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Bank Income Taxes and Interest Rate Risk Management: A Note

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BANKS AND OTHER financial institutions are concerned with the management of their interest rate risk. In the frictionless markets of most finance theory, however, one interest rate risk management policy is just as good as another. Hence, the finance literature does not provide convincing reasons for managers to want to control interest rate risk. Consequently, the literature has provided little guidance on what to control, how far to go with this control, or on how to explain differences in interest rate risk exposure among banks.[1]

Given frictionless markets, shareholder indifference to the bank's interest rate risk policy plus management's preference to reduce risk could lead to policies that reduce or eliminate exposure to interest rate risk, i.e., to immunization strategies. However, if part of the reason for the existence of banks is the provision of maturity intermediation services, managers who avoid exposure to interest rate risk are likely to come out second best to managers who choose asset and liability portfolios that do expose the bank's shareholders to this risk.

In this note we develop and analyze a model of bank decisions in which tax considerations induce banks to control interest rate risk. In the U.S., banks have many opportunities to shield current income against federal and state taxation. Foreign tax credits, investment tax credits, and investment in tax-exempt securities are three examples. The tax position of a bank can be thought of as a stock of nonsaleable tax shields usable in the current or in future years. The tax shields are an asset and if the bank's income falls below some level, then the value of that asset will be reduced either by the loss of tax shielding opportunities or by the postponement of their realization.[2]

This note treats the bank tax position similarly to the models discussed by Brennan and Schwartz [2], Miller [8], DeAngelo and Masulis [4], and Kim [6]. However, our interest is in the effect of tax shields on risk taking by financial institutions rather than a concern with capital structure decisions.[3]

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[1] For empirical evidence on bank's exposure to interest rate risk see Flannery and James [5].

[2] This is clearly a simplification of the tax shields issue. In practice, their effect is quite complex. See, for example, Rosenberg [9] and DeAngelo and Masulis [4] for discussions on this issue.

[3] Cooper and Franks [3] present a model where the existence of tax credits changes the investment decisions of the firm. Their model is a certainty model in which transactions costs prevent the firm from fully utilizing its tax credits.

I. The Model

We analyze a model of a bank with what we call a tax asymmetry. This asymmetry is created since, below a predetermined level of income, the bank is unable to use its stock of tax shields. We use a two-date framework in which there is a complete set of market prices for $1 in every date 2 state of the world. The bank's managers and shareholders agree on this set of state-contingent prices.[4] In this framework we allow for the possibility that banks are compensated for providing lending services, perhaps at competitive rates.

Formally, we assume:

A.1 There is a set of prices, $p(s)$, for $1 (after taxes) in state s at date 2 such that

$$\int_{s=0}^{s=\infty} p(s)\, ds = r_T^{-1}$$

where r_T is the one-period riskless, after-tax return (one plus the after-tax, riskless interest rate).

A.2 The present value of a bank (V) is given by the (vector) product of the net after-tax value ($V_T(s)$) of the bank's portfolio at date 2 in state s times the state-contingent price ($p(s)$).[5]

$$V = \int_{s=0}^{s=\infty} V_T(s) p(s)\, ds$$

Bank managers are assumed to maximize this value.

A.3 The one-period return ($r(m; s)$) on a $1 default-free loan of maturity m is assumed to follow a single-factor return generating process of the form[6]

$$r(m; s) = r + \alpha(m) + e(m)u(s)$$

where

- r is the before-tax riskless return
- $\alpha(m)$ is the before-tax return to the bank for providing loans of maturity m[7]
- $u(s)$ is a random factor affecting loan returns and the expected value of $u(s)$ is zero
- $e(m)$ is the factor loading for $u(s)$ in the return on a loan of maturity m ($e(1) = 0$, $\partial e(m)/\partial m > 0$).

[4] See Sharpe [10] for a discussion about state-contingent claims in the context of a bank.

[5] For simplicity we will treat the economic earnings of the bank as taxable income, i.e., loans are marked to market at the end of the year.

[6] For a similar model of loan return see Bierwag et al. [1].

[7] $\alpha(m)$ represents the return to intermediation which may consist of a return for providing lending services or a return for providing maturity intermediation services or both.

A.4 The present value of an m-period default-free loan is a nondecreasing function of m up to some maturity $\hat{m}$.

$$\frac{\partial}{\partial m} \int_{s=0}^{s=\infty} r(m; s) p(s)\, ds \begin{cases} \geq 0 & \text{for} \quad m < \hat{m} \\ = 0 & \text{for} \quad m \geq \hat{m} \end{cases}$$

This assumption deserves some clarification. If the change in present value as a result of an increase in the loan maturity is zero for all m, then maturity intermediation is a "value preserving spread" (see Sharpe [10]), and banks do not receive any excess return for providing this service. Conversely, if this change is positive, then increasing the loan maturity is a "value increasing spread," and banks receive excess return for providing maturity intermediation services. We suggest that the latter is a reasonable characteristic of banks' lending opportunities, in particular their lending to individuals and small and medium size businesses. A similar assumption regarding pricing of banks' services can be found in Thakor et al. [11] where banks' opportunities are attributed to "bank customer relationship." We will assume that if the present value is increasing in m, then it is increasing at a decreasing rate.[8]

A.5 The bank's stock of tax shields creates a tax asymmetry point ($\bar{Y}$) in the bank's before-tax income. Below this point the bank underutilizes its tax shields. The bank's after-tax income ($Y_T(s)$) is:[9]

$$Y_T(s) = \begin{cases} [Y(s) - \bar{Y}](1 - T) + \bar{Y} & \text{if} \quad Y(s) > \bar{Y} \\ Y(s) & \text{if} \quad Y(s) \leq \bar{Y} \end{cases}$$

where

$Y(s) = r(m; s)L - rD - (L - D) - C$ is the before-tax income of the bank
$\bar{Y} = r(m; \bar{s})L - rD - (L - D) - C$
L is total loans of maturity m
D is total single-period deposits[10]
T is the corporate tax rate
C is the total costs of producing services[11]
$\bar{s}$ is the state in which the bank's before-tax income is equal to its stock of tax shields.

Given these assumptions, the bank manager's decision problem is to choose

[8] We could have derived the pricing of maturity intermediation endogenously using a more general model without a significant change in the results. See DeAngelo and Masulis [4] for a general equilibrium treatment of the capital structure problem in the presence of tax shields.

[9] The states s are ordered so that $u(s)$ is increasing in s.

[10] We shall treat the single-period deposits as if they offer depositors an after-tax riskless return. This allows us to focus on the effects of the assumed tax asymmetry on interest rate risk policy without the additional tax effects of bankruptcy.

[11] C may be made to depend on m without materially altering the results.

the loan maturity that maximizes the value of the bank's shares.

$$\begin{aligned}
\max V &= \int_{s=0}^{s=\infty} V_T(s)p(s)\,ds \\
&= \int_{s=0}^{s=\infty} (Y_T(s) + L - D)p(s)\,ds \\
&= \int_{s=0}^{s=\bar{s}} (Y(s) + L - D)p(s)\,ds \\
&\quad + \int_{s=\bar{s}}^{s=\infty} [(Y(s) - \bar{Y})(1 - T) + \bar{Y} + (L - D)]p(s)\,ds \\
&= \int_{s=0}^{s=\infty} (Y(s) + L - D)p(s)\,ds \\
&\quad - T\left[\int_{s=\bar{s}}^{s=\infty} (Y(s) - \bar{Y})p(s)\,ds\right] \\
&= [(L - D)r + \alpha(m)L - C]r_T^{-1} + Le(m)\int_{s=0}^{s=\infty} u(s)p(s)\,ds \\
&\quad - T\left\{[(L - D)(r - 1) + \alpha(m)L - C - \bar{Y}]\int_{s=\bar{s}}^{s=\infty} p(s)\,ds\right. \\
&\quad \left. + Le(m)\int_{s=\bar{s}}^{s=\infty} u(s)p(s)\,ds\right\}
\end{aligned} \tag{1}$$

The role of tax asymmetry is clearer in an alternative version of Equation (1)

$$\max V = (L - D)r_T^{-1} + TR - TC$$

where

$$\begin{aligned}
TR &= (1 - T)\left[(L - D)(r - 1)r_T^{-1} + \alpha(m)Lr_T^{-1}\right. \\
&\quad \left. + Le(m)\int_{s=0}^{s=\infty} u(s)p(s)\,ds\right] + T\bar{Y}r_T^{-1} \\
TC &= (1 - T)Cr_T^{-1} \\
&\quad + T\left\{\int_{s=0}^{s=\bar{s}} [\bar{Y} - [(L - D)(r - 1)\right. \\
&\quad \left. + \alpha(m)L + Le(m)u(s) - C]]p(s)\,ds\right\}
\end{aligned}$$

TR is the present value of the bank's after-tax revenues, where the last term of TR is the present value of the stock of tax shields if this stock can be fully utilized. TC is the present value of the bank's after-tax costs, where the last term of TC reflects the present value of the foregone tax shields in those states in which this stock cannot be fully utilized.

II. Tax Asymmetries and Interest Rate Risk Policies

As shown by Brennan and Schwartz [2], DeAngelo and Masulis [4], and others, uncertainty regarding the utilization of tax shields can lead to an internal optimum for a firm's leverage decision. Since we want to focus on the effects of tax asymmetries on interest rate risk policy, we shall restrict our analysis to the case in which bank capital and bank size are fixed.

After some rearrangement of terms, the first derivative of V with respect to m is

$$\begin{aligned}\frac{\partial V}{\partial m} = L\Bigg\{&\frac{\partial \alpha(m)}{\partial m}\, r_T^{-1} + \frac{\partial e(m)}{\partial m}\int_{s=0}^{s=\infty} u(s)p(s)\,ds \\ &- T\left[\frac{\partial \alpha(m)}{\partial m}\int_{s=\bar{s}}^{s=\infty} p(s)\,ds + \frac{\partial e(m)}{\partial m}\int_{s=\bar{s}}^{s=\infty} u(s)p(s)\,ds\right]\Bigg\} \\ &+ T\left[[(L-D)(r-1) + \alpha(m)L + Le(m)u(\bar{s}) - C - \bar{Y}]p(\bar{s})\,\frac{\partial \bar{s}}{\partial m}\right] \qquad (2)\end{aligned}$$

Noting (using A.5) that $\bar{Y} = (L-D)(r-1) + \alpha(m)L + Le(m)u(\bar{s}) - C$ and defining the present value of $u(s)$ as A

$$A \equiv \int_{s=0}^{s=\infty} u(s)p(s)\,ds$$

Equation (2) may be rewritten as[12]

$$\begin{aligned}\frac{\partial V}{\partial m} = L\Bigg\{&\left[\frac{\partial \alpha(m)}{\partial m}\, r_T^{-1} + \frac{\partial e(m)}{\partial m} A\right](1-T) \\ &+ T\left[\frac{\partial \alpha(m)}{\partial m}\int_{s=0}^{s=\bar{s}} p(s)\,ds + \frac{\partial e(m)}{\partial m}\int_{s=0}^{s=\bar{s}} u(s)p(s)\,ds\right]\Bigg\} \qquad (3)\end{aligned}$$

A. Bank Policies with No Tax Asymmetry

If the bank does not face an asymmetry in its tax function (i.e., $\bar{s} = 0$), the necessary first-order condition for an internal solution to the bank maximization

[12] The effects of a tax asymmetry enter the second-order condition of our model. However, they do not materially affect the sufficiency conditions. If an internal optimum is possible without a tax asymmetry, the sufficiency condition will be satisfied for the corresponding case with a tax asymmetry.

problem is

$$\frac{\partial \alpha(m)}{\partial m} r_T^{-1} + \frac{\partial e(m)}{\partial m} A = 0 \tag{4}$$

If the bank receives no excess return for providing maturity intermediation services (i.e., if $\alpha(m) r_T^{-1} + e(m)A = \alpha(1)$ for all m), the maturity gap is irrelevant for the bank. Equation (4) will hold for all values of m. This is the basic maturity indifference result that we mentioned in the introduction.

Alternatively, as we suggested in the introduction, banks may receive compensation for providing maturity intermediation services as part of a package of lending services. This compensation is independent of L, hence it does not imply monopolistic returns to banking. For the present, we assume that the risk-adjusted return to lending, $\alpha(m) r_T^{-1} + e(m)A$, is strictly increasing in m up to maturity $\hat{m}$. From Equation (4) it is clear that the optimal loan maturity for this case will be $\hat{m}$. The bank will be induced to increase the maturity gap as long as there are marginal returns to maturity intermediation.

Clearly neither maturity indifference nor full exploitation of maturity intermediation opportunities provides a rationale for the concerns that bank managers appear to have regarding interest rate risk.

B. Bank Policies with Tax Asymmetry

The underlying concept of a tax asymmetry in our model is that a bank may come to a decision point with an inherited stock of tax shields. These tax shields are a valuable asset, but the value of this asset depends on the ability of the bank to generate income to shelter from taxes.

The existence of such a tax asymmetry has a profound effect on bank policies. The necessary first-order condition for an internal solution to the bank maximization problem includes a term for the present value of tax shields that will be foregone in those states ($s < \bar{s}$) in which the bank income is less than the maximum income that can be sheltered from taxation.

$$(1 - T)\left\{\frac{\partial \alpha(m)}{\partial m} r_T^{-1} + \frac{\partial e(m)}{\partial m}\right\}A = -T\phi_m \tag{5}$$

where

$$\phi_m = \frac{\partial \alpha(m)}{\partial m} \int_{s=0}^{s=\bar{s}} p(s)\, ds + \frac{\partial e(m)}{\partial m} \int_{s=0}^{s=\bar{s}} u(s) p(s)\, ds < 0$$

The term ϕ_m is the result of foregone tax shields when $\bar{s} > 0$. In the bank's equilibrium, this term will be negative for $\bar{s} > 0$.

B.1 Optimal Maturity Gap—With an effective tax asymmetry and no excess return from maturity intermediation, the necessary condition given by Equation (5) cannot be satisfied for any maturity gap policy in which the bank is subjected to interest rate risk. For the maturity matching strategy, the tax asymmetry does not come into play (i.e., for $m = 1$, $\bar{s} = 0$). The optimal loan maturity in this case is $m = 1$ or a policy of maturity matching for loans and deposits.

However, if the risk-adjusted return to lending is increasing in m (at a decreasing rate), the effect of the tax asymmetry will be to induce the bank to choose an optimal maturity $\tilde{m}$ such that $\hat{m} > \tilde{m} > 1$, i.e., the bank will not fully exploit the return to maturity intermediation.

With or without returns to maturity intermediation, the existence of a tax asymmetry will induce bank managers to be concerned about interest rate risk management and to take maturity gap positions that conform to an optimal policy. We emphasize that the only market imperfection that we have invoked to obtain this result is the existence of an inherited stock of tax shields that cannot be fully utilized (or sold) when there is insufficient income.

It is important to note here that these results apply also to a bank which has very large tax shields relative to its zero-exposure income. The asymmetry, which is created in this case at the upper tail of the income distribution (in states $s > \bar{s}$ the bank pays taxes while in all other states its income can be sheltered), will induce the bank to avoid full exploitation of the return to maturity intermediation.[13]

B.2 Extensions of the Model—Our analysis treated the stock of tax shields, and hence the tax asymmetry point, as a variable over which the bank does not have control. If the bank can change its asymmetry point during the period, one may ask what the value to the bank of an additional \$1 of tax shields is.

From a derivative of V with respect to $\bar{Y}$, an increase in $\bar{Y}$ will increase the value of the bank by

$$dV = T\left[\int_{s=\bar{s}}^{s=\infty} p(s)\; ds\right] \leq Tr_T^{-1}$$

which is equal to the present value of the reduction in tax payments, where the possibility of not utilizing the additional tax shields is taken into account. It is clear that the present value of additional tax shields will be smaller the higher the tax asymmetry point is and the larger the maturity gap is. This consideration might prevent banks from being competitive in providing services where part of the profits comes in the form of additional tax shields.[14]

It can also be shown that if the bank's stock of tax shields increases, then its optimal maturity gap will be smaller.

Another possible extension of the model is the incorporation of deposit insurance. Merton [7], Sharpe [10], and others showed that deposit insurance with a fixed premium induces banks to increase their risk. In the presence of both deposit insurance and a tax asymmetry, the bank's decision should take into account the tradeoff between (1) the loss of tax shields, (2) the increase in the bank's value which is accompanied by an equal increase in the insurer's liability, and (3) any gains from providing maturity intermediation services.[15] In contrast

[13] This consideration is important to institutions which suffered large losses during previous years. Of course, in these cases, the opposite effect of limited liability and deposit insurance may be significant also.

[14] See Rosenberg [9] for a discussion of this point in the context of leasing.

[15] In the presence of deposit insurance, Equation (5) has an additional term which represents the insurer's liability in states in which the bank is insolvent.

to Sharpe's results, an internal optimal solution may exist. Its existence does not depend on the presence of excess return to providing maturity intermediation services.

III. Conclusion

Our objective in this paper has been to demonstrate that the existence of tax shields and the circumstances in which these tax shields may not be fully utilizable by a bank can lead to decisions to restrict the maturity gap between loans and deposits. We have shown that this will be the case with or without returns to maturity intermediation and with competitive loan markets.

There are analytical problems that we have not dealt with. Many of these are related to the artificial separation between bank markets and the market that determines the state prices. In fact, in our model, state prices are just a convenient way of pricing the bank's equity in alternative states so we can engage in a partial equilibrium analysis of the bank's policies. If we took the complete market paradigm seriously, there would be no role for banks.

Our model does not deal with the opportunity that banks may have to eliminate some of their risk in the futures market. The effect of interest rate futures on bank behavior will depend on the pricing of futures contracts relative to bank loans and deposits and on the degree to which banks can hedge loans in the futures market. This and other aspects of the question of interest rate risk policy deserve more attention. Whatever the outcome of further research on this topic, we believe that tax shield effects are likely to be a part of the explanation of bank behavior with respect to interest rate risk management.

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