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The Structure and Incentive Effects of Corporate Tax Liabilities

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ABSTRACT

This paper describes situations in which tax liabilities assume the form of a negative position in a call option. This structure motivates an examination of the investment decisions of taxed corporations in the presence of risk. It is shown that the structure of the tax liability creates an incentive to underinvest in more risky projects and an incentive for conglomerate merger. These effects are then evaluated in the presence of conflicts of interest between stockholders and bondholders, and under alternative assumptions about the tax code, and about the timing of investment and financing decisions.

THIS PAPER MAKES AN observation regarding the functional form assumed by the tax liabilities of corporations with potentially redundant deductions and evaluates its consequences for investment incentives. Interest and other deductions against taxable income can be taken, for the most part, only to the extent of that income. In a single-period model, this gives the net tax liability a familiar structure. It can be viewed as a call option where the exercise price on the call is the allowable deductions. The tax-paying entity holds a positive position in the assets which generate the taxable income and a negative position in a call option on those assets.

The analogy between options and the structure of tax liabilities calls attention to some interesting incentive effects concerning risk. Using their model of option valuation, Black and Scholes [5] showed that the value of an option is increasing in the variance of the asset it is written on. Other authors have generalized this result and studied its implications for corporate financing (see Jagannathan [16], Jensen and Meckling [17], and Green [15]). The importance of the risk attributes of the underlying asset in option valuation suggests that taxation may have important incentive consequences for investment decisions involving risk.

It has been recognized in the Public Economics literature for some time that asymmetries in the tax schedule can affect risk-taking behavior. Early papers by Mossin [20] and Stiglitz [25] studied individual portfolio decisions over a riskless and a risky asset. Our analysis differs from these in a number of respects. The most important of these is our use of market valuation rather than expected utility in the decision maker's objective function. This is surely a more appropri-

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ate vehicle for studying corporate decisions. It also abstracts from risk-sharing concerns which lead to distortions, in Stiglitz's as well as Mossin's model, even under strictly proportional taxation. A valuation approach also allows us to employ a more precise definition of relative risk and to generalize the model to multiple investment projects. In a multiproject setting, we are able to analyze externalities among projects which affect the firm's ability to minimize the present value of its tax obligation. Because of these externalities, when agents have other stochastic sources of income, whether from financial assets or labor, Stiglitz's and Mossin's results need not hold. Even with asymmetric treatment of gains and losses, a risky asset may be sufficiently valuable as a hedge that investors will desire to hold it despite an increase in the value of their tax liability. We also examine these risk incentives under alternative treatments of taxation in bankruptcy, and in the presence of other sources of tax deductions and conflicts of interest between bondholders and shareholders.

In Section I, we model the investment behavior of a taxed corporation. It is shown that the firm's objective function assumes the form of its before-tax net present value less the value of a call option representing its tax liability. The convex "shape" of this liability leads to risk-averse behavior. We attempt to make the notion of "more risk-averse" precise in two ways. We show that there are incentives to underinvest in risky projects which are mean preserving spreads of other projects with the same market value, to engage in conglomerate mergers and to purchase corporate insurance.

The assumptions made in Section I give the tax liability a very simple, option-like structure. Having formally characterized the firm's decisions to take risk in this setting, we are able to evaluate how alternative interpretations of the tax code and the timing of investment decisions might affect these risk incentives. Accordingly, Section II studies the effect of the tax option on stockholder-bondholder conflicts which might arise when financing and investment are not simultaneous. Surprisingly, for many capital structures, the form of the tax liability serves to aggravate the difference between the actions of shareholders and the policies bondholders would wish them to pursue. For firms with low leverage and/or high levels of alternative tax shields, however, the incentives for shareholders to take too much risk may be mitigated or even reversed. Section III looks at alternative treatments of tax deductions in bankruptcy. Again, for a certain range of capital structures, these assumptions may lead to ambiguous risk incentives. Section IV evaluates the impact of loss carry-overs on the firm's risk-taking. These possibilities reduce the value of the tax liability, but do not alter the convex shape of the total tax payment as a function of total firm earnings. Accordingly, in Section V we prove that the distortionary incentives described in Section I remain intact under the general case of arbitrary progressive (i.e., convex) effective tax schedules. Section VI summarizes the analytical results of the paper and its policy implications.

I. Corporate Investment Decisions

In this section we show that, in a simple one-period environment, the corporate tax liability assumes the form of a call option. The nonlinear nature of this claim affects the firm's incentives to undertake risky investment projects. The intuition behind the analysis is the reverse of notions which are familiar from studies of agency problems in finance. Our purpose here is to make these ideas precise in a very simple model. Later sections of the paper will focus on the robustness of our results with respect to several key assumptions, which in the present section give the tax liability and the firm's objective function a particularly simple form.

Consider a firm which chooses a vector of investments, $I = \{I_1, \cdots, I_n\}$, in n projects. These investments generate state-contingent cash flows, $X(I, \omega)$ for the firm, according to the additively separable production function:

$$X(I, \omega) = \textstyle\sum_{i=1}^{n} k_i(I_i)(1 + R_i(\omega)). \tag{1}$$

The scale functions $\{k_i(\cdot)\}_{i=1}^{n}$ are concave and twice differentiable in their arguments. The random multiplicative shocks $\{1 + R_i(\omega)\}_{i=1}^{n}$ depend on ω, the state-of-the-world, which is an elementary outcome from the universal set, Ω. We will assume that $k_i'(0) = \infty$, where a prime denotes the derivative, and that $(1 + R_i(\omega)) \in (0, \infty)$ for all i. This is a simple way to ensure interior solutions and that, in accordance with limited liability for the firm, $X(I, \omega) > 0$ for any choice of I.

We will assume for the time being that the firm lasts for a single period. To raise the funds required for operation, the firm can issue debt and outside equity at the initial date. The debt claim is issued at a face value of B, with interest paid at a rate of r. We denote as α the fraction of equity sold to outsiders. The amount of funds raised at the initial date is $\sum_{i=1}^{n} I_i$, and the firm is allowed to depreciate a fraction, ϕ, of this total over the current period. A literal interpretation of the single-period setting would, of course, imply $\phi = 1$.

Taxes are introduced according to the "interest-first" doctrine for treating taxes in bankruptcy, whereby partial payments to debtholders are credited first to interest and then to principal (see Baron [4] and Talmor, Haugen and Barnea [26]). The complications introduced by the "principal first" doctrine will be discussed in Section III.

The firm's tax deductions consist of its interest expense and depreciation expense, and we denote these as $D \equiv rB + \phi(\sum_{i=1}^{n} I_i)$. Note that principal is not assumed to be deductible, except to the extent that the funds raised contribute to depreciation. For this portion of the analysis we also assume that tax losses cannot be marketed or carried over.[1] Section IV will discuss the relaxation of this assumption. Let τ represent the corporate tax rate. We can specify the cash flow to equityholders, X_E, and bondholders, X_B, as:

$$X_E = \max\{X - B(1 + r) - \tau \max\{X - D, 0\}, 0\} \tag{2}$$

$$X_B = \min\{X - \tau \max[X - D, 0], (1 + r)B\}. \tag{3}$$

The sum of these cash flows represents the after-tax cash flow of the firm,

$$X_E + X_B = X - \tau \max\{X - D, 0\}. \tag{4}$$

[1] This assumption is fairly standard in studies of corporate financial policy (see, e.g., Baron [4], Brennan and Schwartz [7], Chen [8], and DeAngelo and Masulis [12]). Cooper and Franks [9] and Warren and Auerbach [28] provide detailed discussions of factors which inhibit the ability of firms to market redundant deductions.

Finally, we assume that the firm's securities are traded in a capital market which is sufficiently complete to "span," or uniquely value, them. Zero-arbitrage conditions in these markets will imply that this valuation is linear (see Ross [22]). Thus we can write the value of any after-tax cash flow from the firm, $Y(X)$, as:

$$V[Y(X)] = \int_{\Omega} p(\omega) Y[X(\omega)] \, d\omega \tag{5}$$

where $p(\omega)$ is the positive price of a state-contingent claim implied by the prices of marketed assets. Normalizing $p(\omega)$ by the probability of state ω creates a random variable $W(\omega)$ which solves:

$$V[Y(X)] = E[WY(X)] \tag{6}$$

where $E(\cdot)$ is the expectation operator. One can think of W as the source of "systematic" risk in the economy, since in an asset pricing model it is proportional to consumers' marginal rates of substitution. It will prove useful in defining what a "riskier" technology is.

The firm's investment and financing problem can now be written as:

$P1$—

$$\max_{I,B,\alpha,r}(1-\alpha) \int_{\Omega} p(\omega)\max[X(I, \omega) - B(1+r) - \tau \max\{X(I, \omega) - D, 0\}, 0] \, d\omega \tag{7}$$

subject to

$$\textstyle\sum_i I_i \leq B + E \tag{8}$$

$$B = \int_{\Omega} p(\omega)\min[X(I, \omega) - \tau \max\{X(I, \omega) - D, 0\}, (1+r)B] \, d\omega \tag{9}$$

$$E = \int_{\Omega} p(\omega)\alpha \max[X(I, \omega) - B(1+r) - \tau \max\{X(I, \omega) - D, 0\}, 0] \, d\omega \tag{10}$$

$$D = rB + \phi(\textstyle\sum_i I_i). \tag{11}$$

In this problem, the firm's management simultaneously chooses investment and financing policies which maximize the value of the initial shareholders' claim. Equation (8) is the flow of funds constraint. It states that the total amount invested in the n projects must not exceed the combined values of the debt and outside equity. Equations (9) and (10) express these values as a function of I, the investment allocation chosen by the firm. The assumption that this variable is observable, and chosen simultaneously with the firm's financing policies, ensures that no conflict of interest arises between bondholders and shareholders concerning investment choice. This is demonstrated formally in Lemma 1. If, on the other hand, shareholders are free to choose or alter the investment allocation *after* the debt is in place and the funds have been contributed, they might choose a different allocation than the one which maximizes the firm's after-tax net present value (NPV). This case is studied in detail in Section II. In the above problem, however, investment choices which would increase the value of the equity claim at the expense of bondholders lead immediately, through the budget constraint (9), to a higher interest payment on the debt. In this way shareholders must fully compensate bondholders for actions which would adversely affect their claim, and they are accordingly led to maximize the after-tax NPV of the firm.

Note that Equation (9) constrains the firm to issue the bonds at par. Without this constraint, the optimal solution would trivially involve a fixed payment consisting entirely of "interest," which is tax deductible, and no "principal." Although the IRS does not require that bonds be issued at face value, it does require that any premium over par received for the bonds be amortized as income, thus offsetting the higher deductions generated by interest payments above the market rate [Commerce Clearing House, ¶674.01]. From a practical point of view, this is equivalent to requiring sale at par.

Given optimal financing policies from $P1$, D^*, B^*, r^*, and α^*, the firm's investment policies will maximize its after-tax NPV, as the following lemma shows. In the absence of taxes (the case of $\tau = 0$), this lemma can be viewed as merely a complete markets version of the Miller and Modigliani result that capital structure is irrelevant and that there is separation between investment and financing. Note that while we treat the financing variables as fixed in order to focus on investment decisions, their endogeneity is important to the structure of the problem. If shareholders perceived the promised payment on the debt as independent of their investment choices, they would behave as described in Section II. The fact that debt generates deductions, while payments to outside equity do not, guarantees that $B^* > 0$.[2]

LEMMA 1. *The solutions to* $P1$ *also maximize the before-tax net present value of the firm, less the tax rate times the value of a call option with exercise price,* D^*. *Formally, they solve:*

P2—

$$\max_{I} \int_{\Omega} p(\omega)X(I, \omega)\, d\omega - \textstyle\sum_i I_i - \tau \displaystyle\int_{\Omega} p(\omega)\max\{X(I, \omega) - D^*, 0\}\, d\omega$$
$$= V[X(I)] - \textstyle\sum_i I_i - \tau V[\max\{X(I) - D^*, 0\}]. \quad (12)$$

Proof: Let $Y = X(I) - \tau\max\{X(I) - D^*, 0\}$. We can substitute for $\sum_i I_i$ by using the budget constraints (8) to (11) evaluated at r^*, B^*, and α^* to rewrite the maximand in (12) as:

$$V(X(I)) - \tau V[\max\{X(I) - D^*, 0\}] - V[\min\{Y, B^*(1 + r^*)\}]$$
$$- V[\alpha^*\max\{Y - B^*(1 + r^*), 0\}] \quad (13)$$

[2] Whether, in fact, any outside equity is issued depends on the presumed tax treatment of interest expense in bankruptcy. Under the tax doctrines modeled here, all outside financing will be debt. The residual claim, however, will still be equity. For situations where bankruptcy costs or alternative tax regimes generate interior solutions with $B^* > 0$, $\alpha^* > 0$, see, e.g., Brennan and Schwartz [7] and Turnbull [27].

or, by the linearity of the valuation operator, as:

$$\begin{aligned} &V[Y - \min\{Y, B^*(1 + r^*)\} - \alpha^* \max\{Y - B^*(1 + r^*), 0\}] \\ &\quad = (1 - \alpha^*) V[\max\{Y - B^*(1 + r^*), 0\}] \\ &\quad = (1 - \alpha^*) V[\max\{X(I) - B^*(1 + r^*) - \tau \max\{X(I) - D^*, 0\}, 0\}]. \end{aligned} \tag{14}$$

But this last expression is simply the maximand of $P1$, evaluated at the optimal financing policies. The envelope theorem now ensures the result. Q.E.D.

A noteworthy feature of $P2$ is that the only way in which the optimal investment policy can depend on the debt-equity mix is through the deductions created by interest expense. One more assumption is needed before proceeding. To characterize the optimal policies with first-order conditions, expression (12) must be differentiable with respect to I. The function $\max\{\cdot, \cdot\}$ has a kink where the two arguments are equal. However, the *value* of such a claim, which is an integral taken over it, will be differentiable so long as the point of nondifferentiability has zero measure. This will be the case if the random components of earnings $\{R_1, \cdots, R_n\}$ and the "systematic risk" variable, W, have a continuous joint density, $f(R, W)$, which we will assume to be the case.

From Lemma 1 it follows that the firm can reduce the value of the government's claim by taking actions which would reduce the value of a call option. We will now turn to examine how these incentives manifest themselves in the investment behavior of taxed corporations.

A. Investment Behavior

We begin by characterizing the investment allocation which prevails in the absence of taxes. Maximizing (12) over I_i with $\tau = 0$ produces the necessary and sufficient condition for an interior maximum:

$$k_i'(\hat{I}_i) \int_\Omega p(\omega)(1 + R_i(\omega))\, d\omega = 1 \tag{15}$$

where $\hat{I}$ denotes the optimal investment choice for this case. Thus, the firm invests until the random marginal product generates value equal to the cost of the last dollar of capital input. If we form the ratio of marginal scale products, we obtain

$$\frac{k_i'(\hat{I}_i)}{k_j'(\hat{I}_j)} = \frac{\int_\Omega p(\omega)(1 + R_j(\omega))\, d\omega}{\int_\Omega p(\omega)(1 + R_i(\omega))\, d\omega}. \tag{16}$$

Equation (16) describes the mix of investment projects undertaken by the firm. The ratio on the left-hand side is monotonically increasing in $\hat{I}_j$ and decreasing in $\hat{I}_i$. Thus, as the present value of the random shock, $1 + R_j$, increases in the ratio on the right-hand side, project j consumes a greater proportion of the firm's capital budget.

With a strictly proportional tax rate, the firm invests less overall but maintains the same "mix" of assets as in the absence of taxes. Assume the firm has deductions of $D^* = \phi(\sum_i I_i) + r^*B^*$ and that the government rebates to the firm $D^* - X(I)$ whenever earnings fall short of deductions. Then the first-order conditions for maximizing the firm's after-tax NPV are, for each $i = 1, \cdots, n$,

$$k_i'(\bar{I}_i)(1 - \tau) \int_\Omega p(\omega)(1 + R_i(\omega))\, d\omega = 1 - \phi\tau \int_\Omega p(\omega)\, d\omega \tag{17}$$

where $\bar{I}$ denotes the optimum for this case.

Investment in project i contributes, at the margin, to the firm's earnings, which are worth $(1 - \tau)$ for each pre-tax dollar in all states. This contribution to the firm's value is given on the left-hand side. On the right-hand side is the one dollar current cost of this investment less the value of its contribution to tax shields through added depreciation. We know, however, that $\phi \leq 1$ and $\int_\Omega p(\omega)\, d\omega = 1/(1 + r_f)$ where r_f is the riskless interest rate. Assuming the riskless rate is positive, the right-hand side of (17) is greater than $(1 - \tau)$ and so $k_i'(\hat{I}_i) < k_i'(\bar{I}_i)$. This, in turn, implies that $\hat{I}_i > \bar{I}_i$, as we have assumed decreasing returns to scale; this is true for all projects. Given the overall scale of the firm, Equation (17) yields the same ratios of marginal products as those described by (16). At the margin, the "mix" of the projects is not changed.

Now consider the case of nonproportional taxes. Casual examination of (12) reveals that the marginal product of investment will be penalized only on the subset of Ω where deductions do not completely shield earnings. This suggests that some projects will be penalized at the margin more heavily than others. In what follows we provide a partial, but suggestive, description of the kinds of projects which are so penalized.

The first-order conditions for the maximization of (12) with respect to I_i are, by the convexity of the $\max\{\cdot, \cdot\}$ function, the concavity of $X(\cdot, \omega)$, and the linearity of valuation, both necessary and sufficient. Leibnitz's rule allows us to ignore the first-order effects of investment on the location of the kinks in the max function. Let I_i^* denote the optimal investment choices, $(i = 1, \cdots, n)$, and Ω^* denote the set of states where taxes are paid, $\Omega^* = \{\omega: X(I^*, \omega) > D^*\}$. Then I_i^* solves:

$$k_i'(I_i^*)\left[\int_\Omega p(\omega)(1 + R_i(\omega))\, d\omega - \tau \int_{\Omega^*} p(\omega)(1 + R_i(\omega))\, d\omega\right]$$
$$= 1 - \tau\phi \int_{\Omega^*} p(\omega)\, d\omega. \tag{18}$$

In this situation, the disincentives to invest are no longer uniform across projects. The "option effects" associated with the tax penality do distort the asset mix of the firm. It will, in general, be the case that

$$\frac{k_i'(I_i^*)}{k_j'(I_j^*)} = \frac{\int_\Omega p(\omega)(1 + R_j(\omega))\, d\omega - \tau \int_{\Omega^*} p(\omega)(1 + R_j(\omega))\, d\omega}{\int_\Omega p(\omega)(1 + R_i(\omega))\, d\omega - \tau \int_{\Omega^*} p(\omega)(1 + R_i(\omega))\, d\omega} \neq \frac{k_i'(\hat{I}_i)}{k_j'(\hat{I}_j)}. \tag{19}$$

In particular, consider two projects which are related as follows: $1 + R_j = 1 + R_i + z$. Let R^c denote the vector $\{R_1, \cdots, R_{j-1}, R_{j+1}, \cdots, R_n\}$. We impose the following condition on the behavior of z:

$$E(z \mid R^c, W) = E(z) = 0. \tag{20}$$

Condition (20) provides a natural generalization of the Rothschild-Stiglitz [23] definition of increasing risk to a world where portfolio opportunities are important. It is similar to the condition employed by Jagannathan [16] to show that the value of a call option increases in the risk of the underlying asset. It ensures that R_j is both a "mean-preserving" and a "price-preserving" spread of R_i. To see this, note that:

$$V(z) = \int_{\Omega} p(\omega)z(\omega)\, d\omega = E(Wz) = E[E(Wz \mid W)] = E[WE(z \mid W)] = 0. \quad (21)$$

The noise term, z, can be thought of as "diversifiable" or "residual" risk. Since it is fully insurable, it adds no meaningful risk to the return of asset j and does not affect its market value. Despite the economic insignificance of z, we show below that the option-like nature of the tax liability penalizes project j. The firm's decision makers avoid the risk associated with z, thus forgoing the full exploitation of economic rents which are valued in the financial market.

PROPOSITION I. *At optimality, there is underinvestment in the "risky" asset j, i.e.,*

$$\frac{k_i'(I_i^*)}{k_j'(I_j^*)} \leq \frac{k_i'(\hat{I}_i)}{k_j'(\hat{I}_j)}. \quad (22)$$

with strict inequality whenever $0 < Pr\{X(I^*) > D^*\} < 1$.

Proof: See Appendix A.

The proof formalizes the following intuition. Conditional on the returns from all the other projects, the variable z is positively correlated with the payment of taxes. When it is large, $X(I^*) > D^*$, and the firm's marginal tax rate is high. The firm prefers projects which are negatively correlated with taxes, which have their biggest payoffs in states where no taxes are paid, because these payoffs flow through entirely to security holders. Condition (20) ensures that the argument also holds unconditionally with respect to both the returns on other projects and the systematic risk in the economy.

It is important to realize that the distortional incentives induced by the option-like tax liability penalize the "risky" project even though the "risk" is not of significance from a market or societal perspective. For example, if all consumers are risk-neutral, financial assets will be priced according to their expectation, $W = 1/(1 + r_f)$, and project j can be taken to be more risky than project i in the Rothschild-Stiglitz sense. Yet even though consumers are risk-neutral, Proposition I holds, and firms underinvest in risky projects.

B. Mergers and Corporate Insurance

Examination of Equation (12) suggests a diversification motive for the firm. Projects which have high payoffs in states where the earnings to the firm as a whole are high will be penalized due to their contribution to the tax liability. The firm will overinvest in opportunities that are negatively correlated with its other projects. Thus, the tax option rationalizes corporate insurance. Insurance truncates the distribution of the firm's cash flows in states of the world where losses are redundant, and substitutes premium payments in states where the firm is solvent, and these premium payments are deductible. In this way, redundant deductions are transformed into deductions which truly shield income. Like insurance, pure conglomerate mergers are zero net present value activities in the face of no taxes or a proportional tax. They will, however, be rational responses to a tax regime in which noncash deductions may be redundant. Note that this motivation for merger is different than the unused-tax-shields explanation of mergers traditionally cited in the literature (e.g., Brealey and Myers [6, p. 705]). This latter motive is based on ex post considerations. That is, *after* a loss, a firm may wish to merge with a profitable concern to utilize its losses. We emphasize, on the other hand, the ex ante value of coinsurance provided through merger.

We can formalize this argument by considering the case of two firms. We hold their investment policies constant and evaluate the consequences of merger. Firm 1 generates earnings, X_1, and has noncash deductions, D_1. X_2 and D_2 are analogously the earnings and deductions for the second firm. The following demonstrates that for the tax regime described previously, there are gains to merger under virtually all circumstances. The proof is simple. It merely exploits well known properties of the $\max\{\cdot, \cdot\}$ function.

PROPOSITION II. *Net of taxes, and holding investment policies fixed, the value of the two firms merged is greater than or equal to the sum of their separate values. The inequality is strict unless*

$$\text{(a)}\quad \Pr\{X_1 > D_1 \mid (X_2 > D_2)\} = 1 \quad\text{and}\quad \text{(b)}\quad \Pr\{X_2 > D_2 \mid (X_1 > D_1)\} = 1$$

that is, unless there is no possibility that one firm has losses when the other does not.[3]

Proof: See Appendix B

Like Proposition I, this result concerning mergers is intended to give formal expression to the intuitive notion that firms with an option-like tax liability should behave in a more risk-averse fashion. As we will see in Section V, however, this result is much less robust to relaxation of the specific assumptions which give the tax liability its form. It depends not only on the convexity of the tax liability, but also quite specifically on the properties of the $\max\{\cdot, 0\}$ function.

II. Effect of Tax Liabilities on Bondholder-Stockholder Conflicts

The analysis in the previous section assumed that shareholder investment decisions were fully observable, so that no "moral hazard" arose between bondholders and stockholders. In this section we analyze shareholders' investment incentives when they take the promised payment on the debt as fixed, and then maximize the value of their own claim. We first show that, in many circumstances, the possibility of redundant deductions aggravates the types of risk-incentive conflicts between stock- and bondholders described by Jensen and Meckling [17].

[3] Conditions (a) and (b) are not equivalent to less-than-perfect correlation between the two firms. Lam and Boudreaux [19] discuss this point in connection with bankruptcy risk.

When the point at which the firm defaults exceeds that at which the firm ceases to pay taxes, the option properties of the equity claim are not affected by the tax liability. In the absence of taxes, shareholders undertake investment policies which are more risky than those which would maximize the NPV of the firm. When taxes are introduced the NPV, maximizing investment allocation becomes even less risky, and yet shareholder incentives are unchanged. The benefits associated with making the tax shields safer flow through to debtholders. Thus, while the tax option does not change the shareholders' incentives, it increases the magnitude of the agency problem those incentives engender.

When the exercise price on the tax option exceeds that on the default option, shareholders' risk incentives are no longer unambiguous. This is because their claim is concave over some regions of the firm's cash flows and convex over others. The nonconvexities imposed on the equity claim by the tax option have a natural interpretation as being analogous to a warrant or conversion privileges on a bond.

When shareholders take as given the capital structure of the firm and the funds at their disposal, the structure of their maximization problem changes, and Lemma 1 no longer applies. Let I^T denote the total amount of funds to be allocated across the n projects. Shareholders solve:

$P3$—

$$\max_I (1 - \alpha^*)V(\max[X(I) - B^*(1 + r^*) - \tau \max\{X(I) - D^*, 0\}, 0]) \tag{23}$$

$$\text{subject to} \quad \textstyle\sum_i I_i \leq I^T. \tag{24}$$

Clearly, the solution to $P3$ will in general differ from that of $P1$. For some capital structures this difference is unambiguous. Suppose depreciation expense is less than or equal to the face value of the debt. This would be the case, e.g., when the firm is entirely debt financed, even if the entire investment could be written off. In these circumstances, $D^* = \phi(\sum_i I_i) + r^*B^* \leq B^*(1 + r^*)$, and taxes are paid in all states where equity is paid. We can rewrite the objective function in $P3$ as $(1 - \alpha^*)(1 - \tau)V[\max\{X(I) - H, 0\}]$ where $H = [B^*(1 + r^*) - \tau D^*]/(1 - \tau)$ denotes the point of default. Note that the equity claim is still a simple call option. The tax rate enters the objective function through the determination of the default point and as a scalar multiple of the objective function. It has no effect on the budget constraint in $P3$, which takes the scale of the firm as given. Scalar multiples of the objective function will not affect the optimal solution. Therefore, the investment allocation determined through $P3$ will be the same as that which would be chosen by the firm if there were no taxes but it was levered with debt having a promised payment of H. Letting I^+ denote the optimal policy and Ω^+ the states with no default, the first-order conditions lead to the following expression:

$$k_i'(I_i^+)(1 - \tau) \int_{\Omega^+} p(\omega)(1 + R_i(\omega))\, d\omega = \lambda \tag{25}$$

where λ is a Lagrange multiplier. Notice now that, compared with (18), (25) treats the entire return of the project, and not just the taxed portion "asymmetrically" across states. If the return on project j is a mean- and price-preserving spread of project i, as described in Equation (20), we will now get overinvestment in the risky project relative to the no-tax case. The decision maker's objective is convex, rather than concave. From (25), the ratio of the marginal scale products for the two projects will be:

$$\frac{k_i'(I_i^+)}{k_j'(I_j^+)} = \frac{V_i^+ + \int_{\Omega^+} p(\omega)z(\omega)\, d\omega}{V_i^+} \tag{26}$$

where $V_i^+ = \int_{\Omega^+} p(\omega)(1 + R_i(\omega))\, d\omega$. Now project j is rewarded, not penalized, by the price of z over the upper portion of the firm's distribution.

PROPOSITION III. *If depreciation expense is less than the face value of outstanding debt,*

$$\frac{k_i'(I_i^*)}{k_j'(I_j^*)} \leq \frac{k_i'(\hat{I}_i)}{k_j'(\hat{I}_j)} \leq \frac{k_i'(I_i^+)}{k_j'(I_j^+)}. \tag{27}$$

Proof: Immediate from the arguments in the proof of Proposition I which imply that the second term in the numerator of (26) is positive. Q.E.D.

From (26), it is clear that the tax incentives described in Section I do not affect the behavior of shareholders when their choice of I is not observable, but that does not imply that they are unimportant. Shareholders take more risk than is "socially optimal," than they would take under proportional taxation with complete observability. But even that much risk-taking is wasteful from the point of view of the firm as a whole. The problem is that the tax savings associated with risk avoidance all benefit bondholders, and because of the "moral hazard" problem, there is no way for shareholders to share in those benefits through lower interest rates on the debt claims they issue.

When depreciation exceeds the face value of the debt (and default is still possible) the risk-taking incentives of shareholders become ambiguous. The shape of their claim is depicted in Figure 1 and is the same as the residual claim

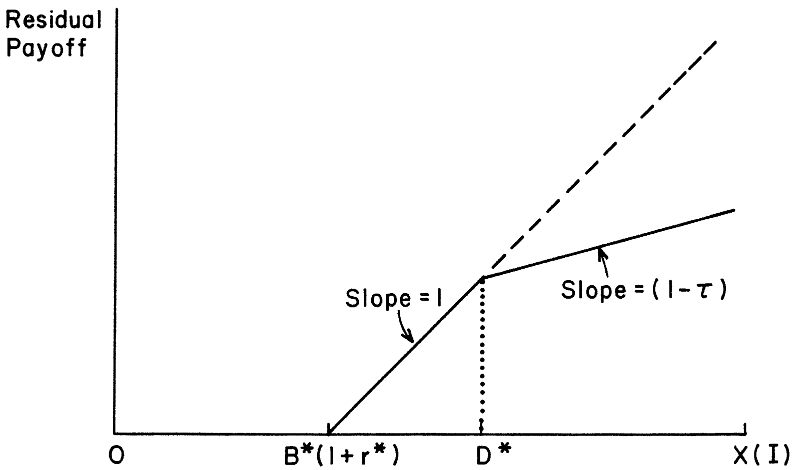

Figure 1. Residual Claim when Depreciation Exceeds Par Value of Debt

associated with an untaxed firm issuing convertible debt or warrants which allow bondholders to purchase a fraction, τ, of the equity. When earnings get high enough, the option on the equity claim is exercised. The residual claim is concave over the no-default region, while it is convex over the no-tax region. The first-order conditions relate the investment in the risky project j and the less risky project i as follows:

$$\frac{k_i'(I_i^+)}{k_j'(I_j^+)} = \frac{V_i^+ + \int_{\Omega^+} p(\omega)z(\omega)\, d\omega - \tau \int_{\Omega^*} p(\omega)z(\omega)\, d\omega}{V_i^+} \tag{28}$$

where now $V_i^+ \int_{\Omega^+} p(\omega)(1 + R_i(\omega))\, d\omega - \tau \int_{\Omega^*} p(\omega)(1 + R_i(\omega))\, d\omega > 0$. The second and third terms in (28) may combine to either penalize or reward the riskier project depending on whether they sum to be negative or positive, respectively.

In fact, it is at least possible that there are some capital structures in the range $0 < B \leq \phi(\sum_i I_i)$ which result in even *less* risk taking by shareholders than when the firm is unlevered or when they maximize firm NPV. This runs counter to the usual notion that bondholder-shareholder conflicts increase with the firm's leverage. A careful consideration of (28) and the definition of V_i^+ reveals how this situation might arise. Starting with an unlevered firm, the second and third terms in the numerator of (28) sum to a negative number since $\Omega^+ = \Omega$ and $\int_\Omega p(\omega)z(\omega)\, d\omega = 0$. As we increase the amount of debt in the capital structure and hence the probability of default, the second term in the numerator becomes positive, and this will increase the numerator unambiguously. Both the denominator and the third term in the numerator also change, however, and these effects are not unambiguous. For example, suppose project i is negatively correlated with the rest of the firm's projects, so that $1 + R_i$ is largest in states where default occurs. Then these are precisely the payoffs we are eliminating from the denominator of (28) as Ω^+ shrinks. Even if the numerator is less negative, the quotient which determines how the risky project is penalized relative to the less risky one may become more negative.

III. Principal- Versus Interest-First Tax Doctrines

Unlike some previous studies, e.g., Kraus and Litzenberger [18], we have not assumed that principal is tax deductible. Thus, in our model, taxes may be paid in default states. When operating income, $X - \phi(\sum_i I_i)$, is positive, shareholders may still default because cash flow after taxes is less than the promised payment to debt holders. If this situation occurs, and the firm makes only a partial payment to debt holders, which "part" of the debt claim are they paying, principal or interest? The amount of taxes paid will depend on this. Suppose, e.g., that the partial payment exceeds the interest but is less than the principal amount. If the payment is credited first to principal the firm will have no interest expense and operating income is fully taxed. If the payment is credited first to interest, the deductions are preserved.

Both the principal-first and the interest-first doctrine have been modeled in previous studies. For example, Baron [4] assumes priority of corporate interest over repayments of principal, and Turnbull [27] assumes a principal-first doctrine. Which most closely approximates the tax code is not obvious. A literal interpretation of the single-period model would suggest that principal-first is appropriate, because it applies in bankruptcy when the debt claim is settled in a lump sum.[4] On the other hand, in many situations the firm may make some or all of its interest payments over a period, and then default when the loan comes due. The interest payments already made in the current tax period are deductible. The interest-first doctrine applies in this situation.[5]

In Section II, we employed the interest-first doctrine because it gives the tax liability a simple, option-like structure. Here we briefly consider the consequences of applying the principal-first doctrine. We note first, however, that in many situations this distinction has no consequence. The issue here involves taxes paid in bankruptcy, and accordingly will not affect the structure of the equity claim or the incentives associated with that structure. If, as in the previous section, shareholders act to maximize the value of their claim rather than the NPV of the firm, their investment choices will be invariant to the tax treatment of payments to bondholders. Alternatively, when noncash deductions from other sources, such as depreciation, exceed the principal amount on the debt, taxes are never paid in bankruptcy. Obviously, in this situation the question of principal- versus interest-first does not arise.

There remains, then, the case where depreciation is less than the principal amount on the debt. If $X(I) < B^*(1 + r^*)$, shareholders will choose to default, and yet $X(I)$ may exceed depreciation. Under interest-first, the shortfall comes out of principal, and the interest deduction is r^*B^*. No taxes are paid if operating income is less than that amount. With principal-first, no interest deductions are allowed until cash flow less taxes exceeds principal, and then only for the residual. Thus, interest expense is zero when

$$X(I)(1 - \tau) + \tau\phi(\textstyle\sum_i I_i) < B^*. \tag{29}$$

or

$$X(I) < \frac{B^* - \tau\phi(\sum_i I_i)}{1 - \tau} \equiv g. \tag{30}$$

Once $X(I)$ exceeds g, as defined by the right-hand side of (30), each marginal dollar is deductible interest and hence tax-free. The interest expense will then be determined as the minimum of this residual quantity and the promised interest. As a function of $X(I)$, then, the tax liability is:

$$\text{Taxes} = \tau \max\{X(I) - \phi(\textstyle\sum_i I_i) - \min[r^*B^*, \max\{X(I) - g, 0\}], 0\}. \tag{31}$$

The effect of this tax liability on risk taking will be ambiguous. Equation (31) shows that it is the maximum of a minimum. It will therefore be concave over some regions and convex over others. An individual project will contribute, at the margin, to the tax liability if it increases earnings in states where operating

[4] See Talmor, Haugen, and Barnea [26] for citations.

[5] Park and Williams [21] provide a detailed discussion of situations where interest-first treatment is appropriate.

income is positive. This tends to make mean-preserving spreads valuable to the government. However, every dollar a project adds to earnings in the states where partial interest payments are made simply increases deductions. For example, a project which had positive payoffs in only these states would be very valuable to the firm. It would be viewed at the margin as tax-free. For mean-preserving spreads, this latter effect is ambiguous in sign and magnitude. Valuing the added risk over these states involves integrating over an interval in the middle of its distribution, and, unlike integrals over the upper tail, these values can be positive, negative, or zero.

IV. Loss Carry-Overs

The incentive effects of the government's tax option may be mitigated by the firm's ability to carry losses forward and back across periods. These opportunities fall short of a fully proportional tax for two reasons. First, the time-value of money implies taxes paid today are more valuable than rebates received tomorrow. Second, losses in future periods are uncertain, so if losses can only be carried back a finite number of years, there is always some probability that the taxes will never be refunded. The estimates of Cordes and Sheffrin [10, 11] and Auerbach [3] suggest that the average marginal rate paid by U.S. corporations is well below the statutory rate, an observation which is consistent with something less than full loss offset.

One can intuitively evaluate the effect of these provisions in the tax code as follows. The distortions we have described result from the fact that projects which have high marginal payoffs in states where earnings to the firm as a whole are high contribute to both the tax liability and the returns for the firm's security holders. These projects are accordingly penalized in terms of the allocation of funds, relative to projects with high payoffs in states where earnings are low and where marginal returns accrue entirely to the firm's financial claimants.

Under loss carry-back, if the firm has positive earnings presently, but a loss in a subsequent period, it can claim a rebate from the government to the extent of its previous tax liability. Thus there is some possibility that a project's marginal contribution to the tax liability will be refunded. But will marginal payoffs in states where the firm pays taxes be as valuable as those in states where the firm has a loss? The answer is clearly no for the two reasons mentioned above. Furthermore, the larger the firm's present earnings, the less likely it is that they can be fully offset by future losses. If corporate earnings tend to be serially correlated over time, such intertemporal dependencies would further reduce the chance that present tax payments will eventually be refunded.

Considering now the impact of loss carry-forward, suppose the firm has a loss this period which it can carry foward to offset earnings the following period. How will this affect decisions taken now which determine the stochastic behavior of earnings next period? The ability to carry losses forward can be viewed as an increase in the allowable deductions for the following period. This makes the exercise price on the option held by the government higher but does not alter the basic structure of its claim on the firm. The results in Section I only require that the probability of exercise on the option be between zero and one. They put no other restrictions on the magnitude of the exercise price. Thus, decisions taken now, which determine the behavior of earnings next period, will reflect the incentives to take less risk and lower the value of the government's claim.

These arguments suggest that the firm still has incentives to avoid risky projects because, in any one period, they are correlated with the government's nonlinear claim against the firm. It is difficult to characterize these phenomena in closed form, however, because of the path dependencies introduced by the carry-overs. For example, loss carry-forwards could be viewed as the government holding a call on the firm's cash flow in each period with a path-dependent exercise price. Writing down the associated cash flows, however, is a formidable undertaking. Nevertheless, it is fairly simple to at least "bound" the mitigation of the option effects associated with carry-overs by considering their analogy with mergers. Projects which contribute to the tax liability are penalized because future refunds are (a) discounted and (b) uncertain. Suppose we ignore the first of these factors and assume that all the discount rates are zero. Let X_1 and X_2 be the random earnings in each period, and let D_1 and D_2 be the deductions. If $X_1 + X_2 \leq D_1 + D_2$, the firm pays no taxes, and if $X_1 + X_2 > D_1 + D_2$ it pays taxes of $\tau[X_1 + X_2 - (D_1 + D_2)]$. Thus the government's total claim on the firm is:

$$\tau \max\{X_1 + X_2 - (D_1 + D_2), 0\}. \tag{32}$$

This can be viewed as a call option on a "merged" firm; i.e., a firm with earnings equal to the sum of X_1 and X_2 and deductions equal to the sum D_1 and D_2. Without loss transferability, the governments claim would be:

$$\tau \max\{X_1 - D_1, 0\} + \tau \max\{X_2 - D_2, 0\}. \tag{33}$$

By the arguments presented in the discussion of mergers, (33) stochastically dominates (32); but the present value of (32) will still be increasing in the risk of either X_1 or X_2. Thus loss carryback-carryforward provisions leave the basic option-like structure of the tax liability intact. Serial dependence between X_1 and X_2 will clearly reduce the extent to which the "merger" renders the tax shields riskless.

V. Progressive Corporate Taxes

Because of the complexity of the tax code, the effective marginal tax rate on corporate income is actually not fixed, but tends to have a progressive structure. First, the statutory corporate tax rate is progressive for income up to $100,000. More importantly, as discussed in detail by Cordes and Sheffrin [11], the effective corporate tax rate may differ from the statutory marginal tax rate due to one or more of the following factors: (1) alternative tax on corporate capital gains; (2) rules that link the amount of investment tax credit that can be used to the amount of tax liability;[6] (3) rules for computing and claiming the foreign tax

[6] For a close examination and assessment of the impact of the investment tax credit on effective corporate tax rates across industries, see Gravelle and Kiefer [14].

credit;[7] (4) the imperfect nature of carry-overs of net operating losses; and (5) the method for computing the corporate minimum tax.

The effective marginal tax rate on corporate income might be best described, therefore, as piecewise linear and progressive, with a present maximum rate of 46 percent. The call option structure for the tax liability described in Section I is a simple example of such a progressive (or convex) tax schedule. It has long been recognized in the public finance literature that progressivity can affect "risk-taking" although as Atkinson and Stiglitz [1, p. 98] have stated, "the interpretation of the concept is not entirely straightforward." We have interpreted risk-taking in terms of the firm's choice of asset mix and its incentives to diversify through merger. It seems reasonable to ask, therefore, whether, in our value-maximizing setting, there is reduced risk-taking under arbitrary progressive tax regimes. Interestingly, the answer differs across the two measures of risk-taking we have employed. The distortions in the asset mix which prevailed under the simple tax regime survive under any progressive corporate tax, as the next result shows.

PROPOSITION IV. *Let $\Psi(X)$ be the total amount of taxes paid by the firm, and let the marginal tax rate be positive, nondecreasing everywhere and increasing for some levels of X. Then at optimality there is underinvestment in the riskier of any two assets related as in Proposition I.*

Proof: See Appendix C.

On the other hand, the benefits of merger do not survive for arbitrary progressive tax regimes. They depend more particularly on the symmetry of the $\max\{\cdot, 0\}$ function around zero. If there are other kinks in the tax schedule at positive earnings levels, merger may not be beneficial because of the "marriage penalty." The certainty case makes clear the nature of the problem. Suppose the tax rate increases at a level of taxable income equal to 10 million dollars. Two firms, each with certain cash flow less deductions of 9 million dollars, would increase the government's take by merging. Some of their income would be taxed at the higher rate while all of it is currently being taxed at the lower rate.

VI. Conclusions

We have attempted to show that tax liabilities assume the form of a negative position in a call option. This analogy was applied to evaluate the effects on corporate investment incentives. It was shown that these incentives are manifest as suboptimally "risk-averse" investment choices and also in gains from merger.

The design and implementation of "neutral" tax systems has long been a concern of economic theorists and policy makers (see, e.g., Sandmo [24] and Auerbach [2]). In view of the incentive problems which this paper highlights, a number of features in the tax code which allow firms to partially utilize tax losses can be better understood. For instance, much of the Economic Recovery Act of 1981 is directed toward this end. Thus, viewing such legislation simply as a

[7] Frisch [13] studies in detail the effect of foreign source income on the marginal U.S. tax rate on *domestic* activities.

windfall for the corporate sector may overlook important benefits to society in terms of investment allocation. Of course, movement towards fully proportional taxation may aggravate other adverse incentives such as the moral hazards described by Atkinson and Stiglitz [1, p. 115]. Further, this paper has highlighted the incentive effects of questions which are often overlooked in discussions of tax policy, e.g., the treatment of taxes in bankruptcy and conflicts of interest between bondholders and shareholders. Formulation and reevaluation of tax policy should be performed, therefore, through a careful balancing of conflicting incentives.

Appendix A

Proof of Proposition I: Let λ be the indicator function for the event, $X(I^*) > D^*$. Noting that

$$\int_\Omega p(\omega)(1 + R_j(\omega))\ d\omega = \int_\Omega p(\omega)(1 + R_i(\omega))\ d\omega + \int_\Omega p(\omega)z(\omega)\ d\omega$$

$$= \int_\Omega p(\omega)(1 + R_i(\omega))\ dw \tag{A1}$$

it immediately follows by Equation (15) that $[k_i'(\hat{I}_i)/k_j'(\hat{I}_j)] = 1$. Denote the value of $(1 + R_i)$ over all states as $\bar{V}_i$. Applying Equation (18) to the case at hand, we obtain

$$\frac{k_i'(I_i^*)}{k_j'(I_j^*)} = \frac{\bar{V}_i - \tau \int_{\Omega^*} p(\omega)(1 + R_i(\omega))\ d\omega - \tau \int_{\Omega^*} p(\omega)z(\omega)\ d\omega}{\bar{V}_i - \tau \int_{\Omega^*} p(\omega)(1 + R_i(\omega))\ d\omega}$$

$$= 1 - \frac{\tau \int_{\Omega^*} p(\omega)z(\omega)\ d\omega}{\bar{V}_i - \tau \int_{\Omega^*} p(\omega)(1 + R_i(\omega))\ d\omega}. \tag{A2}$$

The first-order condition for project i, (18), ensures that the denominator of the right-hand side of (A2) is positive. Thus, our result will follow if it can be shown that

$$0 < \int_{\Omega^*} p(\omega)z(\omega)\ d\omega = E[Wz\lambda]$$

$$= E[WE(\lambda z \mid R^c, W)]$$

$$= E[Wh(R^c, W)]. \tag{A3}$$

If, for a particular R^c, the conditional probability that $\lambda = 1$ is positive and less than one, then $E(\lambda \mid R^c, W) > 0$ and

$$\begin{aligned} h(R^c, W) &= E(\lambda \mid R^c, W) \frac{E(\lambda z \mid R^c, W)}{E(\lambda \mid R^c, W)} \\ &= E(\lambda \mid R^c, W) E(z \mid z > a(R^c), R^c, W) \\ &> E(\lambda \mid R^c, W) E(z \mid R^c, W) = 0 \end{aligned} \tag{A4}$$

where

$$a(R^c) = \frac{D^* - k_j(I_j^*)(1 + R_i) - \sum_{l \neq j} k_l(I_l^*)(1 + R_l)}{k_j(I_j^*)}. \tag{A5}$$

If, for given R^c, the conditional probability that $X(I^*) > D^*$ is zero, then $h(R^c, W) = 0$; and if the conditional probability is one, then z is always greater than $a(R^c)$ so that by (A4) $h(R^c, W)$ is zero. Thus, $h(R^c, W)$ is nonnegative for all R. It is positive for some R^c if $0 < E(\lambda) < 0$. Q.E.D.

Appendix B

Proof of Proposition II: It suffices to show, since the valuation operator is linear and positive, that the government's claim on the two firms separately stochastically dominates its claim on the two firms together. Let $Y_1 = X_1 - D_1$ and $Y_2 = X_2 - D_2$.

$$\begin{aligned} \max\{Y_1, 0\} + \max\{Y_2, 0\} &= \max\{Y_1 + \max[Y_2, 0], \max[Y_2, 0]\} \\ &\geq \max\{Y_1 + \max[Y_2, 0], 0\} \\ &\geq \max\{Y_1 + Y_2, 0\}. \end{aligned} \tag{B1}$$

The left-hand side of the above is proportional to the taxes paid by the two firms separately and the last term to the taxes on the merged firm. If the first condition in the theorm is not met, the first inequality in (B1) will be strict for some event with positive probability. Failure of the second condition implies likewise that the second inequality is strict. Q.E.D.

Appendix C

Proof of Proposition IV: The optimal investment policy of the firm is the solution to

$$P4\text{—} \max_I \int_\Omega p(w)[X(I, \omega) - \Psi'(X[I, \omega])] \, d\omega. \tag{C1}$$

Using the first-order conditions, and defining $\phi(\omega) = 1 - \Psi'[X(I^*, \omega)]$, one obtains:

$$\frac{k_i'(I_I^*)}{k_j'(I_j^*)} = \frac{\int_\Omega p(\omega)[1 + R_j(\omega)]\phi(\omega)\, d\omega}{\int_\Omega p(\omega)[1 + R_i(\omega)]\phi(\omega)\, d\omega}$$

$$= 1 + \frac{E(Wz\phi)}{E(W(1 + R_i)\phi)} \tag{C2}$$

where z and W are related as in Equation (20). Since $k_i'(\hat{I}_i)/k_j'(\hat{I}_j) = 1$ and $E[W(1 + R_i)\phi] > 0$, we need only show that

$$E(Wz\phi) = E[WE(z\phi \mid W, R^c)] < 0. \tag{C3}$$

Since W is positive, (C3) would hold if the expression

$$E(z\phi \mid W, R^c) = E(z \mid W, R^c)E(\phi \mid W, R^c) + \mathrm{cov}(z, \phi \mid W, R^c) \tag{C4}$$

is negative. Realizing the $E(z \mid W, R^c)$ is identically zero, the sign of (C4) will be determined by the covariance term. By the definition of Ψ, and conditional on R^c, $\phi(\omega)$ is a nonincreasing and nonconstant function of z, which implies that $\mathrm{cov}(z, \phi \mid W, R^c) < 0$. Q.E.D.

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