaked (1984) in calculating these variables synthetically from option-based models of deposit insurance. The values

of V and σ_V are obtained by solving two simultaneous equations. These solution values are used to find IPP as the value of a put option on bank assets. The first equation solved is the call-option formulation for equity, E . The second equation states σ_V as a function of E , V , and σ_E (the instantaneous standard deviation of equity returns) via Ito's lemma: The Appendix shows that the FDIC guarantee can be valued from the condition that the value of bank assets equals the value of all claims on those assets. To ensure that inferences are robust to modeling assumptions, we construct synthetic datasets for V , σ_V , and IPP from four different models of deposit-insurance option value.

A. Single-Period Models of Stockholder Benefits from Deposit Insurance

We estimate two single-period models, SPM1 and SPM2. In these models, deposit insurance is a single-period European put option on the bank's assets (Merton (1977)). Bank debt is treated as maturing in one year (the next date the insurer is assumed to audit the bank). Ronn and Verma (1986) introduce FDIC forbearance by permitting asset value to deteriorate to 97 percent of debt value before the equity call kicks in.

SPM1 and SPM2 extend the Ronn and Verma model by allowing shareholders to receive dividends until the next audit occurs, even if the bank becomes insolvent in the interim. Bank equity is modeled as the sum of a dividend-unprotected European call option and the present value of the dividends distributed before the next audit. SPM1 and SPM2 differ in how stockholder benefits from capital forbearance develop. The model designated as SPM1 uses the Ronn and Verma specification of forbearance. As summarized in the Appendix, SPM1 transfers $(1 - \rho)$ times the bank's expected debt repayment as risk capital to stockholders, irrespective of the bank's financial strength, operational complexity, or political clout.

SPM1 treats regulatory forbearance as an automatic rather than a selective strategy. To portray the value that forbearance conveys to stockholders in a one-period context, ρ ought to be conditioned on the bank's ability to circumvent capital discipline and on its exposure to end-of-period insolvency. Ideally, forbearance benefits should be negligible for strong banks and substantial only for insolvent "zombie" banks that creditors would take over or force into liquidation if their debt was not government-guaranteed. To create this pattern, SPM2 ties stockholder benefits from forbearance in a simple way to the capital shortfall stockholders expect regulators to tolerate. SPM2 assigns forbearance benefits only to banks that are already operating in a state of tangible insolvency. Algebraically, this entails suppressing the forbearance benefit at solvent banks.

Intuitively, the value of forbearance ought to increase as economic insolvency approaches and decrease once insolvency becomes very deep. In SPM2, how increases in σ_V and/or B/V affect IPP depends on whether and how much increases in these variables raise the probability that a bank will become economically insolvent but not so decapitalized that forbearance is denied ($\rho B \leq V < B$).

B. Infinite-Maturity Models of Stockholder Benefits from Deposit Insurance

As in Merton (1978), our last two models treat deposit insurance as an infinite-maturity put. In Merton's model, the government randomly audits banks and follows the no-forbearance closure rule $V \leq B$. Model IMM1 uses Saunders and Wilson's (1995) extension of the infinite-maturity Merton model to incorporate interim dividend payments. IMM2 is Saunders and Wilson's model with zero auditing costs and the $V \leq \rho B$ closure rule used in SPM1. The models are summarized in the Appendix.

III. Description of the Sample

A. Sources and Statistical Definition of Conceptual Variables

Observable values for conceptual variables are derived as follows:

B, total debt: calculated as the difference between book values of assets (COMPUSTAT item 044) and common equity (COMPUSTAT item 059).

E, market value of bank's equity: calculated as the end-of-period stock price (COMPUSTAT item 014) times the number of shares outstanding (COMPUSTAT item 061).

σ_E , standard deviation of the return on equity: estimated from weekly stock returns over the previous quarter.¹

δ , dividends per dollar of assets: calculated as the cash dividend per common share (COMPUSTAT item 020) times the number of shares outstanding (COMPUSTAT item 061) divided by the market value of bank's assets (V).

Four additional variables are taken directly from the *SNL Quarterly Bank Digest*: deposits, loan-loss reserves, high-risk real estate loans, and the sum of nonperforming assets and 90-day past-dues.

B. Sample Selection and Data

We use quarterly data covering the first quarter of 1985 through the fourth quarter of 1994. Our sample consists of chartered commercial banks (SIC codes 6021 and 6022) whose shares trade on NYSE, AMEX, or Nasdaq. To be included into our sample, a bank must have at least 16 consecutive quarters of balance-sheet and stock-return data in corresponding COMPUSTAT Industrial Quarterly and CRSP daily returns files.

These screening criteria give us 123 banks and 4,211 bank-quarter observations. Most of our regressions employ 4,088 datapoints because first-differencing the variables absorbs an additional observation per bank.

¹We require at least six weeks of stock-return observations for a particular bank-quarter to be included into our sample. The estimated standard deviation of stock returns is annualized assuming 52 weeks per year.

Table I
Summary Statistics

Summary statistics are given for 123 sample banks over the period 1985 to 1994. The statistics are calculated from quarterly data. SPM1 is the single-period model of Ronn and Verma (1986). SPM2 is the single-period deposit insurance model with selective forbearance. IMM1 is the infinite-maturity model of deposit insurance used by Saunders and Wilson (1995). IMM2 is the Saunders and Wilson (1995) model but with zero monitoring costs and forbearance. Except where otherwise noted, the market value of assets (V), the standard deviation of asset returns (σ_V), and the fair insurance premium IPP reported in the table are derived from SPM1. IMM1 and IMM2 calculate an annual premium by multiplying the present value of deposit-insurance benefits by a conservative 15 percent target rate of return on bank equity.

Characteristic	Mean	Median	Min.	Max.
Total deposits and other debt, B (\$MM)	17,513	6,379	120	242,686
Deposits as a percentage of total debt	83.3	85.2	20.2	100
Market value of equity, E (\$MM)	1,432	631	4	17,792
Annualized std. dev. of rate of return on equity, σ_E (%)	28.2	25.0	5.3	128.8
Market value of assets, V (\$MM)	18,390	6,877	125	251,004
Leverage ratio, B/V (%)	93.6	93.9	65.3	115.6
Annualized std. dev. of rate of return on assets, σ_V (%)	2.9	2.5	0.4	29.8
Risk-adjusted deposit insurance Premium per dollar of deposits, IPP				
Based on SPM1 (%)	0.2508	0.0040	0.0000	14.2371
Based on SPM2 (%)	0.1199	0.0001	0.0000	19.9958
Based on IMM1 (%)	0.3402	0.3114	0.0784	2.4582
Based on IMM2 (%)	0.3267	0.3034	0.0784	2.4582

Regressions using IMM1 data are estimated with many fewer observations because numerical procedures used to solve for B/V and σ_V often do not converge for banks with zero dividends.

Although two biases affect our tests, these biases serve to make our assessment of risk-shifting at troubled banks conservative. First, our screening criteria may create survivorship bias, by eliminating some banks for which particularly intense risk-shifting incentives resulted in early failure. Second, Brickley and James (1986) show that σ_E estimated from market returns is downward-biased due to the banks' access to deposit insurance. This bias, too, would be strongest for failing banks.

Some tests introduce additional control variables: deposits, loan-loss reserves, high-risk real estate loans, nonperforming assets, and delinquent loans ("90-day past dues") for each bank-quarter. These data (2,669 observations) are hand-collected from the *SNL Quarterly Bank Digest* for the years from 1988 to 1994.

Table I summarizes the sample data. Forty-six banks are state-chartered; 77 have a national charter. Forty quarters of data (one-quarter is lost due to differencing) are available for 83 banks. Data for the remaining 40 banks

Table II
Correlations between Insurance Premiums Estimated from
Different Option Pricing Models of Deposit Insurance,
1985 to 1994

SPM1 indicates the single-period model of Ronn and Verma (1986). SPM2 is the single-period deposit insurance model with selective forbearance. IMM1 is the infinite-maturity model of deposit insurance used by Saunders and Wilson (1995). IMM2 is the Saunders and Wilson (1995) model but with zero monitoring costs and forbearance.

	Levels of Fair Insurance Premium (<i>IPP</i>)			Changes in <i>IPP</i>		
	SPM1	SPM2	IMM1	SPM1	SPM2	IMM1
SPM2	0.852**			0.815**		
IMM1	0.009	0.026		0.333**	0.159**	
IMM2	-0.020	-0.016	0.970**	0.318**	0.133**	0.954**

** Indicates the correlation is significantly different from zero at the 1 percent level.

cover 16 to 38 quarters. Observations by calendar year vary from a low of 338 in 1985 to a high of 488 in 1991, 1992, and 1993. While the sample is skewed toward larger institutions, smaller banks are better represented than in previous studies (e.g., Marcus and Shaked (1984), Ronn and Verma (1986), and Duan et al. (1992)). Bank asset size varies from a mere \$129 million to \$258 billion. The magnitude of other characteristics, such as standard deviations of stock and asset returns, parallel those found by Marcus and Shaked and Ronn and Verma.

The last four lines of Table I calculate fair premiums for the four models of deposit insurance. Single-period models assign most sample banks very low risk-adjusted insurance premiums, but several banks show an extremely high *IPP* value. Focusing on average risk-shifting behavior sidesteps the policy issues posed by banks at which the incentive to extract deposit insurance subsidies is particularly strong. Still, average *IPP* values derived from the infinite-maturity models are *larger than explicit FDIC premiums* and are more tightly distributed than the single-period estimates. This divergence between single-period and multiperiod results strengthens the case for examining the robustness of the empirical results to alternative modeling assumptions.

Table II reports coefficients of correlation between the alternative estimates of *IPP* derived from our four models of deposit insurance. Correlation between the estimates of derived from the two single-period models (SPM1 and SPM2) is 0.852. Correlation between the estimates from the multiperiod models (IMM1 and IMM2) is 0.970. Although the correlation between single-period and multiperiod *IPP* estimates is small, it improves when changes rather than levels of *IPP* are considered. The low correlation between single-period and multiperiod valuations traces to the different ways leverage

impacts the two types of models. Leverage is a central determinant of *IPP* value in single-period models but is nearly irrelevant in multiperiod models.

Correlations between the alternative estimates of both B/V and σ_V are comfortably strong. For B/V , correlations range between 0.964 and 0.998. For σ_V , correlations vary between 0.836 and 0.998. However much the *IPP* estimates derived from alternative models differ, the qualitative behavior of B/V and *IPP* remains similar. The robustness of these features leads us to focus our analysis on qualitative patterns of risk-taking incentives, rather than on estimated numerical results for each individual bank.

IV. Tests for Risk-Shifting Incentives

A. Tests of Risk-Shifting

We first examine risk-shifting incentives by applying regressions (1) and (2) to data for all four models of deposit-insurance value. Panel A of Table III uses data generated by the single-period models; Panel B uses data from the infinite-maturity models.

All models reject Hypotheses 1 and 2: α_1 and β_1 are positive and statistically significant. Estimates of α_1 indicate that capital requirements supplied no risk-restraining discipline; the β_1 values imply that outside risk restraints did not neutralize risk-shifting incentives. With capital requirements exercising little influence, the R^2 s observed for the leverage equation are low (between 0.016 and 0.084). On the other hand, the R^2 s for the fair insurance premium are substantial, ranging from 0.460 to 0.998.

In first-difference regressions, coefficient estimators may be interpreted as fixed-effects estimators. Likelihood-ratio and Hausman tests support the fixed-effects model against either a random-effects specification or a model suppressing bank-specific effects.

Another issue is that the variables in the regression equations are generated synthetically. Links between the equations solved may introduce non-zero correlations between the errors in left-hand and right-hand variables of equations (1) and (2) and render OLS estimators inconsistent. We used two-stage least-squares instrumental-variables estimation to address this potential bias.² The 2SLS results have the same implications as Table III. Insignificant 2SLS estimates of α_1 reject the hypothesis of effective outside discipline. Positive significant 2SLS estimates of β_1 imply that risk restraints failed to neutralize risk-shifting incentives. We used the 2SLS estimates and the Hausman specification test (see Greene (1993, p. 287)) to test whether measurement error biases the single-equation results of Table III. For both equations (1) and (2), Hausman statistics are insignificant at the 5 percent level, indicating that errors-in-variables are not a serious problem.

² As instrumental variables, we introduce the second and the third lags of σ_V , loan-loss reserves, high-risk real estate loans, nonperforming assets +90-day past dues, as well as their first lags, all measured relative to total assets.

Table III
Single-Equation Tests of the Risk-Shifting Hypothesis

Ordinary least squares regressions relating changes in the banks' leverage, $\Delta(B/V)$, and in the banks' fair deposit insurance premiums, ΔIPP , to the changes in the riskiness of their assets, $\Delta\sigma_V$. B is the face value of a bank's debt, including deposits. V is the market value of a bank's assets. SPM1 is the single-period model of Ronn and Verma (1986). SPM2 is the single-period deposit insurance model with selective forbearance. IMM1 is the infinite-maturity model of deposit insurance used by Saunders and Wilson (1995). IMM2 is the Saunders and Wilson (1995) model but with zero monitoring costs and forbearance. Coefficient t -statistics are reported in parentheses. Data run from 1985 to 1994.

Panel A: Single-Period Models (SPM)				
	SPM1		SPM2	
	$\Delta(B/V)$	ΔIPP	$\Delta(B/V)$	ΔIPP
Constant	-0.001** (-3.6)	-0.000 (-0.7)	-0.001** (-3.3)	-0.000 (-0.4)
$\Delta\sigma_V$	0.133** (8.2)	0.307** (59.1)	0.328** (19.3)	0.411** (63.8)
R^2	0.016	0.460	0.084	0.499
No. of observations	4088	4088	4088	4088
Panel B: Infinite-Maturity Models (IMM)				
	IMM1		IMM2	
	$\Delta(B/V)$	ΔIPP	$\Delta(B/V)$	ΔIPP
Constant	-0.000** (-2.9)	-0.000* (-0.3)	-0.001** (-3.7)	0.000** (4.2)
$\Delta\sigma_V$	0.192** (9.1)	0.619** (174.0)	0.245** (12.0)	0.679** (1525.0)
R^2	0.022	0.889	0.034	0.998
No. of observations	3800	3800	4088	4088

*, ** Indicate values significantly different from zero at the 5 percent and 1 percent levels, respectively.

B. How Does Risk-Shifting Vary across Banks?

Incentives for risk shifting intensify once a bank falls into financial distress (see Marcus (1984)). This hypothesis of incentive intensification implies that positive α_1 and β_1 would be observed more frequently at poorly capitalized institutions. To protect taxpayers, regulators ought to target troubled banks for stronger discipline. To test for this, we introduce a dummy variable $d = 1$ for banks that fall in the less capitalized (more levered) half of the sample in the previous period and set $d = 0$ otherwise.

To support the hypothesis that regulators selectively target undercapitalized banks for special discipline, a significantly negative shift in α_1 is required. A significantly positive shift in β_1 would constitute evidence that undercapitalized banks expand their access to deposit insurance subsidies vis-à-vis better-capitalized competitors.

Table IV

Tests of the Hypothesis of Targeted Regulatory Discipline

Ordinary least squares regressions relating changes in the banks' leverage, $\Delta(B/V)$, and in the banks' fair deposit insurance premiums, ΔIPP , to the changes in the riskiness of their assets, $\Delta\sigma_V$. B is the face value of a bank's debt, including deposits. V is the market value of a bank's assets. The low-capital dummy is set to one for banks that were in the less capitalized half of the sample in the previous period. The high-premium dummy is set to one for banks that, in the previous period, were in the half of the sample with above-median values of IPP. Results are reported for the single-period deposit insurance model of Ronn and Verma (SPM1). Coefficient t -statistics are reported in parentheses. Data cover 1985 to 1994.

	Tests Using a Low-Capital Dummy		Tests Using a High-Premium Dummy	
	$\Delta(B/V)$	ΔIPP	$\Delta(B/V)$	ΔIPP
Constant	-0.001** (-4.0)	-0.000 (-1.8)	-0.001* (-1.6)	0.000** (3.6)
$\Delta\sigma_V$	-0.041 (-1.8)	0.147** (22.6)	-0.154** (-4.8)	0.117** (11.8)
$\Delta\sigma_V \times$ low-capital dummy	0.346** (10.7)	0.316** (34.6)		
$\Delta\sigma_V \times$ high-premium dummy	0.387** (10.3)	0.256** (22.3)		
R^2	0.043	0.583	0.041	0.519
No. of observations	4088	4088	4088	4088

*, ** Indicate values significantly different from zero at the 5 percent and 1 percent levels, respectively.

Table IV reports results for SPM1 only. However, all four deposit insurance models reject the hypothesis that discipline is targeted to low-capital banks. The α_1 shift is significantly positive for both single-period models and insignificant for the multiperiod models. The total effect of σ_V on the leverage ratio of a low-capital bank is the sum of the two slope coefficients, which is significantly positive for all models. Beta estimates support the incentive-intensification hypothesis for poorly capitalized banks, although the degree of risk-intensification is much smaller in the multiperiod models.

Table IV also tests the incentive-intensification and targeted-discipline hypotheses with a different index of incentive intensification. In the third and fourth columns, $d = 1$ for banks with an above-median IPP in the previous period, and $d = 0$ otherwise. Qualitative results are unchanged. One dissimilar result occurs in the multiperiod models where a small targeted-discipline effect emerges: a significant negative shift in β_1 . But this shift is far too small to outweigh the positive β_1 .³

³ The positive shift in α_1 suggests that, in IMM1, the negative shift in β_1 may trace to the nonmonotonicity of IPP in σ_V and B/V in this infinite-maturity model (Merton (1978)).

C. Does Risk-Shifting Increase the Government's Deposit Insurance Liability?

The FDIC might reasonably lessen its oversight of banks with substantial junior debt, depending on these more vulnerable debtholders to monitor bank risk shifting.⁴ The option-pricing models we use treat FDIC claims as ranking equally in liquidation with uninsured debt. In fact, the definition of which claims are subordinated to the FDIC's position evolved over our sample period. In 1993, The Depositor Preference Act subordinated all nondepositor claims to depositor claims, though some individual states adopted similar provisions as early as the mid-1980s.⁵ As a sensitivity test, instead of assuming that nondeposit debt ranks equally with insured deposits, we rebuild our four datasets using different assumptions about the ranking of nondeposit debt.

Regressions not displayed here show that, when banks increase asset risk, they use proportionately less nondeposit debt and more deposits. If authorities are slow to respond when asset risk increases, a bank can increase stockholder benefits by substituting insured deposits for nondeposit debt. This is profitable because, when σ_V increases, informed junior creditors would promptly raise their cost for holding the bank's nondeposit debt.

A related set of tests sets $d = 1$ for banks with an above-median ratio of lagged deposits to total debt and $d = 0$ otherwise. Because the deposits-to-total-debt ratio is likely to be negatively correlated with bank size, we employ a three-way size partition of small, medium, and large banks. We find that the effectiveness of regulatory discipline declines as banks grow larger. Even worse, at large and medium-sized banks, the intensity of risk shifting proves to be even higher for banks whose deposits-to-debt ratios are high. In all four models (SPM1, SPM2, IMM1, IMM2), outside discipline fails to neutralize risk-shifting incentives at banks with high deposits-to-debt ratios.

Table V summarizes a debt-structure experiment that classifies nondeposit debt as equity. Even with debt made coterminous with deposits, β_1 proves significantly positive for all models.⁶ Hence, even supposing that the FDIC's claim is senior to the claims of all nondeposit creditors, we find evidence that banks shift risk to the FDIC.

D. Have Risk-Shifting Incentives Changed over Time?

The signs for α_1 and β_1 found in the current paper are opposite to the signs found by Duan et al. (1992). Introducing an interactive dummy

⁴ We thank an anonymous referee for drawing our attention to this issue.

⁵ We thank another anonymous referee for telling us about state-level experience.

⁶ Because *IPP* for the fourth model (IMM2) does not directly depend on B/V , the analysis produces exactly the same results as those reported for IMM2 in Table III.

Table V

Analysis of Risk-Shifting Assuming Nondeposit Debt Is Subordinated

Ordinary least squares regressions relating changes in the banks' fair deposit insurance premiums, ΔIPP , to the changes in the riskiness of their assets, $\Delta \sigma_V$. IPP is calculated assuming that nondeposit debt is junior to the FDIC's claim and treating such debt as equity. SPM1 is the single-period model of Ronn and Verma (1986). SPM2 is the single-period deposit insurance model with selective forbearance. IMM1 is the infinite-maturity model of deposit insurance used by Saunders and Wilson (1995). Coefficient t -statistics are reported in parentheses. Data cover 1985 to 1994.

	ΔIPP		
	SPM1	SPM2	IMM1
Constant	-0.000 (-0.5)	-0.000 (-0.4)	-0.000 (-0.9)
$\Delta \sigma_V$	0.111** (24.4)	0.192** (30.6)	0.533** (52.3)
R^2	0.183	0.259	0.527
No. of observations	2669	2669	2453

*, ** Indicate values significantly different from zero at the 5 percent and 1 percent levels, respectively.

variable for the years 1985 and 1986, which appear in both studies, suggests that the divergence traces in part to the difference in time periods covered.⁷

It is even more interesting to estimate the effects of reforms in deposit-insurance pricing and loss control phased in after 1991. To look at this issue, we introduce a second interactive dummy variable that allows changes in α_1 and β_1 to occur after 1991.

Panels A and B of Table VI report the results for the three regimes. Using the single-period models, Panel A finds, consistent with Congressional intent, significant declines in both α_1 and β_1 in the 1992 to 1994 period as compared to the 1987 to 1991 period. This implies that postreform regulatory pressure on risk-taking banks for equity capital is more effective. Nevertheless, even in the 1992 to 1994 period, β_1 remains significantly positive. The infinite-maturity models (Panel B) also show a significant decline in α_1 but they find no significant changes in β_1 . The implication is that regulatory changes improved capital discipline, but not enough to eliminate risk-shifting incentives.

⁷ The coefficients Table VI assigns to the interactive dummy for the years the studies have in common suggest that differences in sample timing may explain some of the divergence between Duan et al. (1992) and our estimates of α_1 . The α_1 estimates for the 1985 to 1986 time period are significantly negative; but β_1 remains significantly positive in all eras. The sign of Duan et al.'s estimates of β_1 is distorted by aggregation bias. These authors' pooled estimate of β_1 is significantly negative, even though most individual-bank coefficients are insignificant and the few significant coefficients (five out of 30) are positive. Unlike our fixed-effects regressions, their pooled regression does not account for firm-specific effects.

Table VI
Differences in Bank Risk-Shifting Behavior over Time

Ordinary least squares regressions relating changes in the banks' leverage, $\Delta(B/V)$, and in the banks' fair deposit insurance premiums, ΔIPP , to the changes in the riskiness of their assets, $\Delta\sigma_V$. SPM1 is the single-period model of Ronn and Verma (1986). SPM2 is the single-period deposit insurance model with selective forbearance. IMM1 is the infinite-maturity model of deposit insurance used by Saunders and Wilson (1995). IMM2 is the Saunders and Wilson (1995) model but with zero monitoring costs and forbearance. Coefficient t -statistics are reported in parentheses. Data cover 1985 to 1994. Note that t -statistics for differences between the α_1 and β_1 in different time periods are significant at 1 percent in all models except in IMM1. In IMM1, the β_1 difference between 1987 to 1991 and 1992 to 1994 is insignificant.

Panel A: Single-Period Models (SPM)				
	SPM1		SPM2	
	$\Delta(B/V)$	ΔIPP	$\Delta(B/V)$	ΔIPP
Constant	-0.001** (-3.7)	-0.001 (-0.7)	-0.001** (-3.2)	-0.000 (-0.1)
$\Delta\sigma_V$ (1985-86 dummy)	-0.471** (-7.8)	0.109** (5.8)	-0.643** (-8.8)	0.033 (1.2)
$\Delta\sigma_V \times$ (1987-91 dummy)	0.280** (14.9)	0.363** (61.5)	0.481** (25.4)	0.473** (65.9)
$\Delta\sigma_V \times$ (1992-94 dummy)	-0.157** (-4.6)	0.184** (17.0)	0.081 (0.2)	0.282** (20.6)
R^2	0.069	0.501	0.151	0.539
No. of observations	4088	4088	4088	4088
Panel B: Infinite-Maturity Models (IMM)				
	IMM1		IMM2	
	$\Delta(B/V)$	ΔIPP	$\Delta(B/V)$	ΔIPP
Constant	-0.000** (-2.8)	-0.000 (-0.5)	-0.001** (-3.6)	0.000** (4.0)
$\Delta\sigma_V \times$ (1985-86 dummy)	-0.190** (-2.9)	0.680** (61.2)	-0.149* (-2.3)	0.690** (13.8)
$\Delta\sigma_V \times$ (1987-91 dummy)	0.339** (12.8)	0.616** (136.1)	0.402** (15.5)	0.675** (1193.0)
$\Delta\sigma_V \times$ (1992-94 dummy)	0.012 (0.3)	0.602** (91.2)	0.062 (1.2)	0.684** (853.8)
R^2	0.043	0.890	0.057	0.998
No. of observations	3800	3800	4088	4088

*, ** Indicate values significantly different from zero at the 5 and 1 percent levels, respectively.

V. Summary and Policy Implications

Corporate finance theory and U.S. experience with the Federal Savings and Loan Insurance Corporation and state deposit-insurance funds support the hypothesis that weaknesses in deposit insurance pricing and capital supervision encourage banks to extract deposit-insurance subsidies by increasing their risk exposure. This paper decomposes this general hypothesis into five testable subhypotheses about the character of risk-shifting incentives.

The first subhypothesis is that risk-shifting incentives exist. We find that, at the margin during 1985 to 1994, aggressive banks could extract a deposit insurance subsidy.

The second subhypothesis is that outside discipline helps. We find that during 1985 to 1994 some market and regulatory discipline was exerted on bank risk taking.

The third subhypothesis is that deposit insurance aggravates risk-shifting incentives and that bank risk-shifting exposes the FDIC to loss. Consistent with this hypothesis, we find higher rewards for risk-shifting at banks with high ratios of deposits to total debt.

The fourth subhypothesis focuses on the magnitude of incentives for risk-shifting at troubled banks. Theory implies that stockholder benefits from deposit insurance increase when a bank falls into trouble. Consistent with this theory, risk-shifting incentives prove strongest at weak banks. Troubled U.S. banks could reap large rewards from risk-shifting during 1985 to 1994 and regulators failed to restrain their behavior adequately.

Finally, we investigate the impact of the deposit-insurance reforms whose phase-in began in 1992. These reforms curtailed but did not eliminate risk-shifting incentives. Apparently, regulators still do not adequately monitor and proactively respond to changes in the *ex ante* riskiness of banks' asset returns. Regulatory discipline focuses too narrowly on accounting measures of bank risk and equity capital.

Even in 1992 to 1994, the FDIC's premium structure priced deposit-insurance services unfairly at the margin. The premium structure's high intercept overcharged most banks, and the slope was so low that the nation's riskiest institutions could extract a substantial subsidy. Although explicit FDIC premiums range only from 23 to 31 basis points in 1994,⁸ estimated fair insurance premiums for 1994 range from zero to 1,140 basis points.⁹ The premium structure encouraged conservatively managed banks to expand their risk exposure to lessen the burden imposed by the high intercept (a move typically accomplished via foreign lending and gambles on interest rates and foreign-exchange rates). During 1994 and 1995, the FDIC reduced risk-shifting incentives at strong banks by lowering the intercept first to 12 basis points and then to zero.

It is important for federal regulators to appreciate that risk remains mispriced at the margin. As long as banks remain well-capitalized, franchise value and managerial risk aversion may—as Gorton and Rosen (1995) stress—be strong enough to counteract the FDIC's pricing weakness. But in a sharp interest-rate swing or business-cycle downturn in which U.S. banks sustain large opportunity losses, the managerial counterincentive could melt away. At such a time, the FDIC's condition could deteriorate sharply.

⁸ See p. 23 of the FDIC's 1994 Annual Report.

⁹ These are estimates for the first single-period model. Over the full 1985 to 1994 sample period, the range of fair insurance premiums is even wider, from zero to 1,424 basis points.

Appendix

As discussed in the text, the values of V and σ_V are obtained by solving two simultaneous equations. The first equation states σ_V as a function of E , V , and σ_E :

$$\sigma_V = \sigma_E \frac{E}{V} \bigg/ \frac{\partial E}{\partial V}. \quad (\text{A1})$$

The second equation is the call-option formulation for equity, E . Four option models of E are summarized below.

SPM1: Ronn and Verma (1986) model the market value of a bank's equity as

$$E = V(1 - \delta)^T N(x_1) - \rho B N(x_2). \quad (\text{A2})$$

They express the per dollar fair deposit insurance premium as:

$$IPP = N(-x_4) - (1 - \delta)^T \frac{V}{B} N(-x_3). \quad (\text{A3})$$

In equations (A2) and (A3), δ is the fraction of the bank's assets distributed at each interim dividend date to stockholders, T is the number of interim dividend payments, $\rho = 0.97$ is the forbearance parameter, and $N(x_i)$ states the probability that the variate value x is $\leq x_i$, given that x is distributed with zero mean and unit variance.¹⁰

Adding back the present value of dividends to be distributed before the next audit gives

$$E = V[1 - (1 - \delta)^T] + V(1 - \delta)^T N(x_1) - \rho B N(x_2). \quad (\text{A4})$$

SPM2: Equation (A4) fails to treat regulatory forbearance as a selective strategy. SPM2 assigns forbearance benefits only to banks that are already operating in a state of tangible insolvency. Bank equity then falls below the value in equation (A4) by the value of the following contingent claim:

$$\begin{cases} (1 - \rho)FV(B) & \text{if } V_T > FV(B) \\ 0 & \text{if } V_T \leq FV(B). \end{cases} \quad (\text{A5})$$

Using the Black-Scholes model (1973) of option pricing, we may write E as

$$E = V[1 - (1 - \delta)^T] + V(1 - \delta)^T N(x_1) - \rho B N(x_2) - (1 - \rho)B N(x_4). \quad (\text{A6})$$

¹⁰ $x_1 = [\ln[V(1 - \delta)^T/\rho B] + \sigma_V^2 T/2]/[\sigma_V \sqrt{T}]$; $x_2 = x_1 - \sigma_V \sqrt{T}$; $x_3 = [\ln[V(1 - \delta)^T/B] + \sigma_V^2 T/2]/[\sigma_V \sqrt{T}]$; $x_4 = x_3 - \sigma_V \sqrt{T}$.

The imbedded value of the FDIC guarantee can be extracted from the conservation-of-value condition that the value of bank assets equals the value of all claims on those assets:

$$LL = E + B - V. \quad (\text{A7})$$

In equation (A7), LL is the value of the limited-liability put option which includes the value of FDIC forbearance. Substituting equation (A4) for E and dividing equation (A7) by B , the fair insurance premium per dollar of explicitly and implicitly insured debt becomes

$$IPP = [1 - \rho N(x_2) - (1 - \rho)N(x_4)] - \frac{V}{B} (1 - \delta)^T N(-x_1). \quad (\text{A8})$$

IMM1. Saunders and Wilson (1995) model deposit insurance as an infinite-maturity put option. They derive the value of fair deposit-insurance premium per dollar of insured deposits as

$$IPP = 1 + \frac{\lambda(1 - r_{21})}{(\delta + \lambda)(r_{21} - r_{12})} \left(\frac{V}{B} \right)^{r_{12}}. \quad (\text{A9})$$

In equation (A9), λ is the auditing frequency, δ is the dividend payout rate,

$$\begin{aligned} r_{12} &= -[\Phi + (\Phi^2 + 2(r - g)\sigma_V^2)^{1/2}]/\sigma_V^2, \\ r_{21} &= [-\Phi + (\Phi^2 + 2(r - g + \lambda)\sigma_V^2)^{1/2}]/\sigma_V^2, \\ \Phi &= r - \delta - g - \sigma_V^2/2. \end{aligned} \quad (\text{A10})$$

In equation (A10), r is the interest rate and g the deposit growth rate. With free entry into banking, $r - g = \lambda c$, where c is the audit cost per dollar of insured deposits. Auditing frequency, λ , is set to one. The audit cost is set at 0.000149, the average FDIC administrative expenses per dollar of insured deposits over 1935 to 1995. Merton (1978) shows that the market value of equity satisfies the differential equations (A11) and boundary conditions (A12):

$$\begin{aligned} \frac{1}{2}\sigma_V^2 v^2 e_1'' + (r - g - \delta)ve_1' - (r - g)e_1 + \delta v &= 0, \\ \frac{1}{2}\sigma_V^2 v^2 e_2'' + (r - g - \delta)ve_2' - (r - g + \lambda)e_2 + \delta v &= 0. \end{aligned} \quad (\text{A11})$$

$$\begin{aligned} e_1(1) &= e_2(1); \quad e_1'(1) = e_2'(1); \quad \text{and} \quad e_2(0) = 0, \\ \text{where } e_a(v) &\text{ is bounded as } v \rightarrow \infty. \end{aligned} \quad (\text{A12})$$

In equations (A11) and (A12), e and v are the market values of respectively equity and assets per dollar of deposits.

With free entry into banking, the market value of equity can be found as

$$E = e \times B = V + \frac{\lambda(1 - r_{21})B}{(\delta + \lambda)(r_{21} - r_{12})} \left(\frac{V}{B} \right)^{r_{12}}. \quad (\text{A13})$$

IMM2: This is a special case of Saunders and Wilson (1995) model with zero auditing costs and a $V \leq pB$ closure rule. Since $c = 0$, $r - g = \lambda c$ is also 0. Therefore,

$$\begin{aligned} r_{12} &= 0, \\ r_{21} &= [-\Phi + (\Phi^2 + 2\lambda\sigma_V^2)^{1/2}]/\sigma_V^2, \\ \Phi &= -\delta - \sigma_V^2/2. \end{aligned} \quad (\text{A14})$$

The resulting expression for the value of IPP is

$$IPP = 1 + \frac{\lambda}{\delta + \lambda} \frac{1 - r_{21}}{r_{21}}. \quad (\text{A15})$$

Note that IPP in equation (A15) does not depend on the ratio of assets to deposits, v , and therefore is not affected by altering the closure rule. The closure rule affects the value of equity via the first two boundary conditions in equation (A12), which now become

$$e_1(\rho) = e_2(\rho) \quad \text{and} \quad e'_1(\rho) = e'_2(\rho). \quad (\text{A16})$$

The expression for the equity value used in IMM2 becomes

$$E = \frac{V}{\rho} + \frac{\lambda}{\delta + \lambda} \frac{1 - r_{21}}{r_{21}} B. \quad (\text{A17})$$

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