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A Theoretical Study on The Bank Capital Structure and Asset Risk Decisions

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I. INTRODUCTION

M-M proposition 1--that the market value of the firm is independent of its capital structure--is based on the assumption that capital markets are frictionless and perfect. For a bank, the irrelevance proposition may not be valid even without corporate taxes since a bank is subject to regulatory constraints. Further, the nature of debt(deposits) of the bank is special in that the debt provides depositors with liquidity services and the debt is serviced at considerable expense of real resources(e.g., processing costs for demand deposits). This makes the capital structure decision of the bank unique.

Several recent studies (Buser, Chen, & Kane, 1980 : Orgler & Taggart, 1983 : Sealey, 1983) apply capital structure theory from corporate finance in order to explain the capital structure decision of banks, taking into consideration the special aspects of banks mentioned above. These studies provide explanations about how capital structure decisions are made, as well as about the cross-sectional and time-series differences of the capital structure of banks.

The present study develops a theoretical model which extends the current capital structure theory of the bank in such a way as to relate the capital structure decision with the asset risk decision(how much asset risk to take). These decisions interact due to the attempt of the bank to maximize the wealth transfer from the FDIC and regulations to constrain the effort.

Previous studies examining the relationship between the capital structure of the bank and its determinants including risk (Mayne, 1972;Dince & Forston, 1980;Marcus, 1983) specify the regres-

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sion model in the context of a single equation model. One implication of the model in this study is that capital structure and asset risk decisions are interdependent and inversely related.

Bank capital has been regulated to improve the banking system's stability by reducing the risk of individual bank failures : regulators argue that increased bank capital reduces the risk of bank failures. However, several theoretical studies(Kahane, 1977 : Koehn & Santomero, 1980 : O'Hara, 1983;Lam & Chen, 1985) show in various frameworks that the regulatory increase of capital ratio, intended to make banks safer, would paradoxically increase the risk exposure of the bank.

Another implication of the model in the present study relates to the effects of the regulatory increase of capital ratios on the asset risk of the bank. The present study explores this theoretically in a different analytical framework, whereby the bank is assumed to maximize the wealth transfer from the FDIC subject to the regulatory constraints.

The objectives of this study are (1) to develp a model which describes the capital structure decision of the bank in relationship with its asset risk decision : and (2) to analyze the effects of the regulatory increase of capital ratios on the asset risk of the bank.

II. THE MODEL

2.1 Assumptions

(1) All debts are assumed to be risk-free. In the real world, the FDIC insures deposits of $ 100,000 or less. For the purposes of this study, larger deposits and debentures are also assumed to be insured for simplicity.

(2) Miller's tax world is assumed, where the tax advantage of the interest deductibility of debt at the corporate level is offset at the investor's level;thus, no tax advantage is associated with debt. [1]

(3) The objective of the bank is assumed to be the maximization of the value of equity.

(4) The bank is assumed to attempt to maximize the value of federal deposit insurance for the bank, that is, to maximize the wealth tranfer from the FDIC to itself by increasing the debt - asset ratio and/or by increasing the asset risk.

(5) Regulatory agencies are assumed to impose regulations on the bank in order to constrain the expropriation of wealth from the FDIC by the bank and to protect the banking system's stability, which may be jeopardized by the failure of banks. That is, more stringent regulatory interference

1. Tax shield substitutes, such as the depreciation deduction and investment tax credit, which contribute to the existence of the optimal capital structure in the framework of DeAngelo-Masulis, are assumed to be of little significance for the bank since the bank carries a small amount of fixed assets. Through mergers, the tax losses of merged banks can be utilized by merging firms.

is imposed as the debt-asset ratio and/or asset risk increase[2] the level of the total risk of the bank, assumed to consist of the debt-asset ratio and asset risk, is also constrained.[3]

2.2 Development of the Model

Federal deposit insurance, which as created after the collapse of the banking system of 1930, has virtually eliminated panics by assuring insured depositors of the safety of their deposits. The failure of a few banks no longer has touched off runs on well-managed banks as long as the wealth of depositors was completely protected.

However, at the same time, the current fixed-rate deposit insurance system has given insured banks an incentive to undertake more risk than they otherwise would. Generally, private insurers charge a premium that varies with the perceived risk of the activity being underwritten (e. g., automobile insurance). A higher insurance premium is required for greater perceived risk. On the other hand, the FDIC requires a fixed premium set at a certain proportion of total deposit balances, regardless of the perceived risk of each bank. The risk of the bank is thus not proportionately related to the premium.

Flannery (1982) explains succinctly this moral hazard problem as follows :

> so long as people retain faith in the FDIC's ability to make payments, the bank's borrowing (deposits) costs are the same no matter how risky its asset portfolio. One natural check on bank risk taking has thus been eliminated. Since riskier assets offer higher expected returns and since deposit costs don't vary with the bank's perceived risk, the bank maximizes expected profits by purchasing the riskiest available asset…… [B] anks have a clear incentive to become more risky when the FDIC begins promising to absorb their default losses.

That is, insuring the deposits of the bank causes the bank to take as much risk as possible unless bank regulations counteract this distortive effect of fixed-premium deposit insurance.

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2. See Buser, Chen, and Kane(1980)
3. Despite the changes of the standards for capital adequacy over the years, the principle of examinations remains such that the debt-asset ratio and asset risk of the bank are regulated in relation with each other. That is, the regulator's determination of bank capital adequacy is based on the reported book capital adjusted for the regulator's estimate of likely loan and security losses(see Flannery, 1982).

   Although the evidence that bank regulations reduce the incidence of bank failure is weak, the relatively small losses sustained by the FDIC in nearly all bank failures indicate that regulations are successful in detecting problem banks and taking the necessary procedures (for more detail, see Horvitz, 1980).

Merton (1977) shows analytically that federal deposit insurance is equivalent to a put option on the assets of the bank which gives the bank the right to sell its assets for the face value of its debt (deposit) if it becomes insolvent.[4] The author derives a valuation formula for the value of deposit insurance in terms of the bank's debt asset ratio and asset risk. One important implication of Merton's model is that the value of the bank increases even in a world without taxes since wealth is transferred from the FDIC as the bank uses more debt and invests in more risky assets.[5]

Regulatory agencies, including the FDIC, constrain the effort of banks to maximize wealth transfers from the FDIC with regulations. As the bank increases its debt-asset ratio and/or asset risk, the regulatory agencies perceive the total risk of the bank to increase and impose regulatory interference costs accordingly : The bank bears the implicit cost of being subjected to frequent surveillance ; the bank is asked to strengthen its asset and impose regulatory interference costs accordingly : the bank bears the implicit cost of being subjected to frequent surveillance ; the bank is asked to strengthen its asset and liability protfolios or to raise new capital and restrict dividend payments ; when the bank becomes insolvent due to excessive risk-taking, the regulatory agencies take over the bank and it loses charter value and, possibly, the benefit of deposit insurance.[6] Furthermore, regulatory agencies are responsible for maintaining a safe and sound commercial banking system and implicitly protecting the insurance fund of the FDIC. They therefore constrain the level of debt-asset ratio and asset risk as if total risk, consisting of the debt-asset ratio and asset risk,

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4. The FDIC's guarantee of the debt of the bank may be viewed as three options, including a put option written by the FDIC : (1) the FDIC has a call option written by the equityholders of the bank which allows the FDIC to purchase the equity for zero at their discretion if the insolvency of the bank is judged to be imminent ; (2) the equityholders of the bank have a call option written by the FDIC which allows them to buy back the bank for zero after the debt is paid off. These two options do not wash out since they have different expiration dates ; (3) the depositors of the bank have a put option to the FDIC which gives them the right to sell their ddeposits for the face value. This view recognizes that the FDIC can take over the bank before its net worth becomes zero.
5. Since the wealth of debtholders is protected by federal deposit insurance, debtholders have no incentive to protect ther wealth from being expropriated. Thus, the risk-taken activity of equityholders to transfer the wealth of debtholders results in the expropriation of the wealth of the FDIC.
6. If the premium of deposit insurance is priced below the value of deposit insurance, insured banks are subsidized. However, the empirical evidence concerning whether the premium is under or over-priced is mixed(see Scott & Mayer, 1971 ; Gibson, 1973 ; Buser, Chen, & Kane, 1980 ; and Marcus & Shaked, 1984).

should not exceed a certain level.

Thus, these regulatory constraints act such that the value of federal deposit insurance for the bank, or equivalently the amount of wealth transfer from the FDIC, is offset by regulatory costs.

2.2.1 Interdependence of Capital Structure and Asset Risk Decisions

The bank attempts to maximize its equity value subject to the regulatory constraints as follows:[7]

$$\underset{p,z}{\text{Max}}\ L=V(p,z)-C\{U(p,z)\} \qquad (2-1)$$

$$\text{s.t. } U(p,z) <- k$$

where:

- p = the debt-asset ratio;
- z = the variance of the change in the value of assets;
- $V(p,z)$ = the amount of wealth transfer from the FDIC, which is an increasing function of both p and z;
- $U(p,z)$ = the total risk of the bank which is an increasing function of both p and z;
- $C\{(U(p,z)\}$ = the regulatory interference costs arising with the level of total risk;
- k = the level of total risk allowed.

The lagrangean expression is formed:

$$\underset{p,z}{\text{Max}}\ L=V(p,z)-C\{U(p,z)\}+\lambda 1\{k-U(p,z)-C\}$$

If the constraint is assumed to be binding, that is, $U(p,z)=k$, first-order conditions of the objective function, a constrained maximization case with the two endogenous variables (p and z) and one exogenous variable (k), are expressed as follows:

$$\partial L/\partial p=\partial V/\partial p-(\partial C/\partial U)\ (\partial U/\partial p)-\lambda(\partial U/\partial p)=0$$

$$MVp=\partial V/\partial p=f(p,z,k)$$

$$\partial L/\partial z=\partial V/\partial z-(\partial C/\partial U)\ (\partial U/\partial z)-\lambda(\partial U/\partial z)=0$$

$$MVz=\partial V/\partial z=g(p,z,k)$$

In equilibrium, the marginal contribution of the debt-asset ratio to the value of the firm, MVp, is a function of the asset risk as well as the constraint on the total risk. Also, the marginal contribution of the asset risk to the value of the firm, MVz, is a function of the debt-asset ratio as well as the constraint on the total risk. In this model, the asset risk decision (how much asset risk to take) as well as the capitial structure decision become a choice variable, and these two decisions

7. The optimum debt-asset ratio and asset risk are then determined, where the ratio of the marginal values of deposit insurance with respect to the debt-asset ratio and asset risk is equal to the ratio of marginal regulatory costs.

are interdependent with each other. The bank adjusts the asset risk (debt-asset ratio) in relation with the debt-asset ratio (asset risk) in order to maximize the value of equity.[8]

The capital structure decision is interrelated with the asset investment dcision through the regulatory constraint imposed on the total risk. In addition, the marginal contribution of the debt-asset ratio (asset risk) to the value of the deposit insurance for the bank varies depending on the level of the asset risk (debt-asset ratio).[9] Hence, decisions to change the debt-asset ratio and asset risk must be predicated on each other : they are interdependent.

If the constraint on the total risk is binding, that is, $k=U(p, z)$, then the total differential of the total risk function is

$$dk=(\partial U/\partial p)\ dp+(\partial U/\partial z)dz$$

Setting $dk=0$

$$(\partial U/\partial p)dp+(\partial U/\partial z)dz=0$$

$$dz/dp=-(\partial U/\partial p)\,/\,(\partial U/\partial z)<0$$

The slope of the total risk function, dz/dp, is negative, where dz/dp is the rate at which a bank would be willing to substitute p for z in order to maintain a regulatory level of total risk. Thus, the constraint on the total risk, where a low (high) debt-asset ratio is offset with a high (low) asset risk, is expected to dictate a crosssectional negative relationship between these two choice variables.

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8. $$\frac{\partial V\partial P}{\partial V/\partial Z}=\frac{(\partial C/\partial U)(\partial U/\partial P)+\lambda 1(\partial U/\partial P)}{(\partial C/\partial U)(\partial U/\partial P)+\lambda 1\quad \partial U/\partial P)}$$

If the asset risk of the bank is assumed to be exogenously given, that is, if the bank does not adjust the asset risk in relationship with the debt-asset ratio, the bank can be modelled as follows :

$$\underset{p}{\text{Max}}\ L = V(P,Z) - C\{U(P,Z)\}$$

$$S,\ t,\ U(P,Z)<K$$

$$\underset{p}{\text{Max}}\ L = V(P,Z) - C\{U(P,Z)\} + \lambda 1\{K - U(P,Z)\}$$

If it is assumed that the constraint concerning the total risk is binding, that is, $U(P, z)=k$, the first order condition is :

$$\partial L/\partial P = \partial V/\partial P - (\partial C/\partial U)\ (\partial U/\partial P) - \lambda 1(\partial U/\partial P) = 0$$

The optimum debt-asset is then determined, where

$$\partial L/\partial P = (\partial C/\partial U)\ (\partial U/\partial P)\ + \lambda 1(\partial U/\partial P)$$

In this case, only the capital structure decision becomes a choice variable and the two decisions are not interdependent.

9. Merton(1974) analytically shows that $\partial g/\partial p=N(h1)/p^2$ and $\partial g/\partial z=N'(h1)/2d/z$, where N(h1) includes both arguments, p and z. It means that the marginal value of deposit insurance with respect to the debt-asset ratio (asset risk) is not constant and is a function of the asset risk (debt-asset ratio).

2.2.2 Effect of a Regulatory Decrease in the Maximum Debt-Asset Ratio on the Bank's Asset Risk

The effect of capital regulation on the asset risk of the bank was previously analyzed by Kahane (1977), Koehn and Santomero (1980), O'Hara (1983), and Lam and Chen (1985). The theoretical result of Koehn and Santomero is that given a well-behaved utility function, the bank shifts its portfolio into riskier assets so that the actual asset portfolio variance increases. Therefore, a regulatory decrease in the maximum debt-asset ratio, presumably to make the bank safer, results in an increased asset risk exposure for the bank, unless the asset risk is properly regulated. In this study, the asset risk is assumed not to be constrained by bank regulators due to the lack of objective standards or guidelines on the asset portfolio risk.

The theoretical results of previous studies are examined by the present study in a different framework, whereby the bank is assumed to maximize the wealth transfer from the FDIC subject to regulatory constraints.

Another assumption is now added to the original assumptions. That is, the debt-asset ratio of the bank is limited explicitly by the regulatory capital standard while the constraint on total risk is maintained (the total risk of the bank, or the bank insolvency, is assumed to be effectively regulated). The asset risk is thus assumed to be constrained in relationship with the debt-asset ratio. This is in contrast with the assumption of the study of Koehn and Santomero. Then two competing models are constructed, where the extent that a bank is able to increase the asset risk subject to the capital regulation depends upon the cost involved with adjusting the asset risk.

2.2.2.1 Model One : Adjustment of Asset Risk in Unlimited Asset markets

If the bank can fully and costlessly adjust its asset risk, then the original model, Equation (3−1), is modified as follows :

$$\text{Max } L=V(p,z)-C\{U(p,z)\} \qquad (2-2)$$

$$\text{s.t. } k \geq U(p,z) \qquad (a)$$

$$p \leq \bar{p} \qquad (b)$$

The constraint (b) is that the debt asset ratio of the bank should be lower than the regulatory capital standard denoted by $\bar{p}$.

If the constraints (a) and (b) are assumed to be binding, then the lagrangean expression is formed :

$$\text{Max } L=V(p,z)-C\{U(p,z)\}+\lambda 1\{k-U(p,z)\}+\lambda 2(\bar{p}-p)$$

F.O.C.

$$\partial L/\partial \lambda 1 = k-U(p,z)=0$$

$$\partial L/\partial \lambda 2\ \bar{p}-p=0$$

$$\partial L/\partial p = \partial V/\partial p-(\partial C/\partial U)\partial U/\partial p)-(\partial U/\partial p)\lambda 1+\lambda 2=0$$

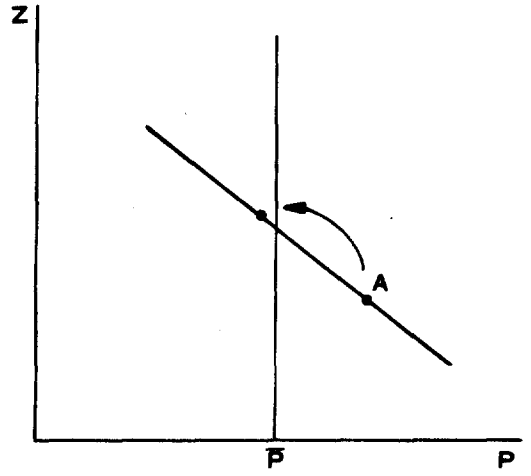
$$\partial L / \partial z = \partial V / \partial z - (\partial C/\partial U)\partial U/\partial z) - (\partial U/\partial z)\lambda 1 = 0$$

By totally differentiating each first order condition and applying Kramer's rule, the comparative static result indicates $\partial z/\partial \bar{p} = (-)$, that is, the regulatory decrease in the maximum debt-asset ratio increases the asset risk.

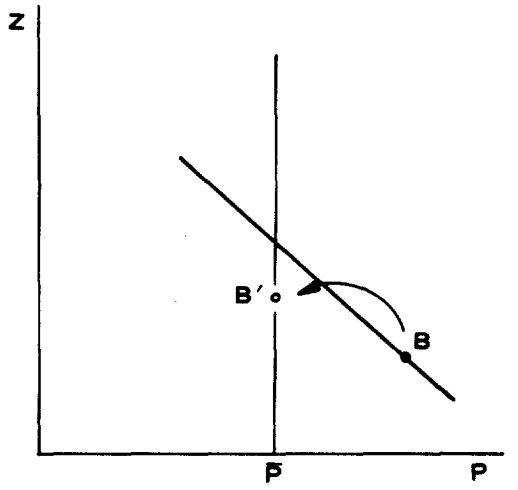
When the bank is forced to decrease its debt-asset ratio due to regulation, then the bank, in order to maximize the wealth transfer from the FDIC, increases the asset risk up to the point where the total risk does not exceed its constrained level. In figure 3-1, Bank A, which is subject to the regulatory decrease in the maximum debt-asset ratio, increases its asset risk fully within the constraint on its total risk.

2.2.2.2 Model Two :Adjustment of Asset Risk in Limited Asset Markets

Alternatively, a cost may be involved with adjusting the asset risk in attaining the otherwise optimal level of total risk predicted by Model One.



Firms having unlimited ability to adjust the asset risk without foregoing optimal NPV projects, subject to the capital regulation, simply move northwest so that they have the maximum total risk allowed (A→A').



Model Two:

Firms having constrained ability to adjust the asset risk, subject to the capital regulation, do not move northwest, at least in the short run, so that they have the lower total risk (B→B').

Figure 3−1. The Change of Asset Risk Subject to Capital Regulation.

It is assumed that a bank faces limited loan and investment markets, where few optimal NPV loan and investment alternatives are available with an asset risk over a certain level. In attempting to maximize the value of equity, or to maximize the total NPV, [10] the bank may have to forego some otherwise optimal NPV loan and investment alternatives in order to attain the maximum asset risk allowed.

The bank is therefore forced to have a lower asset risk and, as a result, a lower total risk than predicted by Model One. In Firgure 31, Bank, B, subject to the capital regulation, does not fully adjust its asset risk since, in doing so, it would forego otherwise optimal loan and investment alternatives.

10. The contribution of a certain risky loan or investment alternative to the value of equity, or the total NPV, is made two ways : (1) the NPV of the alternative, and (2) the wealth transfer from the FDIC resulting from the incerase of the asset risk.

2.2.2.3 Comparison of Two Models

Thus, in both Model One and Model Two, the bank is viewed as maximizing the sum of the net present values across loan and investment alternatives subject to the asset risk allowed by regulation z, whereby the sum of the NPVs is a function of the level of the asset risk, z. That is,

$$\text{Max } NPV(z) = \sum_i NPV\ i$$

$$\text{S.t.} \bar{Z} > Z$$

The difference between the two models is that Model One assumes that the total NPV is independent of the level of asset risk, whereas Model Two assumes that the total NPV can decrease above a certain level of asset risk.

The difference between the two models is that Model One assumes that the total NPV is independent of the level of asset risk, whereas Model Two assumes that the total NPV can decrease above a certain level of asset risk.

In all, the present study, within a different framework, provides another explanation as to why and to what extent the asset risk of banks increases when the debt-asset ratio is forced to decrease by regulation. It shows that although the asset risk is assumed effectively constrained by regulators, the bank would increase its asset risk as long as the total risk does not exceed its constrained level.

III. CONCLUSIONS

This study develops a theoretical model of the capital structure decision of the bank in relationship with the asset risk decision, whereby the bank is assumed to maximize the wealth transfer from the FDIC subject to regulatory constraints. This model shows that the bank capital structure and asset risk decisions are interdependent. It also shows why and to what extent the bank increases its asset risk subject to the regulatory increase of capital rations. Contrary to the study by Buser, Chen, and Kane(1980), the theoretical model of this study assumes that the asset jrisk decision of the bank is endogenously determined. It also assumes that the asset risk of the bank is effectively constrained, which is in contrast with the assumption on which the study by Koehn and Santomero (1980) is based.

Regarding the effect of the regulatory increase of capital ratio on the asset risk of the bank, the theoretical model predicts that, for small banks which face relatively limited asset markets, the capital regulation should be more effective than for large banks. This is because small banks react to the capital regulation by increasing their asset risk to a lesser extent.

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