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The U.S. Savings and Loan Crisis

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1. INTRODUCTION

Between 1980 and March 31, 1992, federal agencies disposed of over 1100 insolvent Savings and Loan (S&L) institutions and, as of March 31, 1992, an additional 408 S&Ls holding 29% of the industry's assets were classified as troubled. Resolving these failures has already cost in excess of $120 billion\(^1\) and the Resolution Trust Corporation (RTC)\(^2\) has projected additional costs of approximately $50 billion to complete the S&L cleanup.\(^3\) Because the Federal Savings and Loan Insurance Corporation reserves have been exhausted, the vast majority of the past and future costs of these failures will be absorbed by U.S. taxpayers. Most of the insolvencies occurred after 1988 and their cause is frequently attributed to the deregulation of the industry in

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\(^1\) These are measured direct costs of S&L resolution and, on the whole, represent wealth transfers from taxpayers to other agents in the economy. There were significant economic costs net of such transfers, costs resulting from inefficient investments, legal and other deadweight costs, and the pre- and post-crisis distortion of national economic policy with resulting long-run effects on real capital growth and real income.

\(^2\) The Resolution Trust Corporation is an institution created by Congress in 1989 for resolving failed institutions from August 1989 through September 1993.

\(^3\) See Barth and Brumbaugh (1992) for data on failures and failure resolution costs. The data on the number of institutions classified as troubled was taken from Office of Thrift Supervision (1992) and includes 354 institutions "considered by OTS to be troubled but not projected to require federal assistance" and 54 institutions that are projected to require federal assistance.
1980 and 1982. In fact, this crisis developed over a substantially longer period and had other significant contributory causes. The abysmal performance of Savings and Loan Associations (S&Ls) over the past decade is, in part, the consequence of a fundamental flaw in the structure of these institutions and is also attributable to regulatory and supervisory mistakes predating the events of the late 1980s and early 1990s.

2. A PREDISPOSITION TO FAILURE

2.1. The Key Roles of U.S. Savings and Loan Associations

Until 1980, S&Ls performed a narrowly defined role in the U.S. financial system. The bulk of their asset operations involved originating, investing in, and servicing home mortgages. On the liability side, they accumulated household savings plus some form of net worth to finance the mortgage portfolio.

S&Ls serve the basic lending function of precontract monitoring of the mortgage borrower. They expend resources to evaluate individual investments in real estate properties and to determine the conditions under which a mortgage loan will be made. Leland and Pyle (1977), Diamond (1984), and others have observed that providing this monitoring service through a financial intermediary can only be sustained if the gains from collective monitoring exceed the costs of convincing the primary investors (mainly the depositors) that the screening process has correctly identified loan values. Models in which collective monitoring justifies the existence of depository and non-depository intermediaries are discussed in Chapter B12.
Collective monitoring need not involve continuing investment by the monitoring firm in the loans it originates. In mortgage markets, brokers provide the precontract monitoring and pass the mortgage loans they originate on to other lenders. Until recently, S&Ls did not engage heavily in mortgage brokerage operations. Instead, they held most of the mortgage loans they originated in their own portfolios. This required them to engage in an asset transformation process. The nature of this transformation changed over time ultimately resulting in an asset/liability structure subject to significant interest rate risk. The maturity mismatch between long-term, fixed rate mortgage assets and short-term deposit liabilities was a major cause of the series of S&L crises that began in the mid-60s.

Diamond and Dybvig (1983) provide a theoretical analysis of maturity transformation by financial intermediaries. See Chapter B12 for additional references and a review of this topic. In its most basic form, maturity transformation involves a mismatch between the contract length of an intermediary's assets and that of its liabilities. Typically, this mismatch involves holding illiquid assets with contract lengths greater than those of the intermediary's liabilities. The resulting risks to an intermediary's net worth come from two sources, default by the borrowers and untimely withdrawal or non-renewal of the liabilities. The first of these risks is common to all intermediary structures; the second can occur only where there is an asset/liability liquidity mismatch. Until the advent of broad secondary markets for mortgage-backed
securities, mortgage loans were illiquid. In contrast, S&L liabilities became more liquid over time, i.e. available on demand or short notice without penalty.

Maturity transformation may also involve interest rate risk. Absent regulatory constraints, it is unnecessary for S&Ls to couple liquidity transformation with interest rate risk as their more recent reliance on adjustable rate mortgages demonstrates. Until the late 1970s, when they were able to loan at variable rates, S&Ls became increasingly short-funded and subject to interest rate risk.

The S&Ls' predisposition to failure involves their adoption of an asset/liability structure subject to significant interest rate risk. The next two sections of this chapter trace the events leading to that flawed structure.

2.2. The Evolution of U.S. Savings and Loan Associations: 1831-1930

The origin of U.S. Savings and Loan Associations has been traced to the Oxford

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4 There is an important link between the monitoring and liquidity creation functions of an intermediary. Even though an underlying asset is long-lived, as is the case for single-family homes, the loan that finances the asset will only be illiquid to the extent that reliable information on the loan's value cannot be efficiently transferred from one holder to another.

5See Chapter B12 for a discussion of conditions under which the coupling of liquidity creation and interest rate risk would be necessary.

6The following discussion of the early evolution of U.S. Savings and Loan Associations draws heavily on Schwartz (1989).
Provident Society of Philadelphia founded in 1831 and to other local building societies. These were mutual associations organized to provide a pool of funds to be loaned to members for home building. Regular contributions by members accumulated as shares and were used to finance mortgage loans. The return on the loans was paid to the holders of the shares. Initially, the shares were a form of equity neither entitled to a fixed dividend nor withdrawable on demand. The association had a limited life being dissolved when every member had obtained a loan and all loans had been repaid. These early S&Ls had two characteristics which provided strong support for their intermediary functions. As local, closed organizations, they provided a simple, efficient means for selecting and monitoring borrowers. Secondly, the equity-like nature of member shares solved the problem of financing illiquid, defaultable assets. Any shortfalls in mortgage payments were, of necessity, absorbed by share-holding members who did not have the option to withdraw their shares.

By 1870, a sharper division between borrowers and savers developed with the introduction of permanent associations and shares issued in series so that new members were permitted to enter the association over time. By the turn of the century, some S&Ls were financing mortgage loans with as many as three kinds of liabilities, the traditional permanent shares, shares that received fixed interest payments at stated

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7Most of these institutions were called building societies and building and loan associations until the 1930s. In what follows, the name savings and loan associations (S&Ls) will be used to describe the institution in both the pre-Depression and the post-Depression periods.
intervals and matured on specific dates (similar to modern day CDs), and shares that could be withdrawn on short notice.\textsuperscript{8}

An S&L liability structure including deposits available on short notice remained in place through the 1920s. Up to the Great Depression, however, S&Ls continued to rely chiefly on accounts that brought in funds likely to stay for several years. The possibility of withdrawal penalties help enforce saver discipline.

Turning to the asset side, there are few data on the contract terms of mortgage loans at S&Ls in the 19th century. The data in Morton's (1956) classic NBER study of urban mortgage lending begin with 1920. These data show contract lengths for straight mortgages made on non-farm homes by S&Ls averaging 11.2 years from 1920 through 1930 with only minor year-to-year variation. Significantly, from the perspective of interest rate risk, the realized maturities of mortgage loans at S&Ls were even shorter averaging 6.9 years over the same period.

S&L asset risk during the first three decades of the 20th century was mitigated further by stable mortgage interest rates. Conventional mortgage rates in Manhattan

\footnote{In the late 19th century, locally-based societies were challenged in deposit markets by competition from "National Building & Loan Associations." These "national associations" grew rapidly until 1896 after which they fell into a steep decline apparently resulting from the depression of 1893-96. Presumably, the local societies fared better because of the superior monitoring and contracting associated with their local focus.}
from 1900 through 1929 averaged 5.59% with a 26 basis point standard deviation.\footnote{Homer (1977), p. 399.}

Morton reported contract interest rates at S&Ls from 1920 through 1930 averaging 6.94% with only a 15 basis point standard deviation.

S&Ls are thus seen to have been immune from significant interest rate risk from their inception up to the Great Depression. Initially, this was due to the absence of a maturity mismatch in the design of the institution. Later, when there was a potential mismatch from increased use of short-term deposit liabilities, S&Ls were protected by a stable interest rate environment combined with a prudent avoidance of a reliance on short-term liabilities. Nonetheless, by 1930, the seeds of a serious problem had been planted. The significance of this was recognized by Lieber (1931) who said:

The inconsistency of considering demand money, money that has been invested in mortgages repayable by amortization over a period of 15 to 20 years is apparent. Whatever the desires or preferences, however altruistic the attempt to have money invested in building and loan associations payable on demand, the theory of long-term mortgage and demand funds will no more work than will oil and water mix.

Lieber’s concern centered on the liquidity mismatch resulting from financing long-term mortgages with demand funds. Ultimately, the problem he anticipated result more from
the effects of a maturity mismatch than from illiquidity, though both played a role in the 
S&L crisis that began some 30 years after his warning.

2.3. The Transformation of U.S. Savings and Loan Associations under the New Deal 

Property devaluations and the precipitous fall in incomes accompanying the Great 
Depression had a profoundly adverse effect on S&Ls and other mortgage lenders. Home 
owners could not meet their mortgage payments and the depressed state of real estate 
markets often made foreclosure a response of questionable worth. On the liability side, 
depositors pressed for immediate access to their savings because of personal liquidity 
needs and from fear of S&L failures. The federal response to the resulting crisis had a 
fundamental and persistent effect in changing the typical S&L asset/liability structure.

Beginning with the *Home Owners Loan Corporation Act of 1933* (HOLC), New 
Deal administrators took bold steps to stabilize the mortgage market. The Corporation 
was an emergency organization which took over more than $3 billion in mortgage loans 
from S&Ls, banks, and other mortgage lenders before its lending function ended in 1936. 
HOLC refinanced home owners' existing mortgage contracts using 5%, 15 year 
amortizing mortgages. The creation of the Federal Housing Administration (FHA) as 
part of the National Housing Act of 1934 was the next New Deal initiative in mortgage 
market stabilization. The FHA (later joined by the Veterans Administration), as a 
federally-backed insurer of mortgage contracts, set the standards for mortgage lending. 
Longer contract lengths on amortizing loans were attractive from the insurer's viewpoint 
and insured mortgages appealed to lenders. By 1947, the average contract length of a
new mortgage at S&Ls had risen to 15.2 years from the 10.8 year average contract length prevailing in 1930.\textsuperscript{10} This trend toward longer contract lengths continued through the postwar period so, by the late 1950s, the average maturity of mortgage loans at S&Ls was in excess of 20 years. Between the start of the Depression and 1960, S&L asset values became substantially more sensitive to interest rate fluctuations.

On the liability side, the consumer liquidity problems created by the drastic fall in incomes put pressure on the institutions to provide depositors their savings on demand. In an environment with unstable asset values, demand liabilities can and do result in depositor "runs" and an unstable financial system. The establishment of the Federal Savings and Loan Insurance Corporation in 1934 put a federal commitment behind S&L deposits. This permitted S&Ls to make short-term deposits a permanent and, ultimately, a dominant feature of their liability structure without incurring the threat of depositor runs.

The asset/liability mismatch that concerned Phillip Lieber in 1931 became the S&L norm through well-intentioned New Deal interventions. By 1947, S&Ls were financial intermediaries backed by a federal guarantee of their major liabilities and predisposed to net worth losses given adverse interest rate movements. This predisposition was further exacerbated between 1947 and 1960 by a secular rise in the average asset maturity at S&Ls. However, the interest rate environment remained

\textsuperscript{10}See Morton (1956).
reasonably benign over most of the 1950s. From 1947 through 1956, the annual average interest rate on conventional mortgage loans in Manhattan rose by 39 basis points. This increase came as a steady secular rise; the maximum year-to-year change was an 11 basis points increase between 1947 and 1948. The situation on the liability side of the typical S&L was similar, but less benign. The average annual yield on savings accounts increased steadily over the 1947-56 period. The total increase was 70 basis points resulting in a 31 basis point erosion on the net interest spread on new mortgage loans and, of course, an erosion in the interest spread on older loans.

2.4. U.S. Savings and Loan Associations and Interest Rate Risk

Entering the 1960s, the interest rate sensitivity of the market value of a typical S&L’s assets was substantially greater than the interest rate sensitivity of its liabilities, subjecting S&Ls to market net worth losses given interest rate increases. For example, the Macaulay duration of a 25 year, 6% yield, amortizing loan is just over 10 years. If taken as a reasonable estimate of the interest elasticity of loan value, this measure implies that a mortgage loan with the stated characteristics will lose (gain) 1% of its value for a 10 basis point change in the market yield on 25 year mortgages. If the economic value of depositor claims had remained unchanged in the process, the 1% decline in asset value would have translated into more than a 14% decrease in the association’s economic net worth given the approximately 7% net worth to asset ratio at the typical S&L.
The typical association's economic net worth in 1960 was somewhat less interest sensitive than this simple duration measure suggests. S&L asset portfolios included seasoned as well as new mortgages so, by the standard Macaulay measure, the average duration of its assets was about 7 years instead of 10 years. Secondly, borrowers had the option to prepay their mortgage loans in whole or part and, since some borrowers used this option, the interest sensitivity of the assets was further reduced.\textsuperscript{11} Finally, changes in association net worth also reflect the effect of changes in market interest rates on the liability side of the net worth equation. If the interest paid on savings deposits does not respond as rapidly to changes in market rates as the interest rates on loans, the effect on association net worth will be lessened.

Unfortunately for S&L managers, regulators, and especially for U.S. taxpayers, the stable interest rate environment of 1947-56 did not persist. Mortgage interest rates rose rapidly from 1956 to 1961. The Manhattan conventional mortgage loan rate rose by 178 basis points over this period.\textsuperscript{12} This upward shift in mortgage interest rates wiped out a significant fraction, perhaps 5\%, of the market value of the typical S&L asset portfolio while having little effect on the value of its liabilities. From an income perspective, the accompanying 90 basis point rise in the interest rate paid to S&L savers sharply reduced

\textsuperscript{11} Although prepayments reduce the interest rate sensitivity of prepayable mortgage loans relative to an otherwise equivalent loan not subject to prepayment, this effect is perversely affected by market interest rate changes. As rates rise, prepayments tend to fall and as rates fall prepayments tend to rise. See Chapter A18 for a detailed analysis of the effects of prepayments on the value of mortgage portfolios.

\textsuperscript{12} Homer (1977).
the S&Ls' interest margins on seasoned mortgages and resulted in an increase in the
faction of net operating income paid out as interest from 72.3% in 1956 to 78.6% in
1961.\textsuperscript{13} Aggregate association net worth to total assets which stood at 7.6% in 1950 was
less than 7% by 1961.\textsuperscript{14}

In 1962, mortgage interest rates fell by over 100 basis points and stabilized at
around 5.8% for the next three years. Unfortunately for anyone concerned with S&L
soundness, the average cost of savings deposits at S&Ls rose by an additional 33 basis
points between 1961 and 1965 so that income paid out as interest rose to 84.5% of net
operating income in 1965. In December 1965, the Federal Reserve Board responded to
rising money market interest rates and the higher deposit account interest rates being
offered by S&Ls by sharply increasing the maximum rate payable on bank time deposits
(from 4% (for less than 90 day maturities) and 4.5% (for 90 days and over) to 5.5%
across the board).\textsuperscript{15} Money market interest rates rose sharply during the first half of
1966 (e.g. the federal funds rate rose by 85 basis points) and banks used their new
deposit interest rate powers to bid aggressively for time deposit balances. Most S&Ls,

\textsuperscript{13}United States Savings and Loan League, \textit{Savings and Loan Fact Book} (1973).

\textsuperscript{14}The net worth used in calculating these ratios is a book value measure was taken
from the Savings and Loan Fact Book of 1977. Given the substantial increase in
mortgage interest rates between 1950 and 1961, the fall in the economic or market value
net worth to total assets ratio is understated by the book value figures.

\textsuperscript{15}Under the provisions of the \textit{Banking Act of 1935}, the Federal Reserve Board was
authorized to set maximum interest rates that could be paid on bank time and savings
deposits. This authority was carried out through Federal Reserve Board Regulation Q.
Until 1966, thrift regulators (e.g. the Federal Home Loan Bank Board) had no interest
rate ceiling powers.
saddled with the income consequences of below-market fixed rate mortgage portfolios and facing higher loan losses in a depressed real estate market, found it difficult to compete. The S&L deposit growth rate fell to less than 2% annually over the first six months of 1966.

The resulting crisis over the vitality of S&Ls and their ability to supply funds to the housing construction industry led Congress to pass and President Lyndon Johnson to sign the *Interest Rate Adjustment Act of 1966*. The provisions of this Act fixed the deposit interest rates payable by S&Ls, lowered the maximum time deposit interest rates payable by commercial banks, and established a positive differential between the rates payable by S&Ls and those payable by commercial banks. The passing and signing of this Act was a tacit recognition that the S&L industry was unable to continue to function in a competitive market for deposits at existing interest rate levels with the typical S&L asset/liability structure. Rather addressing the structural flaw, federal authorities tried to control the effects of the market by mandating cartel pricing across the regulated depository institutions. The seeds of the epidemic of S&L failures in the 1980s and 1990s and of the billions of dollars it has and will cost to resolve those failures were sown by the failure of the federal authorities to address the root causes of the 1966 crisis.

The immediate consequence of the *Interest Rate Adjustment Act*, aided substantially by a fall in money market interest rates, was the temporary stabilization of
the S&L crisis. Predictably, this partial price control solution was not sustainable over
the longer term. 16 The attempt to maintain S&L profitability through deposit interest
rate ceilings might have worked had the need to do so been short-lived. However, the
short-term interest rate levels of the 1960s were mild compared to those that followed,
and the interest cost control strategy unraveled. Because of the interest rate ceilings,
S&L interest expenses grew slowly through the mid-1970s, but increases in money market
rates above the ceilings led to disintermediation into Treasury Bills, money market
mutual funds, and other short-term investments not subject to interest rate controls.
There were numerous, futile attempts by federal regulators to stabilize deposit flows at
S&Ls without causing unduly adverse effects on their total deposit costs. 17 Despite
these attempts, S&Ls were only able to grow at significant rates when short-term market
interest rates were near the ceilings (in 1971-72 and 1975-78). Growth during these
periods of relatively lower mortgage interest rates proved to be dysfunctional from a

16The interest rate controls were partial in that they did not apply to all instruments
accessible by depositors. Cootner (1969) made a prescient comment on the potential for
this legislation to achieve its goal:

Whatever merits one may find in rate regulation, it cannot be accomplished
by one sector of a highly competitive market. It is true that when the [interest
rate] regulation was first attempted, neither the commercial banking sector
nor the debt securities markets were as competitive as they gradually became,
and so the prospects for success were more sanguine at the outset than they
were in retrospect, but that is an outstanding characteristic of partial price
regulation...Their is some serious question about the merits of trying to
control soundness...by rate controls because of its tremendous impact on
liquidity problems.

17These attempts included the introduction of the aborted "wild-card" experiment in
1973, the six month money market certificate in 1978, and the small saver certificate in
1979.
long-run solvency perspective. Overall, the growth in savings between 1970 and 1981 barely kept up with the increase in housing prices.

By 1981, the strategy of housing construction support and S&L cost containment through the use of deposit interest rate ceilings was in complete disarray. Net savings flows at S&Ls were negative, the S&Ls’ average interest cost had risen to 10.71%, aggregate S&L income after interest and taxes was negative, and aggregate book net worth had fallen to 4.3% of total assets. In market value terms, it has been estimated that aggregate S&L net worth which in 1966 was around -$2.8 billion fell to about -$100 billion by 1981.\(^\text{18}\) By contrast, Federal Savings and Loan Insurance Corporation reserves were $1.8 billion in 1966 and $6.2 billion in 1981. The misguided and ultimately failed attempt to shelter the structurally defective S&L industry from the effects of interest rate risk had convert an unfunded federal liability from about $1.0 billion to one of over $90 billion. While the precise magnitude of this unfunded liability may be questioned, there is no doubt that it increased dramatically over the 15 years of deposit interest rate ceilings.

The failure to address the fundamental structural problem of the S&L industry went beyond the misguided use of deposit interest rate ceilings. Variable interest rate

\(^\text{18}\)These estimates are taken from Kane (1985) p. 102, but adjusted to be consistent with the more conservative estimates in Brumbaugh (1988) p. 50. The 1966 S&L net worth estimate was obtained by extrapolation from Kane's net worth estimate for mutual savings banks for that year.
mortgages (VRMs) provided an alternative method of reducing the maturity imbalance faced by S&Ls, one that was successfully adopted by some states for state-chartered S&Ls in the early 1970s. Despite periodic support for VRMs by the Federal Home Loan Bank Board, Congress throughout the 1970s steadfastly opposed VRMs for federally-chartered institutions, belatedly authorizing their use in 1979.\(^{19}\)

Furthermore, as discussed in the sequel, the various legislative and regulatory steps taken to sustain the deposit interest rate cartel, including some consequences of the Interest Rate Adjustment Act of 1966 for the structure of the industry, had significant and adverse effects on the magnitude and cost of the S&L failures in the 1980s and 1990s.

3. THE ROLE OF LEGISLATION AND REGULATION IN WORSENING THE S&L CRISIS

In addition their responsibility for the flawed design of S&Ls, federal and state regulators, supervisors, and legislators took actions that exacerbated the S&L crisis and failed to adopt measures that would have eased the crisis. The asset deregulation of 1980 and 1982 and the subsequent inadequate supervision of S&Ls are chief cases in point and are discussed in the sequel. However, the undertaking that contributed most to the scope and scale of the crisis was the adoption of an actuarially unsound savings and loan deposit insurance system and occurred over a half-century earlier.\(^{20}\)

\(^{19}\)Between 1970 and 1978, federally chartered S&Ls accounted for almost 60% of the total asset growth at S&Ls.

\(^{20}\)See Tobin (1989).
inconceivable that either the broad-scale investment excesses that followed S&L asset deregulation or the rapid growth of deposits at under-capitalized S&L could have transpired without federal deposit guarantees. In the next subsection, I lay out a model of the deposit insurer's liability. The analysis highlights the determining factors of that liability. The implications of this model are then used in the analysis of other key actions by federal and state authorities.

3.1. Deposit Insurance and the S&L Crisis

The basic deficiencies of deposit insurance were well-known, in theory and in practice, well before federal deposit insurance was finally introduced. The federal scheme, enacted for banks in 1933 and extended to S&Ls in 1934, imposed a fixed premium per dollar of deposits on each insured institution in exchange for a guarantee of depositor claims up to a specified limit. For such a scheme to be actuarially sound, each insured bank must present the guarantor with the same risk of loss or, to put it more precisely, with the same contingent liability per dollar of deposits and the value of that liability must be equal to the insurance premium less the guarantor's operating expenses. Failure to meet this actuarial standard has a number of undesirable consequences including the accumulation by the guarantor of an unfunded liability (if the fixed fee does not prove to be large enough) and differential net subsidies or taxes across insured institutions (if the incidence of the difference between the actuarial fee and the

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21The numerous attempts by Congress to introduce federal deposit guarantees in the late 19th and early 20th centuries and the experiences of the fourteen state deposit insurance schemes established between 1829 and 1917 are summarized in FDIC (1950, 1952).

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actual fee is not uniform).

Furthermore, with the fee held constant, an actuarial sound scheme is subject to "moral hazard" in the sense described by Mayers and Smith (1982), namely that the owners of an insured institution may have an incentive to restructure that institution in a way that increases the value to them of the guarantee. In large measure, the S&L crisis was the realization of these and other predictable consequences of an unsound deposit insurance system.

The defective nature of the deposit insurance system introduced in 1933 was apparent to critics at that time\(^{22}\) and its deficiencies were periodically pointed out during the 1960s and 1970s.\(^{23}\) As noted above, the consequences of the S&L deposit insurance flaws were not felt seriously until the mid-sixties because of the unusually benign interest rate environment that persisted until the early 1960s and because of pre-1980 asset and liability restrictions that limited the scope of S&L operations.\(^{24}\) The fact that legislative action to deal with these consequences did not occur until 1989 resulted in

\(^{22}\) In one of the first published critiques of the federal deposit insurance system, Emerson (1934) identified the fact that "premiums are not graded according to the risks involved" and the absence of a "provision for the accumulation of a reserve fund" as two of the major deficiencies in the scheme.

\(^{23}\) See Gibson (1972), Horvitz (1975), Mayer (1965), and Scott and Mayer (1971).

\(^{24}\) Interestingly, there is evidence that, in a less benign environment, the moral hazard consequences of federal deposit insurance were felt as early as 1939. See Grossman (1992).
from a concerted effort by the authorities to deny the existence of an unfunded liability.\textsuperscript{25} The ultimate cost of the crisis was greatly increased due, in large part, to dysfunctional actions to support that denial.

A more systematic theory of the value of the guarantor's contingent liability and its determinants became possible with the development of the analytical option pricing model of Black and Scholes (1973). Merton (1977) showed that "the properties of deposit insurance viewed as a security are isomorphic to those of a put option." The essence of his demonstration follows.

Consider a bank with assets having market value $V$ at a future date $T$, where $T$ is the date of the next audit of the bank. These assets are financed with a combination of insured deposits, having a current value $D$ and a future value $B = De^{rT}$ (where $r$ is a riskless rate of return), plus equity. At $T$, the payoff to the various claimants are:

Payoff to equity at $T$ \hspace{1cm} = \hspace{1cm} \text{Max}(0, V-B)$

Payoff to depositors at $T$ \hspace{1cm} = \hspace{1cm} B$

Payoff to guarantor at $T$ \hspace{1cm} = \hspace{1cm} \text{Min}(0, V-B) = -\text{Max}(0, B-V)$

\textsuperscript{25}See Kane (1989) for a discussion of the political incentives driving this behavior.
The payoff structure for the guarantor is that of a short position in a put option on the bank's assets with an exercise price $B$ and a maturity $T$. The present value of the guarantor's conditional liability is the present value of this put option. The gain to the bank equity holders from mis-priced deposit insurance is that they are able to contract with the depositors at the riskless rate $r$ rather than at $R(T)$, a promised yield necessarily in excess of $r$ to compensate uninsured depositors for the risk that the bank would be unable to pay the promised rate. The present value of the equity holders' gain in this set-up is exactly equal the value of the put. Using Black-Scholes option pricing, Merton is able to write the value of the put per dollar of insured deposits, $g(d, \tau)$, as

$$g(d, \tau) = \phi(h_2) - (1/d)\phi(h_1)$$

where:

$\phi(.)$ is the cumulative normal density function,

$$h_1 = \frac{\ln(d) - \tau/2}{\sqrt{\tau}},$$

$$h_2 = h_1 + \sqrt{\tau},$$

$$d = D/V,$$ (the current deposit-to-asset value ratio)
\[ \tau = \sigma^2 T, \text{ (the variance in the log change in asset value over } T). \]

As long as the deposit-to-asset value ratio and the volatility of the assets are fixed, the cost of the deposit guarantee remains fixed. The nature of the "moral hazard" faced by the guarantor becomes apparent in this set up, since standard comparative statics results show that increases in \( d \) and increases in \( \tau \) lead to increases in the value of the guarantee to the benefit of the owners of the bank and the detriment of the guarantor. In other words, if the risk of the banks assets increases or if the bank's leverage increases, equity holders benefit at the expense of the guarantor.\(^{26}\)

Additional insights into the deficiencies of the deposit insurance scheme can be gained by exploiting this put option analogy. Since \( \tau \) increases with \( T \), the result that the value of the guarantee increases with \( \tau \) can also be interpreted as the effect of an increase in the time until the option is exercised. Suppose that (1) the exercise date depends on the condition of the bank at an audit date, (2) exercise of the option can be forced based on the audit results, and (3) the audit data systematically bias asset values upward.\(^{27}\) The result will be longer times to exercise than would occur with exercise based on the bank's true condition. This increase in \( T \) results in a higher value for the guarantee since it increases the dispersion of the potential asset value outcomes with

\(^{26}\)See Merton and Bodie (1992) for a further explication of this analytical framework.

\(^{27}\)See Merton (1978) for an analysis of perpetual deposit insurance with random monitoring that can trigger exercise of the option.
most of the positive effects accruing to the equity holders and all of the negative to the guarantor.\textsuperscript{28}

To the extent that the guarantor does not have or does not exercise the authority to limit dividends, owner/manager perquisites, and other disbursements of the bank's assets, the proper analogy is to a put option without dividend protection.\textsuperscript{29} In the absence of dividend protection, the holder of a put option who is also able to declare and receive the dividend (broadly construed) and who anticipates that the put may be exercised (i.e. in the case of deposit insurance, that the S&L will fail) has a strong incentive to increase his wealth at the expense of the writer of the put by declaring as large a dividend as possible prior to the exercise date. In other words, the insurance guarantor is faced with a serious agency problem. Note also that a delay in the exercise date, such as that caused by a false positive audit signal, allows an owner/manager more time to exploit the absence of dividend protection to the further disadvantage of the guarantor.

Another important insight into the operational deficiencies of the federal deposit insurance scheme may be gained by considering the effect of increases in the deposit-to-asset value ratio on the sensitivity of the put value to asset risk (i.e. the effect of an increase in $d$ on $\partial g/\partial \sigma$). For a sufficiently low deposit-to-asset value ratio (high capital-

\textsuperscript{28}See Pyle (1986) for an analysis of the effects of biased audit values.

\textsuperscript{29}See Cox and Rubinstein (1985) p. 150.
to-asset ratio), the effect of increased asset volatility on the put value will be insignificant. As the deposit-to-asset value ratio increases toward one (the point of insolvency), the rate at which the put value increases with an increase in volatility becomes larger.\textsuperscript{30} In other words, the lower the true net worth of an S&L, the larger is the incentive to undertake greater asset risk. As the true net worth approaches or falls below zero, the reluctance of risk-adverse owners and managers to "bet the bank" or to exploit the lack of dividend protection or, most likely, to do both will diminish.

In evaluating supervisory actions preceding and during the S&L crisis, it is important to recognize that, if exercise of the put option (i.e. insolvency proceedings or bank reorganization) could be forced at asset value levels at or above the true insolvency point and if the full value of the assets could be realized during the resolution of that insolvency, the put value would be zero. Delays in forcing option exercise and inefficiencies in realizing asset values lead to higher costs for the guarantor.\textsuperscript{31}

Finally, in considering the potential importance of moral hazard on the performance of S&Ls, it is useful to differentiate among these institutions on the basis of organization and control. S&Ls may be either mutually-owned or permanent stock


\textsuperscript{31}See Mullins and Pyle (1992) for an analysis of deposit insurance where there are significant liquidation costs.
organizations. In a mutual S&L, the net income after interest and taxes accrues, in principle, to the depositors; in a permanent stock S&L it accrues to the shareholders. Consequently, it can be anticipated that the incentive to exploit the deposit insurance guarantee will be strongest in permanent stock firms.\textsuperscript{32}

3.2. Adverse Effects of Deposit Interest Rate Ceilings

The \textit{Interest Rate Adjustment Act of 1966} temporarily protected S&Ls from the effects of secularly rising interest rates. Ultimately, this attempt at partial price control broke down and the interest cost for S&Ls rose sharply. In the interim, S&Ls attempted to circumvent the deposit interest rate ceilings by various forms of non-interest rate competition. Some of this competition took the form of variable costs for advertising, gifts to depositors and other incentives that were easily reduced when the ceilings were removed. Other non-interest rate responses involved increases in S&L service capacity and were less easily reversed. S&L offices per capita more than doubled between 1965 and 1982 (from 4.7 offices per 100,000 to 9.7 per 100,000). The number of S&L employees per capita also more than doubled. In constant dollar terms, assets per S&L office fell from $14.1 million to $10.3 million and assets per S&L employee from $1.33 million to $0.84 million. By 1982, S&L operating expenses per dollar of deposits had reached 177 basis points per dollar of deposits, an increase of more than 40% over the

\textsuperscript{32}While the mutual versus permanent stock split may capture the major aspect of differences in the moral hazard incentive among S&Ls, this incentive may also depend on a number of other factors such as the concentration of stock ownership, management incentive systems, and board composition. See Hermalin and Wallace (1992) for a further discussion of these matters.

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expense levels of 1965.\textsuperscript{33}

Furthermore, during the period of interest rate ceilings, new competition for bank and S&L deposits developed in the form of money market mutual funds and other assets that fell outside the depository institutions regulatory purview. The import of these developments vis-a-vis the S&L crisis was two-fold. The increase in the S&L cost structure contributed to S&L losses and the reduction in their net worth. Perhaps more importantly, the increase in competition, whether from the proliferation of banking and thrift offices or from the growth of savings substitutes, reduced the value of a depository institution charter. When a bank or S&L charter has significant value, the potential loss of the charter due to bankruptcy is a counterbalance to the risk-taking incentives inherent in the federal deposit insurance system. Keeley (1990) presents empirical findings consistent with the view that some of the increase in bank and thrift risk and subsequent failures may be due to a decline in the value of bank and thrift charters associated with increased competition in the financial services industry.

By encouraging non-rate competition and the more rapid development of non-regulated substitutes for thrift deposits, deposit interest rate ceilings contributed to that decline in charter values and, therefore, to the depth of the S&L crisis. Perhaps the most significant consequence of the failed attempt to shelter S&Ls from market forces is

\textsuperscript{33}The data on S&Ls in this and subsequent sections of the paper came from various issues of the \textit{Savings and Loan Fact Book} (U.S. League of Savings Associations, Chicago) and its successor publication the \textit{Savings Institutions Source Book}. 

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that it left the industry weakened and ill-prepared to deal with the challenges and incentives of the subsequent deregulated and competitive environment. As shown above, financial theory predicts that economically insolvent institutions will be particularly apt to exploit the risk-taking incentives inherent in fixed price deposit insurance contracts.

3.3. The Effects of Dysfunctional Legislation and Regulation

By 1980, many S&Ls were facing a liquidity crisis due to the effects of deposit interest rate ceilings. In 1977, net new savings at FSLIC-insured institutions totalled $32 billion. Under attack from money market mutual funds and other unregulated deposit substitutes, net new S&L deposits fell to less than half that amount in 1979 and to just over $10 billion in 1980. The flight from S&L deposit classes still subject to binding interest rate ceilings was even more marked becoming negative from the second quarter of 1979 through the third quarter of 1980. At this rate of disintermediation, numerous S&Ls faced the prospect of selling illiquid assets at prices substantially below book to finance the cash withdrawals, an action that threatened to exhaust their book net worth and force insolvency proceedings.

The reduced ability of S&Ls to supply funds to residential mortgage markets became a matter of considerable concern to S&L regulators and the Congress. As Table 1 shows, S&L participation in mortgage markets in 1980 fell to about half of the average rate in the 1970s.

Table 1

ANNUAL GROWTH RATES FOR MORTGAGES ON THE S&L CRISIS
## RESIDENTIAL PROPERTIES, 1970-1982

<table>
<thead>
<tr>
<th>Years</th>
<th>Growth in Total Loans Outstanding (Annual %)</th>
<th>Growth in Loans Outstanding at Savings Associations (Annual %)</th>
<th>Growth in Loans Outstanding at All Other Institutions (Annual %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-79</td>
<td>12.2</td>
<td>13.5</td>
<td>10.4</td>
</tr>
<tr>
<td>1979-80</td>
<td>10.1</td>
<td>6.3</td>
<td>13.0</td>
</tr>
<tr>
<td>1980-82</td>
<td>5.2</td>
<td>-2.0</td>
<td>9.9</td>
</tr>
</tbody>
</table>

Source: *Savings Institutions Source Book 89*, United States League of Savings Institutions, Chicago, 1990

The initial Congressional response to this liquidity crisis was the *Depository Deregulation and Monetary Control Act (1980 Act)* passed in March 1980 which required all deposit interest rate ceilings to be eliminated by March 31, 1986. However, Congress failed to authorize any significant new deregulated deposit accounts for S&Ls.

Predictably, these half-measures were inadequate and disintermediation accelerated. Net new savings at FSLIC-insured institutions were negative in each quarter from first quarter 1981 through the third quarter of 1982. In total, the net S&L deposit outflow during these seven quarters exceeded the net deposit inflows over the previous 10 quarters. This forced S&Ls, in aggregate, to be net sellers of mortgages during 1981 and 1982 (see Table 1). The deposit hemorrhaging at S&Ls was finally stopped with the passage of the *Garn-St Germain Act (1982 Act)* in December 1982. The *1982 Act* mandated the creation of a deposit account that would be competitive with money market mutual funds.
Solving this liquidity crisis put the S&L industry, now in far weaker condition, back into the negative earnings position that led to deposit interest rate ceilings in the first place. Aggregate reported profit margins (net income divided by total income) at FSLIC-insured savings institutions which had averaged 7.78% in the 1970s fell to 1.37% in 1980 and became negative in 1981 and 1982 (-6.96% and -5.49% respectively). Congress responded by authorizing new S&L asset powers. In the 1980 Act, federal savings and loans were authorized to invest up to 20% of their assets in consumer loans, commercial paper, and corporate debt securities (including "junk" bonds) and up to 3% in service corporations which could hold undeveloped land and other here-to-fore disallowed assets. The authority of S&Ls to make acquisition, development, and construction loans was expanded, geographical restrictions on real estate lending were removed, and permissible loan-to-value ratios were increased. The Garn-St Germain Act of 1982 carried this expansion of federal S&L asset powers considerably farther permitting commercial mortgage and consumer lending to be as much as 40% and 30% of assets, respectively, and commercial loans and leases to be up to 10% of assets each. Some state authorities, notably those in California, Florida, and Texas, granted broader powers (e.g unlimited assets in junk bonds) for similar investments by state-chartered institutions.

It was presumed by some authorities that these new powers would enhance the diversification of S&L asset portfolios and provide added earning capacity to help meet the increased S&L deposit costs. Providing these new asset powers, including the
authorization of adjustable rate mortgages at federal S&Ls in 1981, was a belated recognition of the unsuitability of the earlier S&L asset/liability structure in a volatile interest rate environment. These new powers substantially increased the potential for risk-taking by insured institutions and the difficulty of monitoring their performance. If these new asset powers could have been accompanied by suitable monitoring and risk-control mechanisms and offered only to well-capitalized institutions, this change in asset powers would have been a far better response to the S&L earning crisis than the earlier, failed attempt to control liability costs through deposit interest rate ceilings. Given the actual conditions in the S&L industry in the early 1980s...numerous economically insolvent institutions and low capital ratios in general plus grossly inadequate regulatory monitoring and risk-control...the application of financial first-principles that were well-known at the time, such as those presented in section 3.1, would have led to predictions that the 1980 and 1982 Acts would produce a significant increase in S&L risk-taking, especially by the weakest institutions, and a corresponding increase in the unfunded liability of the insurance fund.

Other provisions of the 1980 and 1982 Acts and subsequent regulatory changes exacerbated the problem by encouraging accounting practices and other forms of

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34 Clearly, the new asset powers implied an increased need for the insurer to monitor the risk-taking and the economic net worth of the S&Ls. As Kane (1990, p. 100) has pointed out, "Incredibly, examination and supervisory resources declined in 1983 and 1984, precisely when the economics of FSLIC's exposure to zombie risk taking was expanding and becoming harder to assess". "Zombies", for Kane, are economically insolvent institutions, support by the federal deposit guarantee, whose only hope of becoming profitable is to "grow out of their problems".

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"forbearance" designed to keep insolvent banks from being subjected to insolvency proceedings.\textsuperscript{35} As seen in section 3.1, the failure to close down an insolvent institution in a timely manner is equivalent to an increase in the exercise date of the put option with a concomitant increase in the guarantor’s unfunded liability.\textsuperscript{36}

A further provision of the 1980 Act, the increase in the deposit insurance coverage from $40,000 to $100,000 per account, strengthened the ability of S&Ls to fund an expansion in the new asset categories. When combined with the introduction of money market certificates authorized by the 1982 Act, the higher insurance coverage allowed efficient S&L funding using arms-length, brokered deposits. Given the S&L asset restrictions that prevailed prior to 1980, this would not have been a particularly significant development, at least in the short run, since most S&Ls would have found it difficult to use brokered funds to increase their residential mortgage lending rapidly. It has been argued that access to deposit brokerage and the ability to issue a market rate sensitive, insured liability "leveled the playing field" between S&Ls and large banks for whom interest rate restrictions on large CDs were lifted in 1972. Since large bank depositors were protected by the "too big to fail" practices of bank regulators, those large CDs paid rates close to a default-free rate and large quantities of funds could be raised outside a large bank’s normal deposit base no matter what investment policy and capital

\textsuperscript{35}See Barth (1991) p. 133-141 for a concise history of regulatory capital requirements at savings and loan associations.

\textsuperscript{36}See Eisenbeis and Horvitz (1993) for a further discussion of forbearance and its costs.
ratio were being employed. Insured, brokered deposits gave S&Ls of any size access to similar, non-local funding sources.

Similarly, the introduction of new asset powers without the enhanced opportunity to raise large quantities of arms-length, insured deposits would have been of far less significance. Separately, neither the increased insurance coverage nor the new federal and state S&L asset powers need to have seriously increased the insolvency of the FSLIC insurance fund; together they were a lethal combination. As Table 2 shows, the combination of brokered deposits and new asset powers resulted in a rapid growth in S&L assets after 1980 (82% of that growth occurred after 1982) with almost half of the new funds having been invested in non-traditional asset classes. Furthermore, an indeterminate fraction of the new investment that is classified as mortgage lending in Table 2 was placed in mortgage loans other than the residential mortgages traditionally held by S&Ls, in non-local mortgages, and in mortgage loans with higher loan-to-value ratios, all of which increased the likelihood of less efficient, higher-risk lending by individual S&Ls.
### Table 2

**CHANGE IN ASSETS AT FSLIC-INSURED SAVINGS INSTITUTIONS 1975-1985**

<table>
<thead>
<tr>
<th>Years</th>
<th>Change in Mortgage Loans &amp; Mortgage-Backed Securities Millions of $ (% of Total Change)</th>
<th>Change in All Other Loans Millions of $ (% of Total Change)</th>
<th>Change in Total Loans Outstanding Millions of $ (% of Total Change)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-80</td>
<td>249,733 (86%)</td>
<td>40,634 (14%)</td>
<td>290,367 (100%)</td>
</tr>
<tr>
<td>1980-85</td>
<td>238,834 (53%)</td>
<td>210,552 (47%)</td>
<td>449,386 (100%)</td>
</tr>
</tbody>
</table>

Source: *Savings Institutions Source Book 89*, United States League of Savings Institutions, Chicago, 1990

The most important concern about this rapid and significant use of the new asset powers may have been more a question inefficient investing than of the inherent riskiness of the resulting portfolio of assets held by S&Ls. The idea that adding new asset classes to the set authorized for S&Ls improved the available risk-return frontier in the risk dimension has considerable merit. It is far less clear that it did so in the return dimension. The S&Ls that exploited their new powers extensively were, largely, marginal entrants into existing markets.\(^3\) Despite the reduction in costs of non-interest competition that followed the elimination of deposit interest rate ceilings, operating

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\(^3\)See Gennotte (1990) for a model of bank competition with deposit insurance in which banks with comparative advantage in lending choose safe strategies and banks with greater investment costs choose riskier strategies.

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expense as a fraction of total assets at FSLIC-insured savings institutions rose from 125 basis points in 1979 to 197 basis points in 1985. The diversification power of a class of assets was an insufficient basis for introducing that asset class into the asset mix of an institution receiving deposit guarantees. As long as the new asset investment strategies had the potential to generate sufficiently attractive positive outcomes, an insured institution, especially one with little or nothing to lose, has an incentive to undertake them even when they have a negative present value.

Another prediction of option-theoretic deposit insurance analysis is that put option contracts without dividend protection are subject to exploitation by the holder of the put. In the case of S&Ls, some this exploitation appears to have stepped over the line of legal propriety. The extent to which fraudulent practices contributed to the crisis is debated.\(^\text{38}\) However, it should emphasized that exploitation of the lack of effective "dividend" protection in the deposit insurance contract also involved actions that were not necessarily illegal. For example, owner-managers pursuing high-risk strategies had a very strong incentive to pay themselves above market salaries and owners, in general, had strong incentives to declare dividends rather than to build-up the institution's capital or loan loss reserves.

3.4. Empirical Evidence On S&L Insolvency

There have been a number of investigations of the causes of the massive S&L insolvencies, including the studies by Barth, et.al. (1985), Benston and Carhill (1992),

\(^{38}\)See Barth (1991) p. 44 and references he cites.
Pizzo, et.al. (1991), Williams, et.al. (1991). Hermalin and Wallace (1993) have carried out a very careful study in which they seek to explain an S&L's efficiency and then use those measures of efficiency and other factors as predictors of insolvency. All of these studies are generally supportive of the implications of the option-theoretic model of deposit insurance and its incentives. Because of their care with the data and their attention to econometric details in hypothesis testing, the Hermalin-Wallace study provides particularly compelling evidence cited extensively below.

Hermalin and Wallace begin by studying the efficiency of S&Ls in 1987 using a non-parametric analysis of production based on Varian (1984). They found that the lines of business (i.e. types of investments) undertaken by an S&L had significant effects on the efficiency with which that firm operated and that inefficiency led to insolvency.\(^{39}\) In particular, greater investment shares in service corporations\(^{40}\), mortgages on commercial real estate and raw land, and in their own real capital (offices, furniture, and land) were all found to be negatively related to S&L efficiency while residential mortgage lending was positively related to efficiency. In other words, S&Ls that continued to emphasize traditional lines of business operated more efficiently than those who moved more aggressively into the deregulated lines. Controlling for the lines of business pursued, their study also shows that stock ownership and the proportion of brokered deposits

\(^{39}\)The Hermalin-Wallace findings cited in this section were all significant at the 10% level or better and most were significant at the 1% level or better.

\(^{40}\)Subsidiary corporations in which the primary assets were junk bonds or equity participations in real assets.
employed were both positively related to S&L efficiency. However, the direct effect of each of these two variables (i.e. the effect without line of business controls) was strongly negative; stock firms were less efficient than mutual firms and firms which used brokered deposits heavily were less efficient than those which did not.

An implication of these results is that stock ownership (presumably through better control of owner/manager agency problems) and brokered deposits (through their relative efficiency in raising funds) were per se efficient, but more likely to be associated with the adoption of the less efficient, deregulated lines of business.

A second set of findings in the Hermalin-Wallace study addresses the determinants of the types of assets held by S&Ls. These assets may be divided into three groups: deregulated lines of business (service corporations, commercial mortgages, and non-mortgage lending), hedging instruments (futures, options, and other derivatives), and traditional investments (residential mortgages and mortgage backed securities).

They found that S&Ls that grew rapidly from 1982 to 1986 (presumably a set highly correlated with those which used brokered deposits extensively), those that were stock organizations, those with lower tangible net worth in 1982, and those located in California, Florida, or Texas\(^4\) tended to emphasize the less efficient, deregulated lines of business and to de-emphasize the use of hedging instruments (presumably risk-reducing) and investment in residential mortgages.

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\(^4\)Recall that these three states allowed the broadest use of deregulated assets by state-chartered institutions.
The third aspect of the Hermalin-Wallace study is an analysis of S&L insolvency in the period from 1987 to 1990 as a function of prevailing conditions, investment strategies, and efficiency. Insolvency in 1987-90 was found to be strongly related to S&L inefficiency as of 1986. Controlling for this inefficiency and some other prevailing conditions (e.g. total assets), they found that greater 1982 tangible net worth led to a lower likelihood of insolvency, a finding consistent with the option-theoretic prediction on the effect of solvency on the incentive to exploited the deposit insurance contract. S&Ls that emphasized residential mortgage lending and the use of hedging instruments were less likely to become insolvent and those that emphasized commercial real estate lending were more likely to fail. The coefficients for investment in service corporations and non-mortgage lending, given the institution's overall efficiency, were insignificantly different from zero suggesting that inefficiency in these investment classes was more important than their inherent risks as a determinant of which firms became insolvent. Given the firm's investment strategy and its overall efficiency, S&Ls located in the California, Florida, or Texas were more likely to fail while stock firms and those which employed more brokered deposits were, statistically, no more likely to fail than mutual firms and those which did not rely heavily on brokered funds.

In interpreting the Hermalin-Wallace results on the effects of investment strategies, stock ownership, and the use of brokered deposits on insolvency, it is important to remember that stock ownership and the use of brokered deposits significantly increased the likelihood that an S&L would engage in the deregulated lines
of business, that emphasis on those investments tended to make S&Ls less efficient, and that less efficient firms were more likely to fail.

Finally, the larger its investment in real capital (offices, furniture, etc.) the more likely an S&L failed, presumably an indication of the perverse agency incentives induced by the lack of effective "dividend" protection in the deposit insurance contract.

4. CONCLUDING REMARKS

The thesis of this essay has been that the U.S. Savings and Loan crisis of the late 1980s and early 1990s was caused and exacerbated by

1) a flaw in the structure of S&Ls that predisposed them to economic insolvency given rising interest rates,

2) the use of an incentive-incompatible deposit insurance scheme and its exploitation by S&Ls (especially permanent stock companies) that became poorly capitalized as a result of 1), and

3) legislative and regulatory actions to avoid recognizing the economic insolvency of numerous firms and the general under-capitalization of the industry, actions which in many case were dysfunctional in the context of the existing deposit insurance contract.
Evidence on the determinants of efficiency and insolvency in S&Ls are strikingly supportive of this thesis and the option-theoretic model used in its development.
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