The Tax (Dis)Advantage Of A Firm Issuing Options On Its Own Stock *

Robert L. McDonald†

First draft: June, 2000

January 27, 2003

Abstract

It is common for firms to issue or purchase options on the firm's own stock. Examples include convertible bonds, warrants, call options as employee compensation, and the sale of put options as part of share repurchase programs. This paper shows that option positions with implicit borrowing—such as put sales and call purchases—are tax-disadvantaged relative to the equivalent synthetic option with explicit borrowing. Conversely, option positions with implicit lending—such as warrants—are tax-advantaged. I also show that firms are better off from a tax perspective issuing bifurcated convertible bonds—bonds plus warrants—rather than an otherwise equivalent standard convertible.

Keywords: Corporate tax, options, put warrants, convertible bonds, compensation options

JEL Codes: G32, H25

*I thank two anonymous referees, participants at the 2001 UNC Tax Conference, NBER Summer Institute, 2001 International Seminar in Public Economics, Alan Auerbach, Andy Brown, Mehir Desai, John Graham, Michael Knoll, Stewart Myers, Mitchell Petersen, Todd Pulvino, Lemma Senbet, Chester Spatt, David Stowell, and Alvin Warren for helpful conversations. I also thank John Graham for providing his firm-specific measure of marginal tax rates. The latest version of this paper is available from http://www.kellogg.nwu.edu/faculty/mcdonald/htm/.

†Finance Dept., Kellogg School, Northwestern University, 2001 Sheridan Rd., Evanston, IL 60208, tel: 847-491-8344, fax: 847-491-5719, E-mail: r-mcdonald@northwestern.edu.

1 Introduction

Tax issues play a central role in discussions of capital structure and security design. However, little consideration has been paid to the tax consequences of a firm issuing options on the firm's own stock, despite the fact that such issues are relatively common. For example, firms issue convertible bonds, warrants, call options as part of employee compensation, and sell put options and sometimes purchase calls as part of share repurchase programs. This paper shows that some of these transactions are tax advantaged and others tax disadvantaged, and provides a simple summary measure of the tax (dis)advantage.

For some firms, options can be a significant part of capital structure. To take one prominent example, Microsoft in June 2002 had compensation options outstanding on 832 million shares, against 5.4 billion outstanding shares. In addition, "Microsoft enhanced the program by selling put warrants to independent third parties."[1] taking in $472 million in premium from sales of puts in 2000 alone.[2] For firms which make any use of compensation options, Core and Guay (2001) find that options are 6.9% of shares outstanding. Using a broader sample, Eberhart (2001) finds options to be 12% of shares outstanding.

In the U.S., transactions by a firm in its own stock and options on its own stock have no tax consequences for the firm under Section 1032 of the Internal Revenue Code. However, any option position has a synthetic equivalent comprised of some position in the stock and either borrowing or lending. Interest income or expense is taxed. By comparing the cash flows of the option position, which is not taxed, with that of the equivalent synthetic position, for which interest but not equity is taxed, it is straightforward to show that option positions with implicit borrowing—long forward contracts, put sales and call purchases—are tax-disadvantaged relative to the equivalent position with explicit borrowing. Conversely, option positions with

[1] Microsoft 2000 10-K

[2] Companies typically describe put sales as a way to reduce the cost and/or risk of share repurchase programs. We discuss possible rationales later in the paper. Gibson and Singh (2000) suggest that put sales serve to signal firm quality, although many such sales are conducted in secrecy and hence cannot be a signal. In the practitioner literature they are often described as a risk-management technique for share repurchase programs. For example, see Thatcher et al. (1994). A number of companies have sold puts; Angel et al. (1997) report that option traders believe that over 10% of firms repurchasing their shares sell puts, and according to Gibson and Singh (2000), over 100 firms have issued puts since 1988.

implicit lending—short forward contracts, put purchases, and call sales—are tax-advantaged.

Both Titman (1985) and Warren (2000) have previously shown that firms can effect tax arbitrage by shorting forward contracts on their own stock.[3] I discuss their example of forward contracts in Section 2 and then extend the existing analysis of forward contracts to other claims on the firm's stock such as options. I derive a simple formula that measures the tax advantage or disadvantage of a European derivative. I then use this analysis to examine the importance of the tax cost for several common option types, including calls, puts, and convertible bonds. I also examine the tax cost of specific transactions undertaken by Microsoft and Dell. The paper's contributions are thus to show how the tax issues for forward contracts extend to options, to provide an easy way to assess the tax cost of claims on the company's stock, and to provide specific examples illustrating this cost. Since it turns out that common transactions are tax-disadvantaged, I discuss possible reasons for firms to nevertheless undertake these transactions.

For European options, I show that the tax advantage or disadvantage of the option is $\tau r T B$, where τ is the corporate tax rate, r the continuously compounded interest rate, T the maturity of the option, and B the lending implicit in the option. The sign of B determines whether the option position is tax-advantaged or disadvantaged. This expression is the present value of the cash flow difference between the implicit and explicit debt component of the option.

This result depends only on the corporate tax rate, and thus seems to ignore the tax treatment of the investor emphasized by Miller (1977). However, I make the comparison between the issuance of an actual option and a synthetic option by using a dealer as a tax intermediary, thereby holding fixed the tax position of investors. Specifically, suppose Firm A issues an actual option to a dealer, who in turn hedges the position. The hedging transaction results in the dealer selling a synthetic option, which means that investors in the aggregate hold a synthetic option. Firm B issues the synethetic option, trading in its own stock and bond to achieve the same result as Firm A. Both strategies result in the ultimate investors holding the *same* position in shares and bonds. Since the ultimate investors hold the same position in either

[3] Titman (1985) argues that firms in general should issue debt and sell forward contracts on their own stock in lieu of issuing equity, with low tax investors being the counterparty.

case, personal taxes are held fixed in comparing the two alternatives so they can be ignored. Dealers do in fact intermediate in this way when firms sell put options, and dealers sometimes buy convertible bonds and sell the components.

As an illustration of this tax measure I examine in detail firm sales of put warrants, a transaction that has recently received a great deal of publicity. A put warrant obligates a firm to buy its stock back at a fixed price if the stock at a specific future date is worth less than the fixed price. Companies that have sold puts include Microsoft, Dell, Intel, EDS, and Maytag. The analysis in this paper shows that put sales are tax-disadvantaged, so a question is why firms nevertheless undertake such transactions. Firms may gain some non-tax benefit from selling puts, in which case the tax disadvantage is a lower bound on the value of this non-tax benefit. For example, the debt implicit in put sales could have provided a way for firms to issue debt without the debt being recognized by ratings agencies. Another issue is that put-selling firms may have low marginal tax rates, in which case the tax disdavantage is less important. Graham et al. (2002) and Kahle and Shastri (2002) provide both direct and indirect evidence that in recent years firms with signficant exercise of compensation options have low marginal tax rates. Some of the prominent put-selling firms also make heavy use of compensation options. I discuss these and several other possibilities in Section 5.

The plan of the paper is as follows. Section 2 discusses Section 1032 of the tax code, which governs the treatment of transactions in a firm's own stock, and presents examples of tax non-neutrality for forward contracts and put options. Section 3 discusses the effect of taxes in pricing derivatives. The calculation of the tax benefit implicitly assumes that the option is traded in a public market, or priced as if it were. In this case, I assume the option price is determined by market-makers who are taxed symmetrically on all forms of income and hence are tax-netural.

Section 4 values the tax non-neutrality by comparing the cash flows to a firm selling a put option to one synthetically creating a put by transacting in shares and borrowing. The sale of puts by Dell and Microsoft, and related institutional issues, is examined in Section 5. Section 6 looks at convertibles, and shows that firms are better off issuing straight debt plus warrants (a bifurcated convertible) rather than an otherwise equivalent convertible. Section 7 concludes.

2 Section 1032

Section 1032 of the Internal Revenue Code governs the tax treatment of the corporate exchange of stock for money or property. It reads, in part, as follows:

> (a) NONRECOGNITION OF GAIN OR LOSS.—No gain or loss shall be recognized to a corporation on the receipt of money or other property in exchange for stock (including treasury stock) of such corporation. *No gain or loss shall be recognized by a corporation with respect to any lapse or acquisition of an option to buy or sell its stock (including treasury stock).* [emphasis added]

The non-taxability of option transactions (such as put sales) was added to Section 1032 in 1984.

The following example, similar to an example in Warren (2000), illustrates how the non-taxability of equity transactions generates a tax difference between transactions that are equivalent on a pre-tax basis.

2.1 Forward Contracts

Suppose a firm with a stock price of $S_0 = \$100$ has a 40% tax rate. The interest rate is $r = 10\%$. Given these assumptions the forward price is $F = S_0 \times (1 + r) = \$110$. Consider the following two transactions:

1. The firm today sells one share for \$100 and invests the \$100 in a bond paying 10% pre-tax. In one year the firm has $\$100 \times [1 + .1 \times (1 - .4)] = \$106$.

2. The firm enters into a short forward contract to sell the share in one year for \$110. One year from now the firm completes the transaction and receives \$110.

In both cases, the firm after one year has an additional share outstanding and has cash with a pre-tax value of \$110. In the first case the firm issues a share and buys a bond today. In the second case the short forward contract is economically equivalent to issuing a share and buying a bond. The difference in the two cases stems from the fact that interest income is taxed when the firm *explicitly* buys a bond, but is untaxed when the firm *implicitly* buys a bond by selling a forward contract that is completely free of tax under Section 1032.[4]

2.2 Put Options

The example using a forward contract generalizes to other derivatives. We illustrate this by considering a firm that buys a put option with one year to expiration and a \$110 strike price. This put enables the firm to sell a share for \$110 in one year if the stock price is less than \$110, guaranteeing a minimum price (\$110) at which the firm will be able to sell its stock. I assume that if the price in one year exceeds \$110, the firm sells a share at the higher market price. Thus, this example is similar to the forward contract in the previous example except that the price at which the firm sells a share is contingent on the future stock price.

Assume that the stock price today is \$100 and after one year will be either \$50 or \$150. The top panel of Figure 1 illustrates the payoff to a put with a strike price of \$110. The value of the put in one year is 0 if the stock price is \$150 and \$60 if the stock price is \$50. Given the assumption about the behavior of the stock, the option price and synthetic equivalent of the option can be computed using standard binomial pricing calculations (for example see Cox et al. (1979) or McDonald (2003)).[5] If the risk-free rate is 10%, the theoretical price of the put, given the stock price distribution in the top panel of Figure 1, is \$21.82.

The bottom panel of Figure 1 illustrates that the purchase of a 110-strike put on one share is equivalent to selling 0.6 shares and lending \$81.82. The cost of this strategy, which also equals the price of the put, is

$$0.6 \times \$100 - \$81.82 = -\$21.82$$

Thus, the purchase of a put option is a way for the firm to perform the economic equivalent of selling 0.6 shares at the current market price and 0.4 shares in one year.

We now compare the after-tax cash flows of a firm that buys a put with the

[4]There have been proposals to tax the interest component of a forward sale on the firm's own stock, which would cause both transactions to have the same after-tax return. However, options have not been included.

[5]Equations (16) – (19) in Appendix A.1 are used to produce this example.

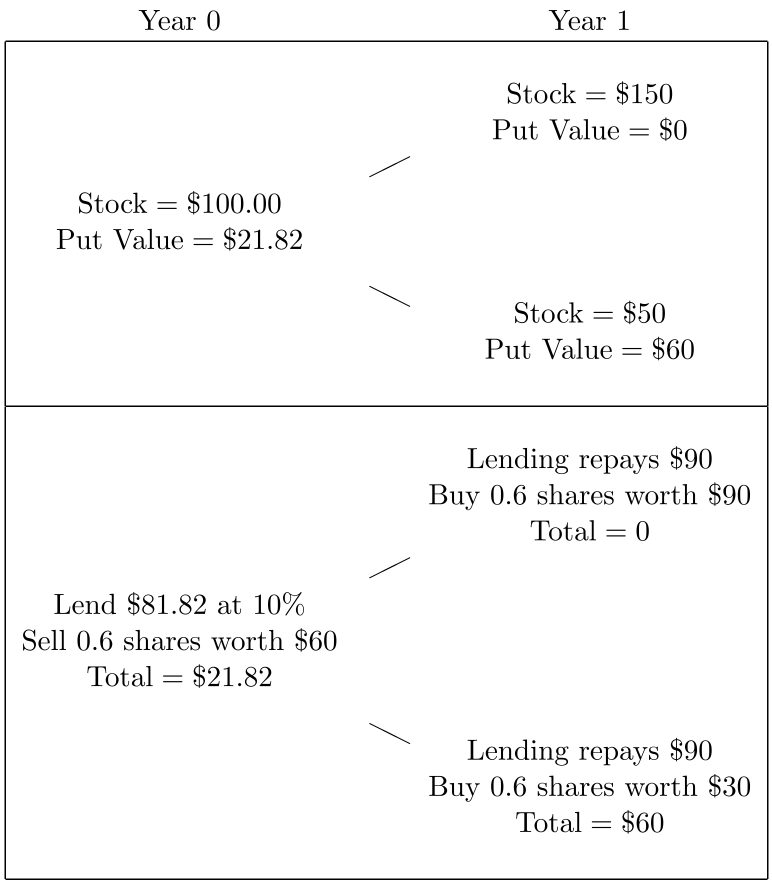

Figure 1: Top panel depicts binomial stock price movements and put option values, assuming the current stock price is $100 and the pre-tax interest rate is 10%. Bottom panel depicts transactions in the stock and borrowing which replicate a purchased put option.

Table 1: Cash flows for a put buyer. The table assumes that the firm borrows \$21.82 to buy a put at time 0. If the share price in one year is \$50, the firm exercises the put, selling a share for \$110. If the share price in one year is \$150, the put expires worthless and the firm sells a share for the market price of \$150. In either case, the firm must repay \$23.13, the value of the borrowed option premium plus 6% interest.

Time 1 Stock Price	Revenue From Sale of Share	FV(Option Premium)	Net Cash Flow
\$150	\$150	-\$23.13	\$126.87
\$50	\$110	-\$23.13	\$86.87

Table 2: Cash flow for an actual issuer of shares, where the share issues are equivalent to those with a put. The firm sells 0.6 shares at time 0 and invests the \$60 proceeds at the 6% after-tax interest rate. At time 1, the firm sells an additional 0.4 shares at the market price. The "Total" column is the sum of the revenue from the share sale at time 1 and the invested proceeds from the time 0 share sale. The "Difference" column is the difference between the Total time 1 cash from the actual share sale and the total time 1 cash flow from buying an actual put, detailed in Table 1.

Time 1 Stock Price	Revenue From Sale of 0.4 Shares	FV(Revenue From Sale of 0.6 Shares)	Total	Difference
\$150	\$60	\$63.60	\$123.60	-\$3.27
\$50	\$20	\$63.60	\$83.60	-\$3.27

after-tax cash flows of a firm that undertakes the synthetic equivalent of buying the put. In both cases, we assume the firm's goal is to have one additional share outstanding at time 1. Table 1 shows the after-tax cash flows of a firm that buys the put for \$21.82, borrows this cost, and then after one year exercises the put if the stock price is below \$110 and otherwise sells the share for \$150. In year 1, the after-tax repayment of the borrowed amount is $\$21.82 \times [1 + 0.1(1 - .4)] = \$23.13$.

As an alternative to the put purchase, the firm can sell 0.6 shares today at the market price of \$100, investing the proceeds of the sale, and sell the remaining 0.4 shares in one year at the market price at that time. The time 1 cash flows from this transaction are shown in Table 2.

The "Difference" column in Table 2 shows that the firm earns \$3.27 less with the synthetic put purchase than with the actual put purchase in Table 1. To understand this, consider the difference in taxable interest expense generated by the two strategies. The firm buying the actual put borrows the money, deducting interest expense on \$21.82. The firm undertaking the synthetic strategy invests \$60 and pays tax on the resulting interest income. The difference in taxable interest for the two cases is $10\% \times \$81.82 = \$8.182$, which generates tax payments of $0.4 \times \$8.182 = \$3.27$. From Figure 1, \$81.82 is the borrowing required to synthetically create the purchased put.

In this example, synthetically creating a put entails the explicit purchase of taxable bonds. The purchased put, by contrast, has implicit lending, which has tax-free interest. The actual purchased put is therefore tax-favored relative to the synthetic equivalent.

As discussed in the introduction, it is quite common for firms to *sell* puts in conjunction with the repurchase of shares. To analyze a written put we can simply reverse the transactions in Tables 1 and 2. The written put implicitly contains a borrowing position, and thus is tax-disadvantaged relative to a synthetic written put for which interest expense is deductible.

3 Dealer Taxation and Derivative Pricing

The examples in Section 2 assume that derivative prices do not depend on tax rates. For example, we assumed that the forward price, F, is determined by the standard formula

$$F = S_0(1 + r) \tag{1}$$

where S_0 is the current stock price, r the interest rate, and F the time 0 forward price for delivery of one share at time 1. Similarly, the put-writing example in Section 2 depends on the option pricing formula not depending on taxes.

It is natural to ask whether the forward or option price *should* be affected by the taxation of market participants. If the forward price in the previous example had been \$106 instead of \$110, the forward sale would have generated the same return as a bond investment. In this section we discuss the tax treatment of dealers as the reason that the standard formulas for forward and option prices (such as equation (1)) include no adjustment for taxes.[6]

[6] The impact of taxes on derivative prices was studied by Scholes (1976), Cornell and French (1983), and Cox and Rubinstein (1985, pp. 271-274), who showed how prices depend upon taxes when capital gains, dividends, and interest are taxed at different rates. In Cornell and French (1983), the timing of tax payments differs across sources of income, so there is a non-neutrality even when tax rates are the same. This issue is also discussed in Scholes and Wolfson (1992).

Consider a dealer who, at time t, holds a derivative expiring at time T, with a price of $\phi_t(S_t, T)$. (We will hereafter assume the expiration time is T and not include it in the notation.) The dealer can hedge this position by taking an offsetting position in shares and bonds. Under standard assumptions (see Appendix A.1), a derivative with price $\phi_t(S_t)$ can be synthetically created by buying $\Delta_t(S_t)$ shares and buying $B_t(S_t)$ bonds, with $\Delta_t(S_t)$ and $B_t(S_t)$ varying as time passes and the stock price moves. The price of the derivative is the cost of the replicating portfolio, or

$$\phi_t(S_t) = S_t\Delta_t(S_t) + B_t(S_t) \tag{2}$$

We will refer to $\Delta(S_t)$ as the *implicit share* and $B_t(S_t)$ as the *implicit debt* in the derivative. A dealer owning N units of a derivative can offset the position by selling $N\Delta_t(S_t)$ shares and $NB_t(S_t)$ bonds. This synthetic position is *self-financing*, meaning that as Δ and B change over time, the replicating portfolio can be maintained without the need for additional payments.

To see how taxes affect the price of a derivative, suppose that each form of income for the dealer is taxed at a different rate: interest is taxed at the rate τ_i, capital gains on stocks at the rate τ_g, capital gains on options at the rate τ_O, and dividends at the rate τ_d. We assume that there exists a marginal investor for whom taxes on all forms of income are paid on an accrual basis, with no limit on the ability to deduct losses, or to offset losses on one form of income against gains on another form of income. Given these assumptions, Appendix A.1 demonstrates the following proposition.

Proposition 1 *When the marginal investor is taxed, the fair price for a derivative is obtained by making two substitutions in the standard formula:*

1. *Replacing the dividend yield, δ, with $\delta^* = \delta\frac{1-\tau_d}{1-\tau_O} + r\left(\frac{1-\tau_i}{1-\tau_O} - \frac{1-\tau_i}{1-\tau_g}\right)$*
2. *Replacing the interest rate, r, with $r^* = r\frac{1-\tau_i}{1-\tau_O}$.*

In practice, dealers face the same tax rate on all forms of income. It follows from Proposition 1 that the fair price for any derivative for a dealer is independent of taxes. Put differently, dealers are tax-neutral in the sense that they value any security on a pre-tax basis. To see this a different way, if V_t is the value of the security at time t and D_t its cash flow, and if the dealer is marked to market for tax purposes, then the value of the security is given recursively by

$$V_t = \frac{E_t[D_{t+1}(1-\tau) + V_{t+1} - \tau(V_{t+1} - V_t)]}{1 + r(1-\tau)}$$

where E_t is the time t expectation. This can be rewritten

$$V_t = \frac{E_t[D_{t+1} + V_{t+1}]}{1+r}$$

This result relies on two assumptions: all forms of income are taxed on accrual at the same rate, and taxable income includes changes in fair market value.[7]

If dealers are the marginal investor, the forward price will be given by equation (1). (Cornell (1985) shows empirically that taxes do not seem to affect the pricing of S&P 500 futures contracts.) An implication is that investors who are not in the same tax bracket with respect to all forms of taxable income will find almost any derivatives positions tax-advantaged or disadvantaged relative to the tax-neutral treatment of the dealer.

While a dealer values the option without consideration of taxes, the fair price for the firm for a derivative on its own stock reflects the differential tax treatment of debt and equity (including derivatives on its equity). For the firm, because of Section 1032, $\tau_g = 0$ and $\tau_O = 0$. Thus, the fair price is obtained by using the after-tax interest rate as the interest-rate.

In the remainder of this paper we will assume that market prices of derivatives are determined by tax-neutral dealers, and hence prices are described by standard formulas without any adjustment for taxes.

4 The Tax (Dis)advantage of Options

We now compute a measure of the tax advantage of a firm buying or selling an option on its own stock. As with the examples in Section 2, we compare transactions entailing actual borrowing (or lending) and transacting in shares, with derivatives positions that entail implicit borrowing and implicit share transactions. The comparison

[7] This result was first proven by Samuelson (1964) in the context of tax-neutral depreciation.

is therefore between two forms of a transaction with different tax consequences at the level of the firm.

We assume that a tax-neutral dealer is the counterparty when the firm buys or sells a derivative. If the firm creates a synthetic option using its own borrowing and shares, investors hold the securities the firm issues. If instead the firm sells an option to a dealer, the dealer hedges the position by selling a synthetic equivalent. This synthetic equivalent must in turn be held by investors in the aggregate. Investors have the same risk and tax treatment as when the firm creates the synthetic. Thus, for example, it is irrelevant for this comparison whether debt is tax-advantaged relative to equity in the sense of Miller (1977).[8]

4.1 Comparing Explicit and Implicit Debt

I now compare the cash flows for two firms. Firm 1 buys or sells a derivative expiring at time T, thereby acquiring a particular implicit debt and share position. Firm 2 achieves the same economic position by explicitly trading debt and shares. For simplicity, I assume that there is no other debt outstanding.

Although I will speak of Firm 1 acquiring a derivative and Firm 2 trading the synthetic equivalent, one can equivalently think of Firm 2 trading its shares and debt to implement a particular strategy, and Firm 1 buying a derivative that is designed to accomplish the same contingent trading strategy.

I assume that there is no default, either by the firm or by the derivative counterparty. Section 4.2 discusses default in more detail. At this point we note that default by the firm is an important issue only with long forward contracts and written puts, which, like debt, create a fixed obligation for the firm. Default should not occur on a purchased call.[9] Default also should not occur on a written call or purchased put since it is always possible to issue new shares to satisfy the option counterparty.

The firms have assets worth A_t, and n shares outstanding. Assets follow a binomial process, where assets in one period, A_{t+h}, can be either $A^+_{t+h} = u_A A_t$ or

[8]Note that for tradable securities issued by firms, the tax advantage computed by assuming that a tax-neutral market-maker is counterparty is a *lower bound* on the net tax benefit. The reason is that in equilibrium the most tax-favored counterparty will bid the highest price for the claim. A potential counterparty who is tax-disadvantaged relative to a dealer will bid a lower price for the derivative.

[9]With a purchased call, a bridge loan with acquired stock as collateral can be used to fund payment of the exercise price.

$A^-_{t+h} = d_A A_t$ with $u_A > d_A$. Corresponding to the process for assets, there is a process for the stock price, where S_t becomes either S^+_{t+h} or S^-_{t+h}.

Since we want to assess the difference in the value of tax deductions for actual and implicit debt, it will prove useful to understand how implicit debt, $B_t(S_t)$ behaves over time. Suppose, as in Section 3, that the stock follows a binomial process, with implicit debt viewed as a function of time and the stock price. Proofs of the following are in Appendix A.2.

Proposition 2 *Implicit debt at time t is the present value of expected implicit debt in the next binomial period, at time $t+h$. That is,*

$$B_t(S_t) = \frac{1}{1+r_h}\left[p_h B_{t+h}(S^+_{t+h}) + (1-p_h)B_{t+h}(S^-_{t+h})\right]$$

Corollary 1 *For a put or call, the absolute value of $B_t(S_t)$ never exceeds the strike price on the option.*

As information about the firm evolves over time, implicit debt may rise or fall. The average value of implicit debt, however, increases at the interest rate. The amount of implicit debt, however, cannot exceed the fixed payment required by the derivative.

4.1.1 Firm 1 (Implicit Debt)

Suppose that Firm 1 at time 0 buys a derivative claim on m shares, where the claim has an initial per-share price $\phi_0(S_0)$. Let A_t, $t \geq 0$, be the value of the firm's assets *after* the derivative or its synthetic equivalent is purchased, so that A_t is net of any initial premium paid or received. The initial value of the claim is $m\phi_0(S_0)$.

At any time t, the total value of the shares is the value of the assets plus the value of the derivative. The price per share is thus

$$S_t = \frac{A_t + m\phi_t(S_t)}{n} \tag{3}$$

4.1.2 Firm 2 (Explicit Debt)

Firm 2 creates a net share and debt position that is equivalent to that implied by Firm 1's derivative position. As discussed above, the value of the implicit debt and shares is the value of the derivative:

$$\phi_t(S_t) = S_t\Delta_t(S_t) + B_t(S_t)$$

In addition, because $\Delta_t(S_t)$ and $B_t(S_t)$ are chosen to replicate the derivative over a period of length h, the value of the derivative at time $t+h$, $\phi_{t+h}(S_{t+h})$, is given by the share and debt position selected at time t, evaluated at time $t+h$ prices:

$$\phi_{t+h}(S_{t+h}) = \Delta_t(S_t)S_{t+h} + B_t(S_t)(1+r_h) \tag{4}$$

where $S_{t+h} \in \{S^+_{t+h}, S^-_{t+h}\}$.

Owning the derivative is equivalent to owning $\Delta_t(S_t)$ shares. Firm 1 therefore implicitly has $n - m\Delta_t(S_t)$ shares outstanding. To replicate this position, Firm 2 at time t will explicitly have $n - m\Delta_t(S_t)$ shares outstanding.[10] In addition, Firm 2 invests $mB_t(S_t)$ in bonds that generate taxable interest income, or tax deductible interest expense if $B_t(S_t) < 0$. The stock and bond positions change over time, but as mentioned in Section 3, this strategy is self-financing.

Because the implicit debt in Firm 1 is untaxed and the interest on explicit debt in Firm 2 is taxed, the after-tax cash flows from Firms 1 and 2 will differ. In order to keep the share prices of the two firms the same, and to value the difference in cash flows, imagine that Firm 2 issues a special claim that pays or receives a dividend each binomial period, q_t, equal to the cash flow difference between the two firms. When the claim is initially issued, Firm 2 pays its value as a dividend (possibly negative) to shareholders. Paying out the cash flow difference keeps the ordinary share price of the two firms the same, and the value of the claim is the value of the difference in cash flows.

Assume that the share price of Firm 2 at time t is

$$S_t = \frac{A_t + mB_{t-h}(S_{t-h})[1 + r_h(1-\tau)] - q_t}{n - m\Delta_{t-h}(S_{t-h})} \tag{5}$$

[10] For example, suppose that Firm 1 enters a forward contract to buy one share. For the forward contract, $\Delta_t(S_t) = 1$, so Firm 2 will buy the share immediately, and will have $n - \Delta_t(S_t) = n - 1$ shares outstanding.

Using equation (4), this can be written

$$
\begin{aligned}
S_t &= \frac{A_t + m\left(S_t\Delta_{t-h}(S_{t-h}) + B_{t-h}(S_{t-h})[1 + r_h(1-\tau)]\right) - q_t}{n} \\
&= \frac{A_t + m\phi_t(S_t) - r_h\tau B_{t-h}(S_{t-h}) - q_t}{n}
\end{aligned}
\tag{6}
$$

Set $q_t = -\tau r_h B_{t-h}(S_{t-h})$. If the derivative has implicit borrowing, $B_{t-h}(S_{t-h}) < 0$ and the firm pays the value of the interest tax deduction, which is a positive amount, to the holders of the special claim. If $B_{t-h}(S_{t-h}) > 0$, owners of the special claim pay taxes on the interest income. We can see by comparing equations (3) and (6) that as long as the dividend q_t is paid, the share prices for firms 1 and 2 are the same in each period. The only difference between Firms 1 and 2 arises from the tax benefit to explicit debt, $mB_t r_h \tau$.

4.1.3 Valuing the Tax (Dis)advantage

As we compare Firms 1 and 2 for subsequent binomial periods, the cash flow difference due to the taxation of interest for Firm 2 will persist, although the amount of the debt will vary over time. From Proposition 2, implicit debt on average grows at the interest rate. It follows that the interest tax deduction grows on average at the interest rate, and thus has a present value proportional to the current value of implicit debt. The following proposition is proved in Appendix A.4.

Proposition 3 *Consider two firms that create the same pre-tax payoff, with Firm 1 issuing a European-style derivative on its own stock and Firm 2 trading its own shares and debt to create the same payoff. Relative to Firm 2, Firm 1 has a tax benefit of $mrT\tau B_0(S_0)$, where m is the number of shares underlying the derivative, r is the risk-free rate, T is the time to maturity, τ is the corporate tax rate, and $B_0(S_0)$ is implicit debt for a derivative with one underlying share.*

Corollary 2 *In the sense of Proposition 3, it is tax-advantaged for a firm to buy puts, sell calls, and short forward contracts (all have $B > 0$), and tax-disadvantaged to sell puts, buy calls, and go long forward contracts (all have $B < 0$).*

If the formula in Proposition 3 seems peculiar, note that is easy to derive under certainty. The price at time 0 of a security paying the continuous tax deduction on a pure discount bond paying \$1 at time T is

$$\int_0^T r\tau e^{-r(T-s)} e^{-rs} ds = r\tau T e^{-rT} \tag{7}$$

$$= r\tau T B(0) \tag{8}$$

where $B(0) = e^{-rT}$. This is the formula in Proposition 3. The size of the tax deduction is on average growing at r and is discounted at that rate, hence the total tax advantage appears undiscounted.

This derivation of the tax cost of a derivative uses a Modigliani-Miller style argument to determine and value the difference in after-tax cash flows from a derivative claim and its synthetic equivalent. The derivation assumes that trading costs and institutional restrictions do not hinder the creation of the synthetic derivative, and that there is a special security paying the interest tax q_t. The special security is an expositional device making it easier to value the cash flow difference. Without this security, one firm would borrow or lend to finance the cash flow differences. The assumption about trading costs and restrictions is more important. In particular, if the creation of the synthetic derivative is not feasible, and if the firm values the particular pattern of cash flows, we might see a firm achieve a desired pattern of cash flows using a tax disfavored transaction.

4.2 Default by the Firm

The firm can default when it is required to make fixed payments. As discussed above, this occurs with long forward contracts and written puts. In general, default by the firm is an issue only with contracts that involve implicit borrowing and hence are tax disadvantaged.

We can use a forward contract to illustrate the issues that arise with default. Suppose that the firm enters into a long forward contract, where the firm is obligated to buy m shares at a price per share of K. The implicit debt component of the forward contract has the same pre-tax payoff as a zero-coupon bond with maturity payment mK that is subject to default.[11] The payment to the counterparty on the

[11] This argument implies that the forward price in this case would be determined using the firm's risky debt yield, rather than the risk-free rate. A more general argument along these lines is in Hull and White (1995).

bond or forward contract is

$$\begin{array}{ll} mK & \text{if} \quad A_T \geq mK \\ \dfrac{A_T}{m} & \text{if} \quad A_T < mK \end{array}$$

In the event of default, the firm repays its debt obligation at a discount, $mK - A_T$. This is a taxable gain to the firm. Because of the possibility of default, the yield on the bond, y, contains a default premium, $y - r$, which is the amortized present value of the expected loss on the bond in default and which is tax deductible as part of interest. Because the expected loss on the bond and the default premium have equal present values, taxes on those amounts have equal present values. Thus, in the case of a forward contract, the value of the tax deduction on equivalent explicit debt is the same for default-free and defaultable debt, and the tax cost of a forward contract is still given by Proposition 3.

For various reasons the tax deduction could be worth more or less than in Proposition 3. When the firm defaults on the debt, there is limited liability for bond and stockholders. If the loss in default is large enough, remaining assets may not be sufficient to pay the tax liability; in this case the present value of deductions from the default premium will exceed that on risk-free debt. Another possibility is that default might occur prior to maturity (for example due to a convenant violation) under different circumstances for a bond and a derivative with equivalent implicit debt.

Default is more complex for written puts than for forward contracts because implicit debt changes randomly over time. The synthetic put strategy, which is used as a benchmark to evaluate the tax disadvantage of the put, requires that the firm repurchase debt as it becomes less risky (the share price rises) and issue debt as it becomes riskier (the share price falls). The hedging problem for the bank is also complicated by the need to hedge put payoffs in default states. Assessing the tax implications of the put requires evaluating the dynamic strategies for both the firm and the dealer. Thus, the relatively simple argument used for forward contracts does not seem applicable to puts. It is possible that option pricing models permitting default (see, for example, Johnson and Stulz (1987) and Hull and White

Table 3: Absolute value of tax benefit/cost for forward contracts, puts, and calls written by a firm on its own stock. All entries are computed as $|\tau r T B(0)|$, with $\tau = .35$, $r = .06$, $\delta = 0$, and σ and T given in the table. For a forward contract (the row labelled "Forward"), $B(0) = e^{-rT}F$. Option strikes are expressed as a percentage of the forward price for a given maturity, K/F. Implicit debt, $B(0)$, and option prices are computed using the Black-Scholes formula.

T		1	1	3	3	5	5
σ		30.00%	60.00%	30.00%	60.00%	30.00%	60.00%
F		106.18	106.18	119.72	119.72	134.99	134.99
	K/F	Tax Benefit/Cost as % of stock price					
Forward		2.10	2.10	6.30	6.30	10.50	10.50
	80%	0.46	0.79	2.18	3.12	4.21	5.82
Put	100%	1.18	1.30	3.80	4.40	6.63	7.86
	120%	1.95	1.83	5.51	5.72	9.17	9.96
	80%	1.22	0.89	2.86	1.92	4.19	2.58
Call	100%	0.92	0.80	2.50	1.90	3.87	2.64
	120%	0.57	0.69	2.05	1.84	3.43	2.64
		Tax Benefit/Cost as % of option premium					
	80%	13.13	6.27	21.64	11.81	28.28	16.48
Put	100%	9.86	5.50	18.52	11.09	25.24	15.80
	120%	7.68	4.94	16.27	10.54	22.99	15.27
	80%	5.17	2.72	9.51	4.13	12.01	4.66
Call	100%	7.76	3.40	12.22	4.79	14.74	5.30
	120%	10.39	4.03	14.74	5.38	17.20	5.85

(1995)) could be used to analyze written puts, but the analysis is beyond the scope of this paper.

4.3 Magnitude of the Tax Benefit

In this section we examine the magnitude of the tax benefit or cost for different options. Table 3 computes the absolute value of the tax benefit of forwards, and calls and puts of different maturities, volatilities, and strikes.

Consider first the tax cost of a long forward contract. A long forward is equivalent to borrowing to buy the stock, and therefore has implicit borrowing. For all maturities in the row labelled "Forward", $B(0) = 100$, and the tax cost is $0.35 \times 0.06 \times T \times 100$, proportional to T. This tax cost is independent of volatility because the forward price does not depend upon volatility.

To interpret the option calculations, note that an investor who buys a call and sells a put, where both have the same time to maturity, T, and strike price, K, is agreeing to unconditionally pay K for the stock at time T. Thus, buying a call and selling a put is a transaction that is implicitly long one share with implicit debt equal to Ke^{-rT}. The total tax disadvantage from buying a call and selling a put with strike price K is therefore $\tau r T K e^{-rT}$. Implicit debt for this position increases with the strike price, and depending upon option characteristics, this total tax disadvantage is split differently across the call and put.

Table 3 shows the tax cost for calls and puts for option strike prices that are 80%, 100%, and 120% *of the forward price for a given maturity.*[12] Because buying a call and selling a put is equivalent to a long forward contract, the sum of the tax benefits as a percentage of the stock price for puts and calls in the $K/F = 100\%$ row equals the tax benefit for the forward contract with the same maturity. For example in the first column, in the row where $K/F = 100\%$, the put and call tax benefits are 1.18 and 0.92. The sum is 2.10, the same as for the forward. As the maturity changes, the forward price changes so the option strike price changes as well. A 20% out-of-the-money call option with 3 years to maturity and a 6% interest rate is approximately at-the-money in the standard sense of the term ($S = K$). Changes in volatility redistribute the tax cost between the call and put. In particular, an increase in volatility increases the premium of an out-of-the-money option proportionately more than an in-the-money option. The top panel of Table 3 shows that an increase in volatility redistributes tax costs to the low-strike puts and high-strike calls.

Table 3 also computes the tax benefit/cost as a percentage of the option premium. This can be misleading because a given amount of implicit debt can be generated using a zero-premium strategy, such as a forward or costless collar. In such cases the tax benefit or cost relative to the premium is infinity. Nevertheless, for the longer-lived options in the table, the tax benefit can exceed 20% of the option premium.

[12] Implicit debt for a call is $-Ke^{-rT}N(d_2)$ where $d_2 = [\ln(S/K) + (r - .5\sigma^2)T]/\sigma\sqrt{T}$, and K is the strike price, T the time to expiration, r the risk-free interest rate, σ the stock volatility, and $N(x)$ the standard normal distribution function. Implicit debt for the put is $Ke^{-rT}N(-d_2)$.

Table 4: Percentage of shares outstanding sold forward using puts or similar transactions. These data were inferred from company 10-Ks. Years are fiscal years.

Company	1996	1997	1998	1999	2000	2001	2002
Dell	2.99	4.43	7.76	1.93	2.72	4.30	1.96
Intel	0.91	0.91	0.15	0.05	0.00	0.00	N/A
Maytag	0.00	2.96	4.48	10.4	7.48	0.00	N/A
Microsoft	1.11	.25	2.49	3.30	2.97	0.00	0.00

5 Put Writing by Microsoft and Dell

A firm planning to repurchase shares can buy shares outright, financing the purchase by borrowing, or can use derivatives, buying shares forward, selling puts, or buying calls. These derivative transactions all entail implicit borrowing, and hence are tax-disadvantaged transactions. In particular, a put written on one share is equivalent to buying a fractional share today and borrowing to finance the share repurchase. Put writing by firms was a relatively popular transaction in the mid to late 1990s. In this section we examine the tax cost of put writing by looking at specific transactions by Microsoft and Dell, and discuss some possible reasons for the practice in spite of the tax disadvantage.

Written puts and related option positions are disclosed in footnotes but are off-the-balance sheet. To gain an idea of the size of these transactions, Table 5 depicts the percentage of shares sold forward by several firms.[13] In some cases the companies sold puts and received substantial premium. Microsoft, for example, received net premium of \$538m in 1998, \$766m in 1999, and \$472m in 2000, and reported a loss in 2001 of \$1,367m from retiring outstanding put options after its share price had fallen. Dell both sold puts and bought calls and therefore the premium raised was presumably small (it is at any rate unreported).

[13] As share prices declined in 2001 and 2002, other companies received press attention for losses on written puts and forward contracts, including EDS, Household International, McDonalds, and Eli Lilly. For example, see "Dell, Eli Lilly Join EDS In Risky Options Game", by Robin Sidel, Gary McWilliams and Thomas Burton, *Wall Street Journal*, Sept. 27, 2002, p. C1, and "Did Bad Accounting Encourage This Fiasco?", by Floyd Norris, *New York Times*, November 8, 2002, p. C1.

5.1 Microsoft

As of June, 2000, Microsoft had outstanding put warrants for 157m shares, with strike prices ranging from \$70 to \$78 and expirations ranging from 3 months to 2.5 years.[14] If these puts were to expire in-the-money, and if the average strike price were \$74, Microsoft would be required to pay $\$74 \times 157m = \$11.618b$ to buy back 157m shares. For an at-the-money put with two years to expiration, implicit debt would be approximately 40-50% of the strike, depending on maturity and assumed volatility. A conservative estimate of implicit debt is thus $B = \$11.618b \times .4 = \$4.647b$. The per-year measure of the tax cost at issue, assuming it is at-the-money, is thus

$$\$4.647b \times .06 \times .35 = \$97.59m.$$

As of June 30, 2000, these puts were approximately at-the-money, with Microsoft trading at around \$78/share. Microsoft's share price subsequently declined and in fiscal year 2001 Microsoft settled all outstanding puts at a cost reported (in the 2001 10-K) to be \$1.376b.

5.2 Dell Computer

Dell undertook a more complicated transaction than Microsoft, described this way in its 1998 10-K:

> The Company utilizes equity instrument contracts to facilitate its repurchase of common stock. At February 1, 1998 and February 2, 1997, the Company held equity instrument contracts that relate to the purchase of 50 million and 36 million shares of common stock, respectively, at an average cost of \$44 and \$9 per share, respectively. Additionally, at February 1, 1998 and February 2, 1997, the Company has sold put obligations covering 55 million and 34 million shares, respectively, at an average exercise price of \$39 and \$8, respectively. The equity instruments are exercisable only at expiration, with the expiration dates

[14] It is interesting to compare Microsoft's 10-K's year-to-year. It appears that outstanding put options are restructured periodically. The strikes outstanding in 1998—\$72-\$77 per share—do not correspond to any strikes outstanding in 1999—\$59-\$65 per share, following a 2:1 stock split in March 1999.

ranging from the first quarter of fiscal 1999 through the third quarter of fiscal 2000.

An interpretation of this passage is that Dell sold puts on 55 million shares at a strike of \$39 and bought calls on 50 million shares at a strike of \$44. However, the vague language in the quoted passage raises the possibility that the purchased "equity instrument contracts" were not plain vanilla calls.[15]

By comparing the 1997 and 1998 10-Ks, one can verify that the higher-strike contracts were entered into between Feb. 1997 and Feb. 1998. At issue, therefore, the expiration of the higher-strike contracts could have been anywhere between about one and three and one-half years.

Lacking further details, we can try to perform a back-of-the-envelope assessment of this transaction. Suppose that at issue the stock price was \$43, hence the puts were 10% out-of-the-money. Also suppose the calls were capped (i.e., the maximum gain from exercise was limited) to give the transaction a zero premium. Further suppose that Dell's stock volatility was 50% (close to its historical volatility from February, 1996 to February, 1998), the risk-free rate was 5.5%, the options at issue had 3 years to expiration, and Dell has a 35% marginal tax rate.

Given these assumptions, the Black-Scholes price for the put is \$8.317. A call with a \$44 strike and a cap at \$88.742 would have a premium of \$9.149. Selling 55m puts and buying 50m of these capped calls would generate a zero premium.

The purchased capped call is replicated by borrowing \$4.143 to buy .309 shares, while the written put is replicated by borrowing \$18.241 to buy .23 shares. Given the number of options outstanding, the implicit amount borrowed is

$$55m \times \$4.143 + 50m \times \$18.241 = \$1.21b$$

One year's interest deduction on this borrowing would be

$$\$1.21b \times 5.5\% \times .35 = \$23.30m$$

[15]By contrast, Dell's 1997 10-K stated explicitly that Dell sold puts and bought calls in an earlier transaction.

This back-of-the-envelope calculation suggests that Dell would lose \$23m annually were it to engage in this option transaction to hedge its repurchases, as opposed to borrowing to fund current repurchases.[16] Using Proposition 3, the present value of the tax disadvantage over 3 years would be \$69m. (In comparing these transactions keep in mind that in any case, Dell will have to pay cash in the future, whether to pay option strikes to repurchase shares at that time, or to repay debt used to repurchase shares at an earlier date.)

If the position were a pure collar, that is if the call were not capped, the loss would be larger because the implicit borrowing is greater. The call would be equivalent to borrowing \$14.697 to hold .725 shares. Net implicit borrowing would be

$$55m \times \$14.697 + 50m \times \$18.241 = \$1.74b$$

One year's interest deduction would be \$33.5m. In this case, the amount of debt implicit in the option position is not very sensitive to the stock price. If the 39 strike puts are in-the-money at expiration, Dell would be required to pay $\$39 \times 55m = \$2.145b$ for shares, while if the 44 strike call is in the money, Dell would be required to pay $\$44 \times 50m = \$2.2b$. The amount \$1.74b reflects the present value of this likely obligation. The implicit debt amount would decline significantly only if Dell's stock price were between \$39 and \$44 with a short time to expiration.

5.3 Why Sell Puts?

In this section we discuss some possible explanations for firms selling put options despite their tax disadvantage. Angel et al. (1997) also discuss put sales in the context of a repurchase program, but without discussing taxes. To anticipate the discussion, there is no obvious compelling reason for firms to sell puts, although it is a way for firms to acquire off-balance-sheet debt. Graham (2000) argues that firms leave money on the table by using too little leverage given their tax rate. Put-writing could be another manifestation of firms apparently failing to fully exploit

[16]For the capped call, implicit borrowing declines, and actually becomes implicit lending—which is tax-advantaged— if the stock price becomes sufficiently great. The reason is that if the capped position is deep-in-the-money, it is equivalent to a fixed receipt of $50m \times (88.74 - 44) = \$2.04b$. In this case Dell effectively holds a zero coupon bond. It is important to keep in mind that this is merely a guess about the structure of the transaction.

tax deductions. Alternatively, even if we cannot identify a clear reason for firms to sell puts, the tax disadvantage provides a lower bound on whatever value firms receive from such transactions.

Puts sold by firms are typically not registered securities, but are sold directly to a dealer. Since the put is implicitly a short position in shares, the dealer buys shares to hedge the put. The transaction is not public, and the quantities of puts sold on a given day are reportedly small enough that trading by the dealer is not expected to have much market impact. The dealer subsequently trades the stock as needed to match the changing implicit share position of the put. Since the transaction is off-balance-sheet for the firm, the dealer is in effect a conduit through which the firm can borrow and transact in its stock.

In this section we discuss several possible reasons for firms to sell puts. One possible explanation is that firms issuing puts were taking advantage of accounting rules that did not recognize puts as having an implicit debt component. There is also evidence that some of these firms have low marginal tax rates, which would lower the cost of engaging in this strategy. I also consider other less persuasive explanations, such as the possibility that firms might have been using puts to trade on inside information or to avoid SEC restrictions on share buybacks.

Regulatory and Accounting Arbitrage According to practitioners and anecdotal accounts in the press, the implicit debt component of forward contracts and written puts has generally not been treated like debt for accounting and regulatory purposes, despite the fact that these contracts create a fixed, debt-like obligation for the firm when the price is low. For example, Household International entered into a forward contract to buy its shares at a time when the equivalent transaction using explicit debt would have resulted in covenant violations.[17] Similarly, acccording to practitioners, ratings agencies at first ignored written puts, but in 2001 began to recognize their implicit debt component. This change coincides with a drop in put-selling for some of the firms in Table 5. (Dell's fiscal year 2002 ended in February 2002, so it primarily reflects calendar year 2001.) Thus, the issuance of puts may reflect a desire to issue debt that does not appear on the balance sheet.

[17] "Did Bad Accounting Encourage This Fiasco?" by Floyd Norris, *New York Times*, November 8, 2002, p. C1.

Table 5: Percentage of shares outstanding sold forward using puts or similar transactions. These data were inferred from company 10-Ks.

Company	1996	1997	1998	1999	2000	2001	2002
Dell	2.99	4.43	7.76	1.93	2.72	4.30	1.96
Intel	0.91	0.91	0.15	0.05	0.00	0.00	N/A
Maytag	0.00	2.96	4.48	10.4	7.48	0.00	N/A
Microsoft	1.11	.25	2.49	3.30	2.97	0.00	0.00

If the firms in Table 5 had issued debt instead, the rise in the debt-equity ratio would, except for Maytag in 1999, have been about 1-3%. A back of the envelope calculation suggests that the cost of a lower credit rating is less than the loss of the interest tax deduction, assuming that firms have a high marginal tax rate. If issuing debt changed the firm's credit rating from AA3 (Microsoft's rating) to BBB2, an extreme change, this would raise the firm's borrowing cost by about 70 basis points (using yields in November 2000). Even double this change would be less than the annual value of the tax deduction (assuming a tax rate of 35%) on that amount of debt. If there are other, indirect costs to a lower credit rating, the lost tax deduction from selling puts would be a lower bound for the magnitude of these costs.

Firms Have a Zero Marginal Tax Rate If firms have a zero marginal tax rate, there is no tax disadvantage to selling puts rather than borrowing to buy an equivalent quantity of shares. As is well-known, it is difficult to infer a firm's marginal tax rate by looking at publicly-available data. All of the firms in Table 5 reported positive incomes taxes paid (on the statement of cash flows) in all years, except Dell in 1999. For example, Microsoft reported incomes taxes paid of \$430m, \$758m, \$1.1b, \$1.1b, \$874m, \$800m, \$1.3b, and \$1.9b in 1995–2002. However, both firms also report significant option compensation expense. Graham's measure of the marginal tax rate (Graham, 1996) is close to 35% for all companies and years through 2000 in the table, except for Maytag in the late 1990's. However, Graham's original measure does not account for the tax deduction stemming from option exercise. Graham et al. (2002) examine the impact of compensation option exercise on marginal tax rates for a sample of NASDAQ and S&P firms, and find

	Microsoft		Dell	
Year	Net Income	Tax benefit of compensation expense	Net Income	Tax benefit of compensation expense
1995	1,453	179		
1996	2,195	352		
1997	3,454	796	518	37
1998	4,490	1,553	944	164
1999	7,785	3,107	1,460	444
2000	9,421	5,535	1,666	1,040
2001	7,346	2,066	2,177	929
2002	7,829	1,596	1,246	487

Table 6: Compensation expense due to option exercise and taxable income. Source: company 10-Ks.

that marginal tax rates decline, especially for the NASDAQ firms.[18] There is of course no way to know what managers believe to be the marginal tax rate of the firm.

Table 6 shows reported net income and the tax benefit of compensation expense for Microsoft and Dell for several years. In many of the years, the tax benefit of compensation expense is greater than 35% of net income, in which case taxable income would be zero. Put issuance would be consistent with companies such as Microsoft and Dell believing their marginal tax rate to be zero.

Firms Have Private Information About their Stock Managers might have private information about either the mean or volatility of the stock. A derivative sold to a dealer is potentially a way for a firm to trade on private information about the *direction* of the stock since the dealer, by delta-hedging, in effect secretly trades on the firm's behalf with the public. A put option by itself earns its maximum profit return when the stock price at expiration is greater than the strike price. However, put selling is typically not the optimal way to profit from a belief that the stock price will increase.

[18] When employees exercise compensation options, the difference between the stock price and strike price is deductible for tax purposes but does not affect reported net income. Companies do report the resulting tax deduction separately in their 10-K. The number reported as tax benefit of compensation expense is described like this in the Microsoft 2000 10-K: "As required by Emerging Issues Task Force (EITF) Issue 00-15, Classification in the Statement of Cash Flows of the Income Tax Benefit Received by a Company upon Exercise of a Nonqualified Employee Stock Option, stock option income tax benefits are classified as cash from operations in the cash flows statement." Hanlon and Shevlin (2002) discuss the accounting issues associated with compensation options.

To understand the implications of having information, consider three alternative strategies for repurchasing a share in the future. The first is simply waiting to repurchase shares at the market price at time 1, S_1. The second strategy is to enter into a forward contract to buy the stock in one year for the forward price, $(1+r)S_0$. On a pre-tax basis, this is equivalent to borrowing in order to immediately buy the stock. The third strategy is to sell a put option, receiving the premium P today and in one year paying a net cost of $\max(K, S_1) - (1+r)P$. Under what circumstances will the put be the *ex post* lowest cost means of repurchasing a share?

First, compare the put to waiting to buy the share at the market price. The put will be the less expensive alternative if $S_1 > \max(K, S_1) - (1+r)P$. Thus, if managers believe the stock price will fall significantly, they expect that this inequality will be violated and they will wait to repurchase the share rather than write a put. Comparing the put to a forward contract, the put will be the *ex post* less expensive alternative if $(1+r)S_0 > \max(K, S_1) - (1+r)P$, or

$$(1+r)(S_0 + P) > \max(K, S_1)$$

It will always be the case that $(1+r)(S_0+P) \geq K$.[19] *Ex post*, the put will be preferred if $(1+r)(S_0+P) > S_1$. Thus, if the manager believes the stock price will rise significantly, the inequality is violated and the forward contract is preferred to writing a put. In summary, the written option is preferable both to waiting and to a forward purchase if the manager believes the future stock price will be in an intermediate range. Put differently, since an option price increases with volatility, an option seller hopes that realized volatility will be less than the volatility used to price the option. Writing a put thus makes sense as a bet on volatility, not as a bet on the direction of the stock *per se*.

It is possible that firms writing put options are speculating, based on inside information, that volatility will be less than that reflected in the option price. If the firm is right, the dealer who buys and hedges the option will lose money. Dealers should take into account the possibility that firms have inside information about volatility. In equilibrium firms will therefore be unable to make money on the

[19] By put-call parity, the value of the put is $P = C + K/(1+r) - S$, where C is the premium on a call with the same strike price and time to expiration as the put. Since $C \geq 0$, $(1+r)(P+S) \geq K$.

information unless they can trade anonymously. Since the trade in written puts is not anonymous, private information does not seem a plausible explanation for put writing.

Regulation SEC rules restrict the ability of firms to trade in their own stock, though the applicability of these rules to put writing is uncertain. Since an exercised written put results in a repurchase, share-repurchase regulations should logically affect the logistics of put-writing. Rule 10b-18, promulgated by the SEC under the Securities Exchange Act of 1934, provides a safe harbor under which a firm can buy its own stock without facing charges of manipulation. One of the key elements is that a firm is permitted to buy up to 25% of its average daily trading volume over the preceding four weeks. In practice, many firms reportedly write European puts and stagger their put-writing to stay within this safe harbor.[20] (This also facilitates secrecy, as discussed above.) Dell's average daily trading volume, for example, was over 5m shares in 1996 and 1997, and over 7m shares in 1997 alone. Thus, Dell should have been able to repurchase over 1m shares daily, and could have issued the options described in Section 5.2 over a several month period. Thus, written puts provide an alternative to open-market share repurchases, but anecdotally, at least some firms regard put writing as subject to the same regulatory restrictions as share repurchases. For those firms, put writing does not create a regulatory advantage.

Dealers Demand Options The purchase of options from a firm might help a dealer manage the overall risk of a hedged option portfolio. Although there are no public statistics, it is widely believed that dealers on average are option writers (end-users on average wish to buy options, rather than sell them). Written option positions are risky and difficult to hedge (Green and Figlewski, 1999). A position where a dealer writes options and hedges the position with stock will lose money when the stock price moves by unusually large amounts, either up or down. Such

[20] The applicability to put writing of various SEC rules, including 10b-18, was clarified by a Feb. 22, 1991 letter from the SEC, file number TP 90-375. The SEC established a safe harbor, which among other things, required adherence to the 10b-18 volume restrictions and required that puts be issued out-of-the-money. This ruling concerned exchange-traded puts, and there is apparently some uncertainty about the extent to which rules apply to private put transactions. Angel et al. (1997) state that Rule 10b-18 applies to the put sale, not the exercise.

a position is said to have negative gamma.[21] Put writing by firms provides an opportunity for brokers to add positive gamma to their market-making portfolio, reducing the consequences of large stock price moves. Brokers might therefore charge lower fees for such a position.

Ignorance Suppose a firm were to write puts for mistaken reasons, and thus bear the tax cost with no offsetting benefit. How would managers understand they had made a mistake? The firm might have obtained competitive quotes for puts from different banks, ensuring "fair" pricing. There is no line item on the income statement that reflects the implicit tax loss. At least in the 1990's, analysts did not appear to criticize firms for these transactions and the secrecy with which they are undertaken made scrutiny difficult. Finally, many put-issuing firms made money on the strategy for years because their stock price went up consistently. Repurchasing shares, however, would have generated only implicit income, while put sales generated explicit gains. Thus, despite the ex-ante tax-inefficiency of put sales, advocates of this strategy might have (mistakenly) looked smarter ex-post.

In summary, there is no one single obvious and compelling explanation for put sales. Since put writing firms also tend to use compensation options, their marginal tax rate is probably lower than the statutory rate. As the ratings agencies initially did not treat puts as debt, it could be that low marginal tax rate firms regarded puts as an inexpensive way to issue off-balance-sheet debt. The use of puts to trade on information or to bypass SEC regulations seem to be less plausible stories.

6 Convertible Bonds

Firms can raise money by selling written calls (warrants) as standalone securities or coupled with ordinary bonds in the form of convertible bonds. Written calls are an implicit sale of shares coupled with implicit lending and thus they are tax advantaged.

A firm selling a call can issue a convertible bond explicitly, or can simultaneously sell a non-convertible bond and a warrant separately, a transaction we will refer to

[21] Gamma is the second derivative of the option price with respect to the stock price.

as a *bifurcated convertible*. The convertible and bifurcated convertible are equivalent transactions except for their tax treatment.

In this section we ask whether bifuraction is tax-advantaged relative to the bundling which occurs with an ordinary convertible. To answer this we can compare the tax deduction in the two cases constructed to have identical pre-tax cash flows. We show that, from a tax perspective, the bifurcated convertible is preferred to the ordinary convertible.

A convertible bond is like an ordinary bond plus a call option to convert the bond into shares. Thus, the coupon on a convertible bond is the coupon on an ordinary bond reduced by the amortized option premium. If a T-period bond is convertible into m shares, we can use standard annuity calculations to show that the convertible coupon, ρ, is

$$\rho = r\left(1 - \frac{m\phi}{D(1-e^{-rT})}\right) \tag{9}$$

where D is the bond principal and ϕ the option premium per share. The option has a strike price of D/m per share.

We can analyze the tax issues associated with bifurcation by comparing two firms:

Firm A issues ordinary T-period convertible debt with par value D and issued for D. The debt is convertible at maturity, at the holder's option, into m shares. The interest rate on the debt is ρ, from equation (9).

Firm B issues m T-period European warrants, each with premium ϕ and strike price D/m. In addition, A issues T-period debt in the amount $D - m\phi$, with a maturity value of D and paying a coupon of ρD.

Both firms A and B raise D. However, firm B bifurcates the convertible bond for tax purposes by issuing separately a warrant and a bond with a lower principal amount. Firm A simply deducts the stated interest on the convertible bond. Table 7 shows that firms A and B have identical pre-tax cash flows.

Although the convertible and bifurcated convertible have the same pre-tax cash flow, their tax treatment is different. For both the convertible and bifurcated convertible, the interest payment ρD is deductible. This is the only tax deduction for

	Firm A	Firm B		
	Convertible	Warrant	Debt	Firm B Total
Time 0	D	$m\phi$	$D - m\phi$	D
Coupon	ρD	0	ρD	ρD
Maturity, $S \leq D/m$	D	0	D	D
Maturity, $S > D/m$	mS	$m \times (S - D/m)$	D	mS

Table 7: Comparison of pre-tax cash flows for firm A, which issues ordinary convertible debt and firm B, which issues an equivalent warrant and discount bond. The cash flows for Firm A's convertible match the total cash flows for Firm B's warrant plus bond.

the convertible. However, the bond portion of the bifurcated convertible is issued at a discount to par. For such an original issue discount (OID) bond, the amortized appreciation from the price at issue ($D - m\phi$) to D at maturity is deductible as interest.

Suppose a bond with par value D is issued for $Q(0) < D$. The original issue discount rules call for amortizing the discount, with the firm receiving a tax deduction each year based on the implied increase in the value of the bond. The annualized rate of appreciation is $\ln(D/Q(0))/T = \lambda$. The flow of tax deductions is therefore

$$\tau \int_0^T e^{-rs} \lambda Q(s) ds$$

where $Q(s) = Q(0)e^{\lambda s}$. Evaluating this integral, the present value of the OID tax deductions is[22]

$$\tau \frac{\lambda}{r - \lambda} \left(1 - e^{-(r-\lambda)T}\right) Q(0) \tag{10}$$

The tax deduction due to the coupon is simply an annuity, with a present value of

$$\tau \frac{\rho D}{r} \left(1 - e^{-rT}\right). \tag{11}$$

We can summarize this discussion in the following proposition.

Proposition 4 *For non-callable convertible bonds which are convertible at expiration, the present value of the tax deduction is given by equation* (11). *For an*

[22]Since a zero-coupon bond has no payouts and thus is a special case of an option, we would expect that for a zero coupon bond, for which $\lambda = r$, equation (10) reduces to $\tau r T Q(0)$. Using L'Hôspital's rule, one can verify that this is correct.

otherwise identical bifurcated convertible, the present value of the tax deduction is given by the sum of equations (10) *and* (11)*, with* $Q(0) = D - m\phi$.

Figure 2 illustrates effects of maturity and volatility on the tax benefit of bifurcation. The top panel of Figure 2 computes the present value of the tax benefit from bifurcation, equation (10). For a wide range of parameters, the benefit of bifurcation exceeds 5% of the value of the bond. Because for a given bond the OID tax deduction increases over time, the annual tax deduction changes over time. The bottom panel computes a level annuity with the same present value as in the top panel.

Since λ is the imputed appreciation to par on the discount bond, $\lambda \rightarrow 0$ as $T \rightarrow \infty$. Thus, in equation (10), the present value of the OID tax deduction approaches 0 as the debt maturity becomes large.[23] This explains why the tax benefit of bifurcation in Figure 2 goes to zero as T becomes large.

This analysis leaves unanswered the question of why firms issue convertibles instead of bifurcated convertibles. It is possible that convertibles solve a problem which might not be solved by a bifurcated convertible. For example, with ordinary debt managers can shift value from debtholders to equityholders by increasing asset risk. Convertibles are not so easily expropriated because of the embedded option. With a bifurcated convertible, shareholders can buy the warrants and then expropriate the straight debt holders.

Conversion of a convertible reduces debt outstanding. Bifurcated convertibles have to offer special incentives (such as favorable conversion terms) to encourage the debt to be used as payment for exercise of the warrant. Finally, Stein (1992) and Strnad (2001), emphasize that convertibles are generally callable. Presumably a warrant/bond package could be made callable by having the warrant callable and again offering incentives if the bond is used as payment for exercising the warrant.

As with written put options, the tax disadvantage of the warrant/bond bundle relative to that of a convertible provides a lower bound on the non-tax value of the convertible to the firm.

[23] I thank Stewart Myers for the observation that the tax benefit of bifurcation must be zero for a perpetuity.

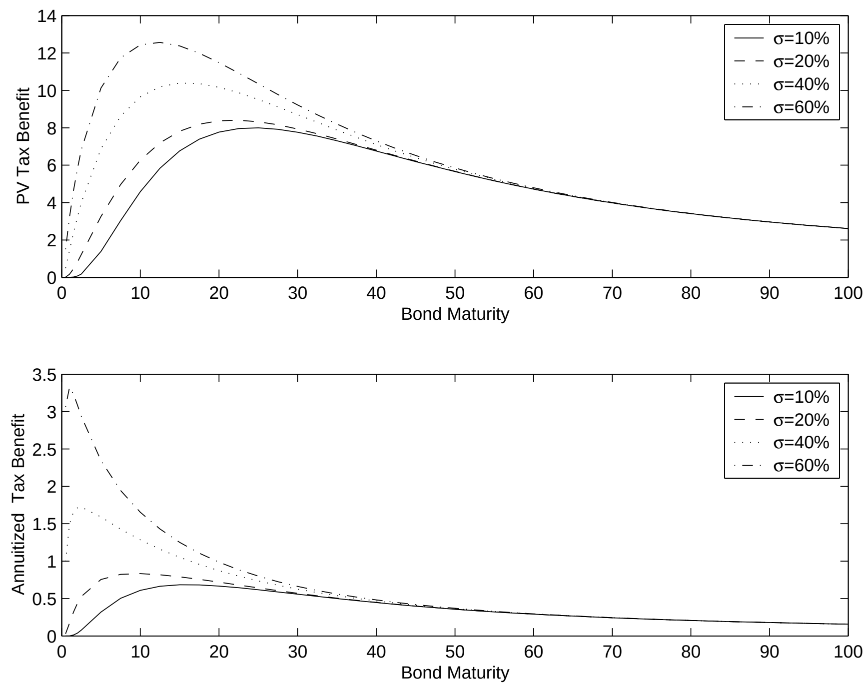

Figure 2: Tax benefit of bifurcation for different times to maturity and different volatilities, σ. The top panel is given by equation (10), with $B(0)$ given by $D - m\phi$. The bottom panel is given by annuitizing equation (10). Calculations assume the tax rate, $\tau = .35$, the stock price is \$70 and the bond maturity value is \$100, with option premia computed using the Black-Scholes formula.

7 Conclusions

A position in options on a firm's own stock is not tax-neutral. This result is relevant for capital structure decisions, including the decision to issue warrants and convertible bonds and write puts. Examples of firms writing put options suggest that the tax implications can be significant, with those firms potentially losing tens of millions of dollars annually in foregone interest deductions. Firms might nevertheless have sold puts as a way to issue debt that did not affect their credit rating or covenants. At least some of the firms selling puts were also significant issuers of compensation options and may therefore have had a low marginal tax rate (Graham et al., 2002; Kahle and Shastri, 2002)

An important class of options that I have not discussed is compensation options, which are call options written by the firm. While the analysis in this paper can be used to analyze compensation options, they are more complicated because they are sold directly to employees, therefore the counterparty for a compensation option is not tax-neutral. The net tax advantage will depend on the idiosyncracies of the counterparty, a problem that has been discussed by Scholes and Wolfson (1992).[24]

The analysis in this paper relies heavily on specific U.S. tax rules. I do not examine the tax treatment of similar share transactions in other countries. It would be interesting to carry out a systematic examination of international tax rules and correlate these cross-sectionally with financial policies.

A Appendices

A.1 Derivative Pricing With Taxes

Suppose that, as in Cox et al. (1979), the stock moves binomially, so that at time t the stock price is S_t, and at time $t+h$ can be worth either $S^+_{t+h} = u_h S_t$ or $S^-_{t+h} = d_h S_t$. A dividend worth $D_t = \delta S_t$ is paid just prior to time $t+h$. The effective interest rate from time t to $t+h$ is $r_h \approx rh$. Given h, there are $N = T/h$ binomial periods between 0 and T.

[24]Mozes and Raymar (2000), in independent work, discuss compensation options. They argue that firms which have issued significant executive options—equivalent to issuing shares and lending—will offset the option position by repurchasing shares and borrowing.

Let $\Delta_t(S_t)$ and $B_t(S_t)$ be defined as in Section 3. We choose Δ_t and B_t by requiring that the after-tax return on the stock/bond portfolio equal the after-tax return on the option in both the up and down states. Thus we require that

$$\begin{aligned}[S_{t+h} - \tau_g(S_{t+h} - S_t) + \delta S_t(1-\tau_d)]\,\Delta_t + [1 + r_h(1-\tau)]\,B_t \\ = \phi_{t+h}(S_{t+h}) - \tau_O\left(\phi_{t+h}(S_{t+h}) - \phi_t(S_t)\right) \quad (12)\end{aligned}$$

whether $S_{t+h} = S^+_{t+h}$ or $S_{t+h} = S^-_{t+h}$. The initial cost of the derivative is then

$$\phi_t(S_t) = \Delta_t(S_t)S_t + B_t(S_t). \quad (13)$$

Solving for ϕ_t gives[25]

$$\phi_t = \frac{1}{1 + r_h\frac{1-\tau_i}{1-\tau_O}}\left[p^*\phi_{t+h}(S^+_{t+h}) + (1-p^*)\phi_{t+h}(S^-_{t+h})\right] \quad (14)$$

where

$$p^* = \frac{1 + r_h\frac{1-\tau_i}{1-\tau_g} - \delta\frac{1-\tau_d}{1-\tau_O} - d}{u-d} \quad (15)$$

is the tax-adjusted risk-neutral probability that the stock price the next period will be S^+_t.

In the absence of taxes, we obtain the standard expressions for the option price and for the replicating portfolio:

$$\Delta_t(S_t) = \frac{\phi_{t+h}(S^+_{t+h}) - \phi_{t+h}(S^-_{t+h})}{S^+_{t+h} - S^-_{t+h}} \quad (16)$$

$$B_t(S_t) = \frac{1}{1+r_h}\frac{u_h\phi_{t+h}(S^-_{t+h}) - d_h\phi_{t+h}(S^+_{t+h})}{u_h - d_h} \quad (17)$$

[25] The solutions for Δ and B are

$$\Delta = \frac{1-\tau_O}{1-\tau_g}\;\frac{\phi_1(S^+_1) - \phi_1(S^-_1)}{S^+_1 - S^-_1}$$

$$B = \frac{1}{1 + r_h\frac{1-\tau_i}{1-\tau_O}}\;\left[\frac{u\phi_1(S^-_1) - d\phi_1(S^+_1)}{u-d} - \frac{\Delta}{1-\tau_O}S_0\left(\frac{\tau_g - \tau_O}{1-\tau_g} + \delta(1-\tau_d)\right)\right]$$

The risk-neutral probability that the stock price will go up is

$$p_h = \frac{1 + r_h - \delta_h - d_h}{u_h - d_h} \tag{18}$$

Finally, the option price is given by

$$\phi_t = \frac{1}{1 + r_h} \left[p_h \phi_{t+h}(S^+_{t+h}) + (1 - p_h)\phi_{t+h}(S^-_{t+h}) \right] \tag{19}$$

By comparing equation (14) with (19), and equation (15) with (18), we obtain Proposition 1.

A.2 Proof of Proposition 2

Denote possible option values next period as ϕ_u and ϕ_d, and for the period after that, ϕ_{uu}, ϕ_{ud}, and ϕ_{dd}. From equation (17), possible values of B the next period are

$$\begin{aligned} B_u &= \frac{1}{1 + r_h} \frac{u_h \phi_{du} - d_h \phi_{uu}}{u - d} \\ B_d &= \frac{1}{1 + r_h} \frac{u_h \phi_{dd} - d_h \phi_{du}}{u - d} \end{aligned} \tag{20}$$

Possible option values next period are

$$\begin{aligned} \phi_u &= \frac{1}{1 + r_h} \left[p_h \phi_{uu} + (1 - p_h)\phi_{du} \right] \\ \phi_d &= \frac{1}{1 + r_h} \left[p_h \phi_{du} + (1 - p_h)\phi_{dd} \right] \end{aligned} \tag{21}$$

where $p_h = (1 + r_h - d_h)/(u_h - d_h)$ is the risk-neutral probability of the stock price going up.

Now consider discounted expected next-period B:

$$\frac{1}{1 + r_h} \left[p_h B_u + (1 - p_h) B_d \right]$$

We can expand this expression and rewrite it, using equations (20) and (21) as

$$\begin{aligned}
&\left(\frac{1}{1+r}\right)^2\left[p\left(\frac{u\phi_{du}-d\phi_{uu}}{u-d}\right)+(1-p)\left(\frac{u\phi_{dd}-d\phi_{du}}{u-d}\right)\right]\\
&\quad=\left(\frac{1}{1+r}\right)^2\left[\frac{u}{u-d}\left(p\phi_{du}+(1-p)\phi_{dd}\right)-\frac{d}{u-d}\left(p\phi_{uu}+(1-p)\phi_{ud}\right)\right]\\
&\quad=\frac{1}{1+r}\ \frac{u\phi_d-d\phi_u}{u-d}\\
&\quad=B
\end{aligned}$$

This demonstrates in a 2-period setting that B is the expected present value of future B. By recursion it will be true in an n-period setting.

As an aside, in the context of the Black-Scholes model, implicit lending for an option at time t which expires at time T is

$$B_t=\int_K^\infty Ke^{-r(T-t)}f(S_T|S_t)dS_T$$

Here it is obvious that $B_te^{r(T-t)}$ is a random walk.

A.3 Proof of Corollary 1

We need only prove that $|B_{T-h}(S_{T-h})|\leq K$, where $T-h$ is the last binomial period before expiration. The result then follows by recursion from Proposition 2.

If a put option is certain to be in-the-money at expiration, then we have

$$\begin{aligned}
B_{T-h}(S_{T-h})=&\frac{1}{1+r}\ \frac{u_h(K-d_hS_{T-h})-d_h(K-u_hS_{T-h})}{u_h-d_h}\\
=&\frac{K}{1+r}
\end{aligned}$$

If the put option is only in-the-money in the down state, then $K<u_hS_{T-h}$. This implies that $u_h(K-d_hS_{T-h})/(u_h-d_h)<K$. Thus, we have

$$\begin{aligned}
B_{T-h}(S_{T-h})=&\frac{1}{1+r}\ \frac{u_h(K-d_hS_{T-h})}{u_h-d_h}\\
<&\frac{K}{1+r}
\end{aligned}$$

The demonstration for calls is analogous.

A.4 Proof of Proposition 3

Let $V_t(S_t)$ denote the present value at time t of the dividend stream of tax deductions beginning at $t+h$, conditional upon the stock price being S_t. In the final period, the value of the dividend is $mr_h\tau B_{T-h}(S_{T-h})$, hence the value of that dividend in period $T-h$ is

$$V_{T-h}(S_{T-h}) = \frac{mr_h\tau B_{T-h}(S_{T-h})}{1+r_h}$$

Discounting occurs at the risk-free rate since this is a traded security priced in the same fashion as any other traded derivative claim on the firm.

Now consider the node at time $T-2h$ at which the stock price is S_{T-2h}. There are two periods worth of dividends to value. First, the debt incurred at time $T-2h$ produces a dividend one period hence of $mr_h\tau B_{T-2h}(S_{T-2h})$. Second, the stock price will either go up to S^+_{T-2h}, with a corresponding dividend value of $V_{T-h}(S^+_{T-2h})$, or down to S^-_{T-2h}, with a dividend value of $V_{T-h}(S^-_{T-2h})$. Thus, at time $T-2h$, the present value of future dividends is

$$\begin{aligned} V_{T-2h}(S_{T-2h}) =& \frac{mr_h\tau B_{T-2h}(S_{T-2h})}{1+r_h} + \\ & \frac{1}{1+r_h}\left[V_{T-h}(S^+_{T-2h})p_h + V_{T-h}(S^-_{T-2h})(1-p_h)\right] \end{aligned} \tag{22}$$

Since V_{T-h} is proportional to B_{T-h}, this can be rewritten

$$V_{T-2h}(S_{T-2h}) = \\ \frac{mr_h\tau}{1+r_h}\left[B_{T-2h}(S_{T-2h}) + \frac{B_{T-h}(S^+_{T-2h})p_h + B_{T-h}(S^-_{T-2h})(1-p_h)}{1+r_h}\right]$$

By Proposition 2, the second term in square brackets equals $B_{T-2h}(S_{T-2h})$. Thus,

$$V_{T-2h}(S_{T-2h}) = \frac{mr_h\tau}{1+r_h}\ 2B_{T-2h}(S_{T-2h})$$

Proceeding recursively back $N = T/h$ steps, we have

$$V_0(S_0) = \frac{mr_h\tau}{1+r_h}NB_0(S_0)$$

Letting $h \to 0$, we obtain[26]

$$V_0(S_0) = mrT\tau B_0(S_0) \tag{23}$$

References

Angel, J. J., Gastineau, G. L., Weber, C. J., Spring 1997. Using exchange-traded equity flex put options in corporate stock repurchase programs. Journal of Applied Corporate Finance 10 (1), 109–113.

Core, J. E., Guay, W. R., Aug. 2001. Stock option plans for non-executive employees. Journal of Financial Economics 61 (2), 253–287.

Cornell, B., Spring 1985. Taxes and the pricing of stock index futures: Empirical results. Journal of Futures Markets 5 (1), 89–101.

Cornell, B., French, K. R., Jun. 1983. Taxes and the pricing of stock index futures. Journal of Finance 38 (3), 675–694.

Cox, J. C., Ross, S. A., Rubinstein, M., Sep 1979. Option pricing: A simplified approach. Journal of Financial Economics 7 (3), 229–263.

Cox, J. C., Rubinstein, M., 1985. Options Markets. Prentice-Hall, Englewood Cliffs, NJ.

Eberhart, A. C., Aug. 2001. The valuation of employee stock options as warrants and the concurrent valuation of common stocks, working Paper, McDonough School of Business, Georgetown University.

Gibson, S., Singh, R., Aug. 2000. Using put warrants to reduce corporate finance costs, working Paper, Carlson School of Management, University of Minnesota.

Graham, J. R., Oct. 1996. Proxies for the corporate marginal tax rate. Journal of Financial Economics 42 (2), 187–221.

Graham, J. R., Oct. 2000. How big are the tax benefits of debt? Journal of Finance 55 (5), 1901–1941.

Graham, J. R., Lang, M. H., Shackelford, D. A., Jul. 2002. Employee stock options, corporate taxes and debt policy, duke University working paper.

Green, T. C., Figlewski, S., Aug. 1999. Market risk and model risk for a financial institution writing options. Journal of Finance 54 (4), 1465–1499.

[26] The calculation can only be done numerically for American options, since the tax advantage stops accruing when the option is early-exercised.

Hanlon, M., Shevlin, T., Mar. 2002. Accounting for tax benefits of employee stock options and implications for research. Accounting Horizons 16 (1), 1–16.

Hull, J. C., White, A., 1995. The impact of default risk on the prices of options and other derivative securities. Journal of Banking and Finance 19, 299–322.

Johnson, H., Stulz, R., Jun. 1987. The pricing of options with default risk. Journal of Finance 42 (2), 267–280.

Kahle, K. M., Shastri, K., September 2002. Firm performance, capital structure and the tax benefits of employee stock options, working paper, University of Pittsburgh.

McDonald, R. L., 2003. Derivatives Markets. Addison Wesley, Boston, MA.

Miller, M. C., May 1977. Debt and taxes. Journal of Finance 32 (2), 261–275.

Mozes, H. A., Raymar, S. B., Sep. 2000. Granting and hedging employee stock options: A tax motivation and empirical tests, working Paper, Fordham University Graduate School of Business Administration.

Samuelson, P. A., Dec. 1964. Tax deducutibility of economic depreciation to insure invariant valuations. Journal of Political Economy 72 (6), 604–606.

Scholes, M., 1976. Taxes and the pricing of options. Journal of Finance 31 (2), 319–332.

Scholes, M., Wolfson, M., 1992. Taxes and Business Strategy: A Planning Approach. Prentice-Hall, Englewood Cliffs, New Jersey.

Stein, J. C., Aug. 1992. Convertible bonds as backdoor equity financing. Journal of Financial Economics 32 (1), 3–21.

Strnad, J., 2001. Taxing convertible debt, working Paper, Stanford University Law School.

Thatcher, K. L., Flynn, T., Ehrlinger, J., Reel, M., April 1994. Equity put warrants: Reducing the costs and risks of a stock repurchase program. Tech. rep., Salomon Brothers, New York.

Titman, S., Mar. 1985. The effect of forward markets on the debt-equity mix of investor portfolios and the optimal cpital structure of firms. Journal of Financial and Quantitative Analysis 20 (1), 19–27.

Warren, Jr., A. C., Jun. 2000. Income taxation and financial innovation, unpublished, Harvard Law School.