The Optimal Capital Structure Decision of Depository
Financial Intermediaries: A Contingent Claim Analysis

Andrew H. Chen
Neil A. Doherty
Hun Y. Park

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Andrew H. Chen
Southern Methodist University

Neil A. Doherty, Professor
Department of Finance

Hun Y. Park, Assistant Professor
Department of Finance

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This paper attempts to develop the optimal capital structure of
depository financial intermediaries integrating the operating and
financial decisions. We draw together deposit insurance, reserve
requirement, liquidity services and taxation. An option pricing
framework is used to value the claims of each interest group, i.e.,
deposit holders, equity holders, the Fed, the FDIC and the tax
authority. Our results admit various capital structures, corner solu-
tions and interior optimums, depending upon the characteristics of the
firm's cash flows and upon the tax, insurance and regulatory environ-
ment in which it operates. In particular we show that the interaction
of operating and financing decision results in a much richer array of
possible structure than previously perceived.

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If there is an accepted academic view on the capital structure,

it probably echoes Myers's view that it is a puzzle.[1] Possibly some

consensus exists that taxation and other market imperfections counter-

balance in a nonlinear fashion that may result in an interior optimal

capital structure, but may equally well produce empirically embarrassing

corner solutions. Not surprisingly, the capital structure puzzle for

the depository financial intermediary is in no better shape. One view

is that the competitive banking process will result in a similar capi-

tal structure irrelevancy proposition that may exist under similar con-

ditions for any other firm (see Fama (1980)). But this leaves the

relevance of financial intermediaries unexplained. Other models

suggest high leverage based upon the gains from liquidity services

(Sealey (1983)) or an intermediate optimal leverage based upon the

effects of the Federal Deposit Insurance Corporation (FDIC) insurance

and regulation superimposed upon the usual tax and agency arguments

(Buser, Chen and Kane (1981)).

The capital structure issue is especially challenging for the case

of banks. For banks, there is no clear conceptual separation of

operating and financing decisions. Deposits might alternatively or

simultaneously be considered to be operating revenue or debt capital.

Thus, as pointed out by Sealey (1983), we cannot conveniently assume

the operating decisions have been made and then separately analyze the

financing decision.

Our purpose is to provide a somewhat broader treatment of the capital structure issue than previously undertaken. For example Fama (1980) suggests that the capital structure problem is essentially no different for financial and nonfinancial firms; the balancing of tax effects and other imperfections may well result in an interior optimum. Buser, Chen and Kane (1981) go one step further. They superimpose the effects of FDIC coverage and argue that the joint effect of premium and regulatory cost will not disturb the prospect of a non-corner solution. Sealey (1983) takes issue with both views, demonstrating that the liquidity services provided by depository institutions are not compatible with the separation of operating and financing decisions. Consequently, analysis derived for nonfinancial firms cannot be uncritically used to explain the capital structure of a financial intermediary. He shows that this liquidity effect alone is sufficient to explain nonzero leverage and may produce an interior optimum. His work, however, can be criticized of assuming the default risk away and overlooking the fact that liquidity effect is of no importance to the time deposits that account for 70 percent of the bank deposits.

Our contribution is to follow Sealey in addressing the simultaneity of operating and financing decisions. However we argue that such interdependence of operating and financing decisions also affects the tax subsidy provided by leverage and the value to the bank of FDIC coverage. Both effects turn out to be more complex than previously supposed and cannot be universally signed as previously assumed.

The various leverage effects analyzed do not act uniformly in one direction and are not necessarily linear. The result is that we are left with a rich array of possible capital structures, which leaves little difficulty in explaining why such institutions exist. On a different level, our contribution is to show that the implicit assumption behind the piecemeal approach, that leverage effects can be isolated and are additive, is incorrect. The various leverage effects we analyze are intertwined through their dependence upon operating earnings.

After setting out assumptions, we analyze capital structure in a world with reserve requirements but without taxes or FDIC insurance through Section V. In Section VI we introduce FDIC insurance under the alternative assumptions of actuarial pricing and the current flat rate pricing. In Section VII tax effects are added and a brief conclusion follows in Section VIII.

Assumptions

1. The depository institution is referred to as a bank. The bank holds only deposit debt. The asset portfolio, which we refer to as loans, is financed by deposits and by initially contributed equity. The bank is subject to a reserve requirement such that a portion of its deposits must be held in cash, or no interest "near cash."

2. The model is constructed in a single period with financing and operating decisions made at the beginning of the period and operating flows accruing at the end of the period.

3. The bank is assumed to maximize its value. This objective can be supported under somewhat weaker assumptions than complete markets (see DeAngelo (1981)).

4. Claims on the bank will be valued as options. Since our purpose is to make fairly general propositions about capital structure we do not need to use a specific valuation model. However, to sign various derivatives of the option value function we need to assume that options are rationally priced in the sense of Merton (1973).

I. RESERVE REQUIREMENTS

As noted in the introduction, depository financial intermediaries are distinct from nonfinancial firms in the sense that the financial decision of the former requires a simultaneous integration with the operating decision. In order to compare the capital structure decision of depository intermediaries with the Modigliani-Miller Theorem I, we assume first that the capital market is perfect, without deposit insurance (which is unique to the depository intermediary) and taxes.

Consider a bank which finances its loan portfolio and reserve requirements with bank deposits and equity capital. The bank deposit is the only form of debt for the bank. In the U.S. banking system, a bank is subject to a reserve requirement imposed by the Federal Reserve Bank (Fed), so that some of the bank assets must be held in a non-interest bearing cash or near cash (i.e., cash in the bank vault or the deposits with the Fed). It should be noted that major parts of the bank loans are usually in the form of demand deposits in the transactions accounts. Therefore, reserve requirements are assessed both in

relation to time and demand deposits. Bank reserves are used to meet deposit-withdrawals occurring randomly throughout the period. Thus, every bank is faced with a random reserve loss over the period, and is required to pay any penalty costs resulting from a reserve deficiency. In our single-period model, a bank must pay the incurred penalty costs of reserve deficiency before any of its assets can be liquidated and distributed to the depositors and shareholders of the bank at the end of the period.

Let K be the required reserve of the bank, which is determined by the amount of the bank's time deposits and demand deposits created by making bank loans. The current reserve requirements are set at 12 percent of the demand deposits and 3 percent of the time deposits. However, the reserve requirements are in part influenced by bank decisions regarding the leverage and the loan policies. Let R and R_T be the bank reserves held at the beginning and at the end of the period, respectively. At the end of the period, the reserve deficiency penalty cost (RP_T) charged by the Fed can be expressed as follows:

$$RP_T = \max[\theta(K-R_T),0] \tag{1}$$

where θ = the proportional penalty costs of reserve deficiency.[2]

It can be seen from Eq. (1) that, in the presence of reserve requirements in the banking system, the Fed owns a claim equal to θ times a put option against the bank. The put option has an exercise price equal to the reserve requirement, K, and the underlying asset is the reserve held by the bank. Using option pricing, the current

value of the put held by the Fed can be expressed as $P(R,K,\sigma_R^2)$, where σ_R^2 is the variance of the rate of changes in bank reserve.

II. VALUATION OF DEPOSITS

The following additional notation will be utilized in our formal model of the valuation of a banking firm with reserve requirements:

A_T = the gross market value of bank assets at the end of the period;

A_T^* = the net market value of bank assets (i.e., net of the reserve deficiency penalty costs (RP_T)) at the end of the period. That is

$$A_T^* = A_T - \max[\theta(K-R_T),0];$$

B_T = the total promised payments to the bank depositors at the end of the period.

At the end of the period, the bank depositors receive the total promised payments if the net market value of bank assets is greater than or equal to the total promised payments; otherwise they receive the net market value of bank assets. Thus, the value of bank deposits at the end of the period in the presence of reserve requirements can be expressed as follows:

$$D_T = \min[A_T^*, B_T]$$

$$= \min\{A_T - \max[\theta(K-R_T),0], B_T\}. \tag{2}$$

Eq. (2) indicates that the claim of the bank depositors in the presence of reserve requirements is a complex option. It has captured both the reserve requirement and the default risk, the special features in banking operations. The value of a complex option can be determined using the option pricing technique.[3] We define an asset H which pays nothing until the end of the period and pays $A_T - \max[\theta(K-R_T),0]$ at time T. Let $H(A,R,K)$ be the current value of asset H, where A is the current value of bank assets, R and K are the current bank reserve and the reserve requirement, respectively. As defined earlier, $P(R,K)$ is the current value of a European put option on bank reserve, R, which has an exercise price equal to K. Thus,

$$H(A,R,K) = A - \theta P(R,K) \qquad (3)$$

where $P(R,K)$ = put option with relevant parameters in parenthesis.

In other words, the current value of asset H is equal to the current value of bank assets minus θ times a put option on bank reserve with an exercise price equal to the reserve requirement of the bank. With these results, we can express the end-of-period value of bank deposits as a function of the value of asset H_T:

$$D_T = \min[H_T, B_T].$$

Therefore, the current value of bank deposits can be expressed as follows:

$$D = B - P(H, B_T), \qquad (4)$$

where

> D = the current value of bank deposits in the presence of reserve requirements;
>
> B = the present value of the total promised payments, discounted at the riskfree rate of interest, r, that is, $B = B_T e^{-rT}$.

Thus, in the presence of reserve requirements, the current value of bank deposits is equal to the present value of the total promised payments, minus a complex put option, $P(H, B_T)$. Intuition suggests that the presence of Fed's put option reduces the market value of bank assets. The contingent claim analysis affirms and formalizes this intuition. Therefore, Federal reserve requirements reduce the current value of bank deposits.[4]

Based upon Eq. (4) we can show some interesting properties of the value of bank deposits in the presence of reserve requirement as follows:

$$\frac{\partial D}{\partial A} = -P_H \frac{\partial H}{\partial A} > 0 \tag{5a}$$

$$\frac{\partial D}{\partial R} = -P_H \frac{\partial H}{\partial R} > 0 \tag{5b}[5]$$

$$\frac{\partial D}{\partial B_T} = e^{-rT} - \frac{\partial P}{\partial B_T} > 0 \tag{5c}$$

$$\frac{\partial D}{\partial K} = -P_H \frac{\partial H}{\partial K} < 0 \tag{5d}$$

$$\frac{\partial D}{\partial \sigma^2} = -\frac{\partial P}{\partial \sigma^2} < 0 \qquad\qquad (5e)$$

$$\frac{\partial D}{\partial \sigma_R^2} = -P_H \frac{\partial H}{\partial \sigma_R^2} < 0 \qquad\qquad (5f)$$

where $P_H = \dfrac{\partial P(H, B_T)}{\partial H}$ and σ^2 is the variance of the rate of return on bank assets.

The above results indicate that the value of the bank deposits increases if the value of the bank assets or the value of the bank re-serve increases. The value of the bank deposits also increases if the promised payments increase, but it decreases if the required bank reserve increases. Intuitively, the put option in (4) can be inter-preted as the actuarial risk premium in equilibrium, which is a posi-tive function of the reserve requirement but a negative function of the current bank reserve. This will be further discussed in section VI. Finally, the value of the bank deposits decreases if the risk of bank assets or the risk of reserve loss increases.

III. RISK PREMIUMS ON DEPOSITS

Before we examine further the properties of the market value of bank deposits given in Eq. (4), it is useful to derive the value of bank deposits and the risk premium on bank deposits in the simpler case of no reserve requirement using the Black-Scholes option pricing formula. It can be seen that if there were no reserve requirement, the reserve deficiency penalty costs, $\max[\theta(K-R_T), 0]$, would vanish and the current value of bank deposits could be expressed as

$$D_0 = B - P(A, B_T), \tag{6}$$

where D_0 = the current value of bank deposits in the absence of reserve requirement.

Comparing Eqs. (6) and (4), $D_0 > D$, since $P(A,B_T) < P(H,B_T)$. Using the well-known Black-Scholes option pricing formula, D_0 can be expressed explicitly:

$$D_0 = AN(-d_1) + BN(d_2) \tag{7}$$

where,

$$d_1 \equiv \frac{\ln(A/B_T) + (r + \frac{1}{2}\sigma^2)T}{\sigma\sqrt{T}} \ ;$$

$$d_2 \equiv d_1 - \sigma\sqrt{T};$$

$\sigma^2 \equiv$ the variance of the rate of the return on bank assets; and

$N(\cdot) \equiv$ the cumulative standard normal distribution.

We also can show the relationship between the value of a risky bank deposit as given in Eq. (7) and the value of a riskfree bank deposit (i.e., fully insured deposit). We define $L = B/A$ as the leverage factor and rewrite Eq. (7) as

$$D_0 = B[L^{-1}N(-d_1) + N(d_2)] \tag{8}$$

Or simply,

$$D_0 = B \cdot G, \tag{8'}$$

.

where $G = [L^{-1}N(-d_1) + N(d_2)]$, is a price discount factor which re-flects the risk of default of the bank deposits, and $0 \le G \le 1$.

From Eq. (8') the price discount factor, G, is a function of the bank's leverage factor, the risk of bank assets, and the time to maturity as indicated below:

$$G = G(\overline{L}, \overline{\sigma}^2, \overline{T}) \tag{9}$$

Following Merton (1974), the yield on bank deposit is derived in the absence of reserve requirement. Let y be the yield on the bank deposits as defined in the equation, $D_0 = B_T e^{-yT}$, then,

$$y = \frac{\ln[B_T/D_0]}{T}$$

$$= \frac{\ln[B_T/B \cdot G]}{T} \qquad \text{(from Eq. (8'))}$$

$$= r + \frac{-\ln[G]}{T} . \qquad \text{(using } r = \frac{\ln[B_T/B]}{T}\text{)} \tag{10}$$

Eq. (10) indicates that the excess yield on bank deposits, $y' = y - r$, is a function of the bank's leverage factor, the risk of bank assets, and the time to maturity as follows:

$$y' = y'(\overset{+}{L}, \overset{+}{\sigma^2}, \overset{+}{T}). \tag{11}$$

It should be noted that, in the presence of reserve requirement, the excess yield on bank deposits should be larger than that indi-cated in Eq. (11). On the other hand, if banks provide liquidity ser-vice to the depositors in terms of lower costs of meeting transactions demand for money, the excess yield should be smaller than that given in

Eq. (11). The yield should include both the risk premium (larger if the risk of default is higher) and the liquidity premium (smaller if bank deposits provide greater liquidity service).

Therefore, even if the liquidity premiums are approximately the same among firms in the banking industry (because of a perfect competition in liquidity services), it does not follow that the risk premiums of different banks will be the same. Thus, the yield cannot be expected to be the same among a large number of different banks. One can raise serious questions about the validity of Sealey's (1983) conclusion on optimal capital structure for a banking firm based upon the assertion that the risk premium on bank deposit is uniform across all firms in the banking industry.

Thus, it is clear that a bank's leverage policy, investment policy and required reserve management policy jointly determine the yield on the bank's deposits.

IV. VALUATION OF EQUITY CLAIMS

The preceding contingent claims analysis can be employed to derive the current value of bank equity in the presence of reserve requirements. The residual claim of shareholders of the bank at the end of the period can be expressed as

$$S_T = \max[A_T^* - B_T, 0].$$ (12)

Therefore, the current value of the bank equity is given as follows:

$$S = C(H, B_T)$$

$$= C(A - \theta P(R,K), B_T), \tag{13}$$

where $C(\ )$ = the call option with relevant parameters in the parenthesis.

Eq. (13) indicates that the equity of a bank in the presence of reserve requirement is equal to a complex call option to purchase asset H from the bank depositors with an exercise price equal to B_T, the total promised payments to bank depositors. The effect of reserve requirements is represented as the issue of a put option on bank reserve to the Fed, which reduces the current value of the bank equity.

V. OPTIMAL CAPITAL STRUCTURE WITH RESERVE REQUIREMENTS

For analytic convenience, to examine the impact of a leverage change on the total value of a banking firm in the presence of reserve requirement, we can express the boundary conditions of two alternative end-of-period bank states with two possible sub-states for each:

Alternative States	Conditions
I. Bank Solvent	$A_T^* \geq B_T$
A. Sufficient Reserve	$K \leq R_T$
B. Insufficient Reserve	$K > R_T$
II. Bank Insolvent	$A_T^* < B_T$
A. Sufficient Reserve	$K \leq R_T$
B. Insufficient Reserve	$K > R_T$

For each of these possible states, the claims of depositors, stockholders, and the Fed at the end of the period may be listed as follows:

States	Depositors	Stockholders	Fed	Sum of Depositors and Stockholders
IA	B_T	$A_T - B_T$	0	A_T
IB	B_T	$A_T - \theta(K-R_T) - B_T$	$\theta(K-R_T)$	$A_T - \theta(K-R_T)$
IIA	A_T	0	0	A_T
IIB	$A_T - \theta(K-R_T)$	0	$\theta(K-R_T)$	$A_T - \theta(K-R_T)$

In the presence of reserve requirements the sum of the depositors' and the stockholders' claims is A_T in states IA and IIA, and is $A_T - \theta(K-R_T)$ in states IB and IIB. In the absence of reserve requirements, the sum of the depositors' and the stockholders' claims will be A_T in all states. Thus, the value of a bank is affected negatively by the reserve requirement.

The total current value of a bank in the absence of reserve requirement is A, while the total current value of the bank in the presence of reserve requirement is $D + S = A - \theta P(R,K)$. In the presence of reserve requirements the value of a bank is

$$V_{LR} = V_U - \theta P(R,K) \qquad (14)$$

where V_{LR} = the value of a levered bank in the presence of

reserve requirements;

V_U = the value of an unlevered bank in the absence of
market imperfections such as reserve requirement,
deposit insurance and taxes. This bank will be
termed a "pure bank."

Therefore, if we ignore the possible effect of reserve requirement
on reducing the agency costs of a bank, there will be a negative joint
effect of the leverage and the reserve requirement on the value of a
bank, since $\frac{\partial P}{\partial B_T} = \frac{\partial P}{\partial K} \cdot \frac{\partial K}{\partial B_T} > 0$. The implication is that all banks
should have the zero-deposit corner solution to the capital structure
decision. Of course, this result is contrary to the empirical obser-
vations in the banking industry. However, there are several plausible
explanations of why banks hold deposits. These explanations include
the popular tax-incentive arguments, the liquidity-service argument of
Sealey (1983), the most recent agency-cost-reduction argument of Fama
(1985), and the benefit of deposit insurance under the current banking
system. In the next section, we attempt to analyze the joint effects
of reserve requirement and deposit insurance on the value of a bank and
to provide an explanation of the presence of bank deposits in the capi-
tal structure.

VI. OPTIMAL CAPITAL STRUCTURE WITH RESERVE REQUIREMENT AND FDIC INSURANCE BUT WITHOUT TAXES

We assume that the FDIC provides full insurance protection to depo-
sit holders, i.e., that all accounts do not exceed $100,000 which is the
current limit of protection per depositor. This implies that deposits
are riskless from the viewpoint of the depositors. As shown in the pre-
vious section, in the presence of reserve requirement, the claim of the

depositors at the end of the period is B_T if the bank is solvent and is $A_T^* = A_T - \max[\theta(K-R_T),0]$ if the bank is insolvent. With full insurance protection from the FDIC, the claim of the depositors is B_T in all possible bank states. Thus, in the presence of both the reserve requirement and the deposit insurance the claims of depositors, stockholders, the Fed, and the FDIC at the end of the period may be listed as follows:

States	Depositors	Stockholders	Fed	FDIC	Sum of Depositors and Stockholders
IA	B_T	$A_T - B_T$	0	0	A_T
IB	B_T	$A_T-\theta(K-R_T)-B_T$	$\theta(K-R_T)$	0	$A_T-\theta(K-R_T)$
IIA	B_T	0	0	$A_T - B_T$	B_T
IIB	B_T	0	$\theta(K-R_T)$	$A_T-\theta(K-R_T)-B_T$	B_T

It is clear from the above table that the presence of deposit insurance results in further changes in the value of depositors' and stockholders' claims. The sum of depositors' and stockholders' claims with and without reserve requirements (RR) and deposit insurance (DI) is now summarized.

	Sum of Depositors' and Stockholders' Claims		
States	Without RR and DI	With RR Only	With RR and DI
IA	A_T	A_T	A_T
IB	A_T	$A_T-\theta(K-R_T)$	$A_T-\theta(K-R_T)$
IIA	A_T	A_T	B_T
IIB	A_T	$A_T-\theta(K-R_T)$	B_T

Therefore, in the presence of both the reserve requirement and the deposit insurance, leverage affects the total value of a bank through its effects on the cost of reserve requirement and the benefit of deposit insurance under the current banking system. Before we analyze these effects in detail, we shall first examine the fair value of deposit insurance.

From Eq. (4) we know that the deposit insurance in the presence of reserve requirement is simply a complex put option with an exercise price equal to B_T. Thus, the fair value of the deposit insurance (I) must be equal to the current value of this complex put option. That is

$$I = P(A-\theta P(R,K), B_T). \tag{15}$$

The following properties of the deposit insurance can be easily obtained:

$$\frac{\partial I}{\partial A} < 0; \qquad \frac{\partial I}{\partial B_T} > 0; \qquad \frac{\partial I}{\partial R} < 0;$$

$$\frac{\partial I}{\partial K} > 0; \qquad \frac{\partial I}{\partial \sigma^2} > 0; \quad \text{and} \quad \frac{\partial I}{\partial \sigma_R^2} > 0. \tag{16}$$

The contingent claims analyses have helped us identify the cost of reserve requirement as a put option given to the Fed and the benefit of deposit insurance as a put option acquired from the FDIC. Therefore, the total value of a levered bank in the presence of reserve requirement and deposit insurance (V_{LRI}) can be expressed as:

$$V_{LRI} = V_U + \Delta V(R) + \Delta V(I), \tag{17}$$

where $\quad \Delta V(R) = -\theta P(R,K)$

$\qquad\qquad\qquad$ = the change in total value of a bank due to reserve

$\qquad\qquad\qquad$ requirement;

$\qquad\quad \Delta V(I) = P(H,B_T)$ - Insurance Premium

$\qquad\qquad\qquad$ = the change in total value of a bank due to deposit

$\qquad\qquad\qquad$ insurance.

Eq. (17) indicates that the total value of a levered bank is equal
to the sum of the value of the pure bank, the change in value due to
reserve requirement, and the change in the value due to deposit in-
surance. Leverage affects the value of the bank through its influences
on reserve requirement and deposit insurance. To address these effects,
we must first clarify the insurance structure and financing of the
insurance premium. In our single-period model, we assume that the pre-
mium is paid at the beginning of the period.

In a contingent claim framework, the actuarial value of insurance
is the equilibrium value of a complex put option as shown in Eq. (15).
However, the FDIC currently charges a flat rate premium b on deposits.[6]
Since the flat rate does not discriminate between banks according to
their default risk (other than on the basis of size), it effectively
subsidizes high risk banks at the expense of low risk banks (see
Campbell and Glenn (1984)). These subsidies would be removed if each
bank faced an insurance premium equal to the actuarial value of the
loss payment. Therefore, in order to separate the effects of the
transfer of risk under the insurance arrangement from the effects of
the specific pricing structure adopted by the FDIC, we compare two
alternative premium structures.

A. Optimal Capital Structure with an Actuarially
Fair FDIC Premium

If the FDIC adopted a fair risk-adjusted pricing of insurance,
then the premium for deposit insurance should be set equal to the
current value of the insurance put as given in Eq. (15). With such a
fair price, $\Delta V(I)$ will be zero and the value of the bank will be

$$V_{LRI} = V_U - \theta P(R,K), \tag{18}$$

which is identical to (14); the FDIC insurance has a neutral effect
on the total value of the bank. This result is not surprising. The
gain from the insurance accruing collectively to equity holders and
deposit holders is zero. Certainly the insurance brings benefits to
the deposit holders since the current value of their deposits is
increased. In equilibrium, the value of this benefit is the value of
the put option as discussed earlier. However, the insurance is priced
at its actuarial value so that equity holders must pay a premium which
also is equal to the value of the insurance put. In total, the FDIC
insurance has a neutral effect on the combined value of deposits and
equity. However, it is important to note that this does not imply
that the deposit holders are net gainers and the equity holders are
net losers from the insurance provision. The deposit interest rate
will reflect the presence or absence of insurance. In summary,
insurance per se does not necessarily affect the optimal capital struc-
ture. If insurance is actuarially priced, the cum-insurance value of
the bank coincides with its uninsured value at every level of leverage.
This point also has been made by Merton (1977), Sharpe (1978) and
Buser, Chen and Kane (1981).

B. Optimal Capital Structure with FDIC Flat Rate Premium

If the FDIC charges a flat rate b on deposits, the premium is bB = bLA and the change in total value of a bank due to deposit insurance will be

$$\Delta V(I) = P(H, B_T) - bLA \qquad (19)$$

The total value of a levered bank is

$$V_{LRI} = [V_U - \theta P(R, K)] + [P(H, B_T) - bLA]. \qquad (20)$$

Note that the first square bracket is the same as both the "no insurance" and the "fair insurance" case. The second part represents the value added by the insurance contract, i.e., the difference between the put option and the insurance premium.

Before examining the effect of insurance on the capital structure, it is worthwhile to note that (20) suggests adverse selection problems as those encountered in private insurance markets in which differences in loss expectancy are not reflected in premium rates (see Rothschild and Stiglitz (1976)). If the flat premium is of sufficient value to cover the average default costs of all banks in the market, the second square bracket in (20) will be positive for higher than average risk banks and negative for lower than average risk banks. This implies that the incentive to join the FDIC is higher for higher than average risk banks and this factor in particular helps explain the other regulatory activities of the FDIC such as entry regulation, inspection of bank records and supervision of managerial activity, etc.[7]

The effects of changes in leverage on the value of the bank can be examined by taking the partial derivative of V_{LRI} in (20) with respect to L as follows:

$$\frac{\partial V_{LRI}}{\partial L} = -\theta \frac{\partial P(R,K)}{\partial L} + \frac{\partial P(H,B_T)}{\partial L} - bA \qquad (21)$$

It can be seen from (21) that the leverage affects the value negatively through reserve requirement and positively through deposit insurance. The combination of the two effects in the opposite direction yields various possible optimal capital structure depending on which effect dominates over what range of L. Therefore, it can be shown that the financial structure is relevant to the value of the banking firm and an interior optimal capital structure can be reached even without the consideration of tax subsidy and bankruptcy costs. This result is due to the interaction between the financing decision and the operating decision which is caused by the reserve requirement. Note that the reserve requirement affects the Fed's put option through the exercise price, and the FDIC insurance put option through the underlying asset.

VII. OPTIMAL CAPITAL STRUCTURE WITH TAXES IN THE PRESENCE
OF RESERVE REQUIREMENT AND DEPOSIT INSURANCE

In the corporate finance theory taxes have been a dominant factor for explaining an increase in leverage ever since the Modigliani-Miller theorem. In this section the effects of corporate taxes on the value of the bank in the presence of reserve requirement and deposit insurance are analyzed using the contingent claims analysis. Some simplifying assumptions are made in our single-period model. τ is the

corporate tax rate which, for convenience, is assumed to apply to the
end-of-period net worth. To maintain the analogy with the deductibility
of interest payments under the U.S. income tax code, the bank's entire
debt is assumed to be deductible from the tax base. Furthermore, both
the reserve deficiency penalty costs and the insurance premium are tax
deductible. With these assumptions, the claims of depositors, the
stockholders, the Fed, the FDIC and the tax-man at the end of the period
may be listed as follows:

States	Depositors	Stockholders	Fed	FDIC	Tax-man
IA	B_T	$(1-\tau)(A_T-B_T-bB)$	0	bB	$\tau(A_T-B_T-bB)$
IB	B_T	$(1-\tau)(A_T-\theta(K-R_T)-B_T-bB)$	$\theta(K-R_T)$	bB	$\tau(A_T-\theta(K-R_T)-B_T$·
IIA	B_T	0	0	A_T-B_T	0
IIB	B_T	0	$\theta(K-R_T)$	$A_T-B_T-\theta(K-R_T)$	0

Therefore, in the presence of corporate income taxes, the value of
a levered bank with reserve requirements and deposit insurance is dif-
ferent from that without them. This is apparent from comparing the sums
of the depositors' and the stockholders' claims in the two different
cases given below:

	Sum of Depositors' and Stockholders' Claims	
States	Without RR and DI	With RR and DI
IA	$(1-\tau)A_T + \tau B_T$	$(1-\tau)A_T + \tau B_T - (1-\tau)bB$
IB	$(1-\tau)A_T + \tau B_T$	$(1-\tau)A_T + \tau B_T - (1-\tau)bB - (1-\tau)\theta(K-R_T)$
IIA	$(1-\tau)A_T$	B_T
IIB	$(1-\tau)A_T$	B_T

If the tax system is asymmetric such that the tax authority takes a proportion (τ) of taxable income when they are positive but makes no refund when they are negative, the tax authority has a claim which is equivalent to a call option on τ times the firm's taxable income with zero exercise price (or τ times a call option on the total income with exercise price equal to the tax deductions) (see Pitts & Franks (1984), Smith and Stultz (1984), and Galai (1983)). Thus, in the presence of reserve requirement and deposit insurance, the current value of the tax authority's claim (τ) can be expressed as follows:

$$T = \tau C(A, TD), \tag{22}$$

where   TD = the total tax deductions

$$= \max[\theta(K-R_T), 0] + B_T + bB$$

Therefore, in the presence of reserve requirement and deposit insurance, the tax authority's claim is a complex call option as shown in (22). The exercise price of this call option is equal to the sum of the tax deductions that includes the reserve deficiency penalty costs, the interest payments and the deposit insurance premium.

The total value of a levered bank in the presence of reserve requirement, deposit insurance, and taxes (V_{LRIT}) can be expressed as

$$V_{LRIT} = V_U + \Delta V(R) + \Delta V(I) + \Delta V(T) \tag{23}$$

where $\Delta V(T)$ = the change in total value of a bank due to the tax
deductions interest payments, reserve deficiency
penalty costs and deposit insurance premium.

It can be seen that $\partial \Delta V(T)/\partial L$ is positive because $\partial T/\partial L$ is negative.

It is clear now that the optimal capital structure of depository intermediaries is influenced by not only the reserve requirement, but also the insurance put option and government tax call option whose value is influenced in turn by the insurance and the reserve requirement which affect the exercise price. Note again that the Modigliani-Miller theorem with taxes (e.g., 100 percent leverage) would hold only in a special case, i.e., in the absence of reserve requirement and financial transaction cost, and where insurance is fairly priced.[8]

Consistent with the literature for nonfinancial firms, leverage reduces the value of the government's corporate income tax claim on the bank. But here, the tax subsidy includes some additional effects that are peculiar to the financial intermediary. In examining the effects of leverage on the value of the insurance put, we saw that the reserve requirement created interdependence between operating and financing decisions. A similar effect emerges in valuing the tax call option. Through its effect on the expected value and variance of operating earnings, the reserve requirement reduces the effect of leverage on the value of the tax option.

It is also notable that (23) indicates that the risk affects the value of the bank in three ways, through the reserve requirement put, through the insurance put and through the tax call, which has important implications for the risk management of depository financial intermediaries.

VIII. CONCLUSION

The optimal capital structure issue can be described at best as a puzzle in the corporate finance theory. This issue is especially challenging for the case of depository financial intermediaries since there is no clear conceptual separation of operating and financial decisions. Deposits might be considered to be operating revenue or debt capital alternatively. This paper has attempted to develop the optimal capital structure of depository intermediaries integrating the operating and financial decisions. An option pricing framework was used to value the claims of each interest group, i.e., deposit holders, equity holders, the Fed, the tax authority and the FDIC.

First, this paper demonstrates an array of possible capital structures including corner solutions and interior optima even without taxes and other market frictions. This result was due to the reserve requirement and the deposit insurance which are unique to depository financial institutions. We also showed that the optimal capital structure would not change even in the presence of the FDIC insurance if it were priced at its actuarially fair value. However, the current FDIC flat rate premium can provide either positive or negative effects on the leverage decision. Finally, the addition of taxes provides only positive effects on the leverage decision.

In particular, this paper has demonstrated that the well-known Modigliani-Miller theorems without taxes and with taxes would hold for depository intermediaries only in a special case where the reserve requirement is not imposed, the financial transactions of investors are cost-free and the FDIC charges actuarially fair premiums. All of

the positive and negative effects of various factors relevant to the capital structure decision in this paper are due to the fact that the financial and operating decisions are not separate from each other in depository financial institutions. The question of which effect dominates over what range of leverage remains to be answered.

Footnotes

[1] See Myers (1984) for the capital structure puzzle and its complete list of literature.

[2] In case of reserve deficiency, the bank is required either to purchase the Federal Fund or to liquidate some of its assets in order to meet the reserve requirement. The penalty costs include the opportunity costs involved in purchasing the Federal Fund and liquidating the assets as well as the direct penalty.

[3] See Stulz (1982), Chen (1983), and Stulz and Johnson (1985) for the applications of option pricing technique to price various complex options.

[4] For simplicity, we ignored the possible effect of reserve requirement on reducing the agency costs of a bank.

[5] This result is based upon the assumption that an increase in the portion of R in the asset side of the bank balance sheet, for the given level of total capitalization, will not increase the risk of bank assets. Had this not been the case, the direction of the result would be reversed.

[6] The flat rate is currently one-twelfth of one percent. The F.D.I.C. may call for subsequent adjustment in the light of collective loss experience. We will ignore this feature for simplicity.

[7] See Campbell and Glenn (1984) for more details in the adverse selection problem and Buser, Chen and Kane (1981) for a slightly different view of the FDIC's other regulatory activities.

[8] If all financial transaction costs are ignored, the bank has no comparative advantage in providing liquidity services since they can be created at no cost by the depositors direct transactions.

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