Corporate Taxes, Leverage and Business Cycles

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Abstract

This paper evaluates quantitatively the implications of the preferential tax treatment of debt in the United States corporate income tax code. Specifically we examine the economic consequences of allowing firms to deduct interest expenses from their tax liabilities on financial variables such as leverage, default decisions and credit spreads. Moreover our general equilibrium framework allows us to also investigate the consequences of this policy for economy-wide quantities such as investment and consumption. Contrary to conventional wisdom we find that changes in tax policy have only a small effect on equilibrium levels of corporate leverage. The intuition lies in the endogenous adjustment of debt prices in equilibrium that make debt relatively more attractive and largely offset the effect of the changes tax policy.

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1 Introduction

This paper evaluates quantitatively the implications of the preferential tax treatment of debt in the United States corporate income tax code. Specifically we examine the economic consequences of allowing firms to deduct interest expenses from their tax liabilities on financial variables such as leverage, default decisions and credit spreads. Moreover our general equilibrium framework allows us to also investigate the consequences of this policy for economy-wide quantities such as investment and consumption.

A long standing literature in finance tries to estimate the response of firms' leverage to tax incentives. Furthermore, in lieu of the recent fiscal problems faced by the government, several arguments have been put forth to help reduce existing levels of corporate debt, including increased regulation of financial institutions and changes in corporate taxes.

However, to date there is no agreed upon framework to understand the macroeconomic implications of these and several other proposed measures.

In this paper we choose to focus on the role of the corporate tax code. An important challenge to our analysis is generating a suitable macroeconomic model that captures the essential features of both macro and credit market data and is simultaneously a suitable framework to conduct tax experiments. In particular, we require our model to be consistent with observed leverage, default, and credit spread data. This is particularly important given that certain modeling perspectives suggest that firms are under-levered given the current tax incentive (see Graham (2001)). While recent literature has made great progress along measured leverage and credit spreads (e.g., Harjoat, Kuehn, and Strebulaev (2007), Chen (2009), Gomes and Schmid (2009)) analyzing tax policy implications requires a framework that matches these features accounting for general equilibrium effects, increasing the modeling burden in a non-trivial way.

Our approach is to integrate the advances of the literature in corporate finance literature with core lessons from the study of macroeconomic fluctuations and asset prices. Our starting point is a detailed model of corporate investment and leverage, where firms choose leverage by trading off tax shield benefits of debt and bankruptcy costs. Each firm faces persistent idiosyncratic and systematic productivity shocks which can lead to default. We then embed this model within a general equilibrium environment of a representative consumer-worker-investor. Relative to the existing literature we also add a more detailed treatment of the U.S corporate income tax code. We calibrate the model to match salient features of leverage, default rates, and equilibrium credit spreads within a production general equilibrium environment.

Our general equilibrium approach that explicitly considers the price of risky default has considerable quantitative advantages over the classic risk neutral models of leverage and are thus unable to match debt levels and prices at the same time. Standard models of risky debt usually abstract form investment and offer fairly stylized descriptions of the behavior of firms and investors. By contrast popular macro models that allow for a role for leverage rule out an explicit role for corporate taxes and are thus unsuitable for the type of policy experiment that we have in mind.

This paper is organized as follows. Section II describes our general equilibrium model and some of its basic properties. Section III describes the properties of the implied cross-sectional distribution of firms and some basic macro aggregates. Our main quantitative findings are discussed in Section IV. Section V concludes.

2 The Model

In this section we develop a dynamic general equilibrium environment with heterogeneous firms that allows for complex investment and financing strategies. We combine this optimal behavior of firms with household optimal consumption and portfolio decisions to determine equilibrium prices of debt and equity securities as well as the equilibrium behavior of macroeconomic aggregates.

In our model individual firms make production and investment decisions while choosing the optimal mix of debt and equity finance, subject to the natural financing constraints and equilibrium prices. These must be reconciled with optimal behavior of a representative household/investor/worker who owns a diversified portfolio of stock and corporate bonds. In line with existing policies a key feature of the model is the existence of asymmetries in the tax-code treatment of interest and dividend income. Specifically, deductability of interest payments will generally encourage firms to choose higher levels of corporate leverage and generally distort allocations.

Two key difficulties arise when solving this model. First, the endogenous determination of state prices links optimal consumption and leisure choices of households to the investment an financing policies of firms. Second, explicit consideration of corporate defaults requires us to keep track of the evolution of a cross-sectional distribution of firms over time. We now describe our model in detail and the key steps required for computing its solution.

2.1 Firms

2.1.1 Profits and Investment

We begin by describing the problem of a typical value-maximizing firm in a perfectly competitive environment. Time is discrete. The flow of after-tax output per unit of time for each individual firm, denoted Y_t, is described by the expression

$$\Pi_t = (1-\tau) Z_t X_t K_t^{\alpha_k} N_t^{\alpha_n}, \quad 0 < \alpha_k, \alpha_n < 1 \tag{1}$$

where X_t and Z_t, capture, respectively, the systematic and firm-specific components of productivity, and the variables N_t and K_t denote the amount of labor and capital inputs required in production.

Both X and Z are assumed to be lognormal and obey the laws of motion

$$\begin{aligned} \log(X_t) &= \rho_x \log(X_{t-1}) + \sigma_x \varepsilon_{xt} \\ \log(Z_t) &= \rho_z \log(Z_{t-1}) + \sigma_z \varepsilon_{zt}, \end{aligned}$$

and both ε_x and ε_z are truncated (standard) normal variables to ensure that both processes remain in a bounded.The assumption that Z_t is entirely firm specific implies that

$$\begin{aligned} E\varepsilon_{xt}\varepsilon_{zt} &= 0 \\ E\varepsilon_{zt}\varepsilon_{z't} &= 0, \text{for } z \neq z'. \end{aligned}$$

Individual firms hire labor in competitive markets, thus taking the wage rate, W_t as given in their optimization problem. We find it convenient to separate this choice, which is essentially static, from the remaining decision of the firm. Accordingly we define operating profits as

$$\Pi_t = \max_{N_t} \{Y_t - W_t N_t\} \tag{2}$$

Each individual firm is allowed to scale operations by adjusting the size of its capital stock. This can be accomplished through investment expenditures, I_t, and is subject to costs of adjustment. Investment is linked to productive capacity by the standard capital accumulation equation

$$I_t = K_{t+1} - (1-\delta) K_t, \tag{3}$$

where $\delta > 0$ denotes the depreciation rate of capital per unit of time. Adjustment costs are expressed in units of final goods and assumed to follow the quadratic form:

$$\Phi(I_t, K_t) = \left(\frac{I_t}{K_t} - \delta\right)^2 K_t$$

2.1.2 Financing

Corporate investment as well as any distributions to shareholders, can be financed with either the internal funds generated by operating profits or net new issues, which can take the form of new debt (net of repayments) or new equity.

We assume that debt takes the form of a one-period bond that pays a coupon c_t per unit of time. This allows a firm to refinance the entire value of its outstanding liabilities in every period. Formally, letting B_t denote the book value of outstanding liabilities for the firm at the beginning of period t we define the value of net new issues as

$$B_{t+1} - (1 + c_t)B_t.$$

Clearly both debt and coupon payments will exhibit potentially significant time variation and will now depend on a number of firm and aggregate variables.

The firm can also raise external finance by means of seasoned equity offerings. For added realism, however, we assume that these equity issues entail additional costs so that firms will never find it optimal to simultaneously pay dividends and issue equity. Following the existing literature we allow these costs to include both fixed and variable components. Formally, letting E_t denote the net payout to equity holders, total issuance costs are given by the function:

$$\Lambda(E_t) = (\lambda_0 - \lambda_1 \times E_t)\, \mathbb{I}_{\{E_t<0\}},$$

where the indicator function implies that these costs apply only in the region where the firm is raising new equity finance so that the net payout, E_t, is negative.

Investment, equity payout, and financing decisions must meet the following identity between uses and sources of funds

$$E_t + I_t + \Phi_t = \Pi_t - T_t + \tau\delta K_t + B_{t+1} - (1 + c_t)B_t, \tag{4}$$

where T_t captures the corporate tax payments made by the firm in period t which are discussed in more detail below.

Given operating, investment and financing decision we can now define net distributions to shareholders, denoted D_t, which are equal to total equity payout net of issuance costs:

$$D_t = E_t - \Lambda(E_t).$$

When this value is negative the firm receives an injection of funds from its shareholders - the equivalent of a seasoned equity offer. Moreover since they have similar tax implications we do not think it necessary to make any distinction between dividend payments and share repurchases.

2.1.3 Taxes

The tax bill depends essentially on the level of the corporate income tax rate, τ, and the allowed tax deductions. In addition the tax code in most countries is often asymmetric in its treatment of gains and losses as most tax governments are reluctant to offer full loss offsets. Accordingly the total tax liability of the firm depends also on the absolute level of operating earnings, Π. The key features of the corporate tax code can be summarized as follows. First, define the firm's taxable income as

$$TI = \Pi - \delta K - \omega RB, \quad \omega \in [0, 1]$$

This definition reflects the fact that corporate interest and depreciation expense are tax deductible. To examine changes in the tax deductibility of interest expense, we define the parameter ω as the fraction of interest expense which is tax deductible. Note that under the current U.S. tax code, the interest expense is fully tax deductible, which corresponds to the case of $\omega = 1$. For the case of $\omega = 0$, none of the firm's interest expense is tax deductible and there is no tax incentive to issuing debt.

To handle loss offsets in the firm's tax bill, we follow Hennessy and Whited (2007) and specify the tax rate on corporate profits as

$$\tau_{c,\pi} = [\mathbb{I}_{\{TI>0\}}\tau^{+}_{c,\pi} + (1 - \mathbb{I}_{\{TI>0\}})\tau^{-}_{c,\pi}],$$

where the indicator function is equal to 1 when taxable income is positive and zero otherwise. This assumes that positive taxable corporate is taxed at a rate $\tau^{+}_{c,\pi}$. When taxable income is negative, a fraction $\tau^{-}_{c,\pi}$ of the losses are offset. In reality, this offset is in the form of a future tax credit and thus its value depends on future profits. Furthermore, these tax credits cannot be carried forward indefinitely. In the model, however, the tax credit comes in the form of a lump sum payment in the current period. To account for this discrepancy, we assume $\tau^{-}_{c,\pi} < \tau^{+}_{c,\pi}$. It follows that when $\tau^{-}_{c,\pi} = \tau^{+}_{c,\pi}$ the firm can fully offset its losses while $\tau^{-}_{c,\pi} = 0$ implies that no losses can be offset. The tax rate applied to corporate interest expense, $\tau_{c,int}$, is thus given by:

$$\tau_{c,int} = \omega\tau_{c,\pi}. \tag{5}$$

Total tax liabilities are than equal to

$$T_t = \tau_{c,\pi}\Pi_t - \tau_{c,int}(\delta K + c_t B_t), \tag{6}$$

2.1.4 Valuation

Given the environment detailed above we can now define the equity value of a typical firm, V, as the discounted sum of all future equity distributions.

To construct this value we need to be explicit about the nature of any default decisions on outstanding corporate debt. We assume that equity holders will optimally choose to close the firm and default on their debt repayments if and only if the prospects for the firm are sufficiently bad, that is, whenever V reaches zero. This assumption is consistent with the existence of limited liability for equity in most bankruptcy laws and seems both a minimal and plausible restriction on the problem of the firm.

However we could further expand default by assuming that firms also default "sub-optimally", due to the violation of some technical loan covenant. A common requirement is to impose that flow profits must be positive for survival, or alternatively to require that operating profits cover interest expenses. While this type of involuntary default is often imposed in the literature we find it difficult to rationalize without allowing for explicit renegotiation costs between borrowers and lenders. Without these it seems difficult to understand why both parties would not agree to allow the firm to remain a going concern in exchange for some transfer between them.

The complexity of the problem facing each firm is reflected in the dimensionality of the state space necessary to construct the equity value. This includes both aggregate and idiosyncratic components of demand, productive capacity, and total debt commitments, defined as

$$\hat{B}_t \equiv (1 + (1 - \tau)c_t)B_t.$$

In addition as we is often the case in these problems the current cross-sectional distribution of firms $H(\cdot)$ is also part of the state space because of its impact on current and future prices. To save on notation we henceforth use the $S_t = \{K_t, \hat{B}_t, Z_t, X_t, H_t\}$ to summarize our state space.

We can now characterize the problem facing equity holders taking all prices, including coupon payments as given. These will be determined endogenously in the next subsection. Shareholders jointly choose investment (next-period capital stock) and financing (next-period total debt commitments) strategies to maximize the equity value of each firm, which accordingly can then be computed as the solution to the dynamic program

$$V(S) = \max\{0, \max_{K(S)', B'\hat{(}S)} \{D(S) + E\left[M'V(S')\right]\}\} \tag{7}$$

where the expectation in the left-hand side is taken by integrating over the conditional distributions of X and Z and we economize on notation by following the convention of using primes to denote next period values. Note that the first maximum in 7 captures the possibility of default at the beginning of the current period, in which case the shareholders will get nothing. Aside from the budget constraint embedded in the definition of D_{it}, the only significant constraint on this problem is the determination of equilibrium coupon rates, c_t.

The greatest challenge to solving this problem comes from the endogeneity of the discount factor used to discount future cash flows, $M' = M_{t,t+1}$. This needs to be reconciled with the optimal choices on investors in a general equilibrium setting. For the moment however we focus solely on the characterization of the optimal investment and financing decisions of firms for any given set of intertemporal prices while postponing discussions surrounding their determination until we describe the behavior of households in this economy.

2.1.5 Default and Bond Pricing

We next turn to the determination of the required coupon payments, taking into account the possibility of default by equity holders. This follows readily from the optimal pricing equation for one period bonds by its holders. Assuming debt is issued at par, the market value of any new bond issues must satisfy the condition

$$B_{t+1} = E\left[M_{t,t+1}((1 + c_{t+1})B_{t+1}\mathbb{I}_{\{V_{t+1}>0\}} + RC_{t+1}(1 - \mathbb{I}_{\{V_{t+1}>0\}}))\right], \tag{8}$$

where RC_{t+1} denotes the recovery payment to bondholders in default and $\mathbb{I}_{\{V_{t+1}>0\}}$ is again an indicator function that takes the value of one if the firm remains active and zero when equity chooses to default.

Since the equity value V_{t+1} is endogenous and itself a function of the firm's debt commitments, this equation cannot be solved explicitly to determine the value of the coupon payments, c_t. However, using the definition of $\hat{B}$, we can rewrite the bond pricing equation as

$$\begin{aligned} B_{t+1} &= \frac{E\left[M_{t,t+1}(\frac{1}{1-\tau}\hat{B}_{t+1}\mathbb{I}_{\{V_{t+1}>0\}} + RC_{t+1}(1 - \mathbb{I}_{\{V_{t+1}>0\}}))\right]}{1 + \frac{\tau}{1-\tau}(E\left[M_{t+1}\mathbb{I}_{\{V_{t+1}>0\}}\right])} \\ &= \mathbf{B}(K_{t+1}, \hat{B}_{t+1}, X_t, Z_t). \end{aligned}$$

Given this expression and the definition of $\hat{B}$ we can easily deduce the implied coupon payment as

$$c_{t+1} = \frac{1}{1-\tau}(\frac{\hat{B}_{t+1}}{B_{t+1}} - 1).$$

Note that defining $\hat{B}$ as a state variable and constructing the bond pricing schedule $\mathbf{B}(\cdot)$ offers important computational advantages. Because equity and debt values are mutually dependent (since the default condition affects the bond pricing equation), we would normally need to jointly solve for both the interest rate schedule (or bond prices) and equity values. Instead, our approach requires only a simple function evaluation during the value function iteration. This automatically nests the debt market equilibrium in the calculation of equity values and greatly reduces computational complexity (see Appendix A for details).

2.2 Optimal Firm Behavior

Before proceeding to describe the full general equilibrium of the model it is useful to gain some intuition by first exploiting some of the properties of the dynamic program (7). Our assumptions ensure that this problem has a unique solution if prices are continuous functions of the state variables as it is the case in equilibrium (Gomes and Schmid (2010)). Unfortunately however it cannot be solved in closed form and we must resort to numerical methods, which are detailed in Appendix A. The solution can be characterized efficiently by optimal distribution, financing, and investment policies. We now investigate some of properties of these optimal strategies.

Our choice of parameter values, summarized in Table I, follows closely the existing literature (e.g., Gomes and Schmid (2010)). The values are picked so that the model produces a cross-sectional distribution of firms that matches key unconditional moments of investment, returns, and cash flows both in the cross-section and at the aggregate level. Appendix B discusses our choices in detail.

2.2.1 Investment and Financing

Figure 1 illustrates the optimal financing and investment policies of the firm for various levels of firm and aggregate productivity. The dashed line corresponds to the optimal choice of next period debt, $b'(S_t)$ while the solid line shows the desired investment policy, $k'(S_t)$. These policies all depend on the other components of the state space and the pictures show only a typical two-dimensional cut of these. However, since we are only focusing on some basic qualitative properties these exact choices are not very significant and we focus on values where the level of current capital and debt are set close to their cross-sectional averages

These panels neatly illustrate the interaction of financing and investment decisions and the role of the current state of the economy on these choices. The choice of debt in particular is affected dramatically by the current state of firm and aggregate productivity. When the current state is sufficiently bad optimal debt is very low and book leverage (debt relative to assets) remains under control. However when the current state is high, leverage rises to reach levels close to 100% in some cases.

By comparison investment is only mildly responsive to the state of productivity. This is a result of our adjustment costs which are sizable enough to dampen some of the response to changes in expected future profits. Together these panels confirm that leverage choices can be made in ways that are often quantitatively close to independent from the optimal investment choice.

2.2.2 Default Risk and Credit Spreads

Figure 2 investigates the implications of these firm decisions on credit market indicators. This figure plots the annualized credit spread (in basis points) and probability of defaulting in the next quarter as a function of current capital stock and current debt obligations. Note that these spreads and default probabilities are consistent with the firm's optimal policies for investment and financing given the current level of capital stock and debt outstanding. The solid line corresponds to a realization of the aggregate productivity, X, equal to its mean. The dashed and dotted lines represent a realization of X that is one standard deviation above and below its mean, respectively.

The figure shows that, not surprisingly, both measures are sensibly declining in expected future profits. Nevertheless, and unlike several macro models of credit constraints our framework can match the empirical finding that credit spreads are strongly countercyclical.

More interestingly, the model can also produce sizable credit spreads and defaults observed in the data. The intuition is very similar to that in Bahmra, Kuehn and Strebulaev (2007, 2009) and Chen (2007): what matters for credit spreads are not so much the actual default probabilities shown but the risk-adjusted default probabilities. Our parameter choices ensure that the joint variation in the pricing kernel and physical default probabilities produce large risk-adjusted probabilities and thus generate significant credit spreads.

From a cross-section point of view, credit risk rises substantially when the firm is very small and leverage is high, since this scenario leads to a dramatic increase in the probability of default.

2.2.3 No Interest Deduction Allowed

For comparison Figures 3 and 4 offer the same policy functions and prices in the case where the tax policy allows for no deductability of interest expenses. It is apparent from Figure 3 that this change in corporate taxes has a significant impact on the financing policy of an individual firm. Now optimal debt choices lead to significantly lower levels of leverage for nearly all values of expected future profits. Nevertheless investment decisions remain largely unaffected by these choices, confirming once again that the two policies are largely independent.

Figure 4 allows us to compare the impact of this change on default rates and credit spreads. The figure shows that as expected both of them are significantly reduced across the entire state space. Credit spreads in particular rarely reach 100% in the panels shown. The two figures thus confirm the standard intuition from simple optimization analysis that the tax deductability of interest expenses is a major factor behind the optimal choice of leverage. What is missing from this simple calculation however is the effect of these changes in an equilibrium setting where the stationary distribution of firms over this state space changes endogenously. It is this effect that we proceed to quantify in our general equilibrium analysis below. We now proceed to close the model.

2.3 Households

We now turn to describe the role of households in our economy. We assume that aggregate consumption and leisure is determined by the optimal choices of a representative agent with Weil (1990) and Epstein-Zin (1991) preferences over an aggregate of these two goods. Formally we assume that the household's utility flow in each period is given by the Cobb-Douglas aggregator:

$$u(C, N) = C^{\alpha}(1 - N)^{1-\alpha}. \tag{9}$$

where $1 - N$ denotes the fraction of time spent by the representative household in leisure and the parameter $\alpha \in (0, 1)$. The household maximizes the discounted value of future utility flows, defined through the recursive function

$$U_t = \{(1 - \beta)u(C_t, N_t)^{1-1/\sigma} + \beta E_t[U_{t+1}^{1-\gamma}]^{1/\kappa}\}^{1/(1-1/\sigma)}. \tag{10}$$

The parameter $\beta \in (0, 1)$ is the household's subjective discount factor. The parameter $\sigma \geq 0$ is its elasticity of intertemporal substitution, $\gamma > 0$ is its relative risk aversion, and $\kappa = (1-\gamma)/(1-1/\sigma)$. We assume that this representative household has access to a complete set of Arrow-Debreu securities and derives income from both wage earnings and dividend and interest payments from its diversified portfolio of corporate stocks and bonds. These assumptions are embedded in the following household budget constraint:

$$C_t + A_{t+1} = W_t N_t + R_t A_t + T_t \tag{11}$$

where A_t is total household wealth at time t that earns an equilibrium rate of return of R_t. Note that we assume that corporate income taxes, T_t, are rebated to the household.

Total household wealth is given by the sum of equity and bond holdings across firms:

$$A_t = \int V(S_t) + B(S_t) dG(S_t). \tag{12}$$

while the gross rate of return on this portfolio is

$$\begin{aligned} R_{t+1} &= \int \left[(1 - w(S_t)) \frac{V(S_{t+1})}{V(S_t) - D(S_t)} + w(S_t)(1 + c(S_{t+1})) \right] \mathbb{I}_{\{V_{t+1} > 0\}} dG(S_t) + \\ &+ \int w(S_t) R(S_{t+1}) \mathbb{I}_{\{V_{t+1} = 0\}} dG(S_t) \end{aligned}$$

Here we have defined the leverage ratio $w(S_t) = \frac{V(S_t)}{V(S_t)+B(S_t)}$. The second term in this expression captures the payout to debt when the firm chooses to default. Absolute priority implies that equity value must be zero for defaulting firms.

3 Cross-Sectional Implications

In this section we investigate some of the empirical implications of the general model of Section II by comparing our theoretical findings with data on firm investment and leverage.

3.1 Basic Methodology and Definitions

We begin by constructing an artificial cross-section of firms by simulating the investment and leverage rules implied by the model. The simulation details are described in Appendix A. We then construct theoretical counterparts to the empirical measures widely used in the CRSP/Compustat data set. In our model the book value of assets is simply given by K, while the book value of equity is given by $BE = K - B$. To facilitate comparisons with prior studies we will henceforth use the notation $ME = V$ to denote the market value of equity. Book leverage is then measured by the ratio B/K, while book-to-market equity is defined as BE/ME. Tobin's Q is measured as the ratio of market equity plus debt over the book value of assets, K.

3.2 Findings

The first column in Table II offers some summary statistics for key quantities of the model and compares them with the available data. This table can thus be used to judge the ability of our model to fit basic empirical facts about the cross-section of firms.

4 Policy Experiments

The previous section shows that our quantitative model offers a reasonable description of key features of the cross-sectional patterns in firm investment, financing and distribution policies and it is thus a useful laboratory to conduct policy experiments. We are particularly interested in the effects of alternative tax treatments of debt expenses for firms. Much of the popular literature suggests that the tax code creates a powerful incentive for the use of debt by corporations, much of the argument relies on the microeconomics of the optimal response of a single firm in a competitive setting where all prices are held constant. In this section we use our general equilibrium model to revisit this question from a truly macroeconomic perspective.

We consider three possible experiments and compare our results with the benchmark corresponding to the current US tax code used in the calibration of our model in sections 2 and 2. In the first experiment we investigate the effects of a cut in corporate income taxes to 25%. We then consider a second experiment where there is no deductability for interest expenses and finally we look at the case where both interest and equity distributions are tax deductible. While the first experiment merely reduces the asymmetry between equity and debt cash flows imposed by the current tax code, the last two offer two alternative ways for entirely removing it. For completeness, we consider a fourth modification of the tax code where the government introduces a full loss offset provision in the corporate tax code.

4.1 No Interest Deductability

Table II compares the results of our benchmark model with the case where the tax policy allows for no deductability of interest expenses. As expected this policy reduces the incentive for firms to use debt finance and leads to a reduction in the equilibrium level of corporate leverage. Moreover this reduction in leverage lowers the default rate as well. Nevertheless this reduction has very little impact on the price of debt: credit spreads remain essentially unchanged across the two columns as does the risk free rate.

It is also apparent that this policy has a sizable impact on equity prices. Both the equity risk premium and the market to book ratio change significantly and in predictable ways. As leverage falls equity risk naturally falls and the equity premium is reduced. This in turn raises the market to book ratio in this economy.

4.2 Lowering Corporate Income Taxes

This section needs to be completed

4.3 Deducting Interest and Equity Distributions

This section needs to be completed

4.4 Full Loss Offset

This section needs to be completed

5 Conclusion

This paper evaluates quantitatively the implications of the preferential tax treatment of debt in the United States corporate income tax code. Specifically we examine the economic consequences of allowing firms to deduct interest expenses from their tax liabilities on financial variables such as leverage, default decisions and credit spreads. Moreover our general equilibrium framework allows us to also investigate the consequences of this policy for economy-wide quantities such as investment and consumption. Contrary to conventional wisdom we find that changes in tax policy have only a small effect on equilibrium levels of corporate leverage. The intuition lies in the endogenous adjustment of debt prices in equilibrium that make debt relatively more attractive and largely offset the effect of the changes tax policy.

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Appendix A. Computational Details

Computation of the optimal policy functions is complicated by the endogeneity of the coupon schedule on corporate debt, that is, the fact that the coupon schedule depends on firms' default probabilities, which in turn depend on their equity values. We use a two-step procedure to speed up calculations.

- Step I: Specify a fairly coarse grid for the state space with $n_K^0 \times n_B^0 \times n_Z^0 \times n_X^0$ points. We use the Tauchen-Hussey procedure to transform the autoregressive processes for X and Z into finite Markov Chains.

  1. Given an initial guess for $c(S) = c^0(S)$, iterate on (7) until convergence. Given our assumptions this procedure has a unique fixed point.
  2. Given the computed equity value $V(S)$ and the implied default policy, construct a revised guess for the coupon $c^1(S)$ from equation (8).
  3. Compute the distance $\|c^1(S) - c^0(S)\|$. If this is small we stop, otherwise we return to Step 1.

- Step II: Implement the direct computation described in the text on a finer grid with $n_K \times n_B \times n_Z \times n_X$ points. Specifically:

  1. Use the values of $V(S)$ and $c(S)$ obtained in Step I to construct an initial guess for the value function on the finer grid.
  2. Iterate the Bellman equation for equity value until convergence. Our convergence criterion is set to be 0.0001.

3. Use this to construct the market value of debt and the implied coupon value.

In principle we can use the procedure described in Step I alone and this is guaranteed to converge to the true solution (Gomes and Schmid (2010)). Computation speed, however, increases significantly if we use the two-step procedure. Since the algorithm described in Step II is not a contraction mapping it is important to start close enough to the actual solution, which is why Step I must be used first.

Our two-step approach is very robust and the accuracy of the direct computation was confirmed for a number of parameter values by simply using the method in Step I for very small tolerances and in large grids.

To construct an artificial cross-section of firms we simulate the investment, leverage and default rules implied by the model. For all simulations our artificial data set is generated by simulating the model with 2,000 firms over 1,500 monthly periods and dropping the first 1,000 periods. This procedure is repeated 50 times and the average results are reported.

For the leverage regressions we construct annual data by accumulating monthly profits and sales over 12 periods. We then run the regressions on the annual observations and report both the mean coefficient estimates and the average t-statistics across simulations.

Appendix B. Parameter Choices

The persistence, ρ_x, and conditional volatility, σ_x, of aggregate productivity are set equal to 0.983 and 0.0023, which is close to the corresponding values reported in Cooley and Hansen (1995). For the persistence, ρ_z, and conditional volatility, σ_z, of firm-specific productivity, we choose values close to the corresponding values constructed by Gomes (2001) to match the cross-sectional properties of firm investment and valuation ratios.

The depreciation rate of capital, δ, is set equal to 0.01, which provides a good approximation to the average monthly rate of investment found in both macro and firm level studies. For the degree of decreasing returns to scale we use 0.65. Although probably low, this number is almost identical to the estimates in Cooper and Ejarque (2003) as well as several other recent micro studies.

We follow Hennessy and Whited (2007) and specify the deadweight losses at default to consist of a fixed and a proportional component. Thus, creditors are assumed to recover a fraction of the firm's current assets and profits net of fixed liquidation costs. Formally, the default payoff is equal to

$$RC_{it} = \Pi_{it} + \tau\delta K_{it} + \xi_1(1-\delta)K_{it} - \xi_0$$

We set ξ_1, which is one minus the proportional cost of bankruptcy, equal to 0.75, which is in line with recent empirical estimates in Hennessy and Whited (2007) as well as consistent with values traditionally used in macroeconomics. Additionally, under the assumption that near default the asset value of the unlevered firm is close to its book value, this number is consistent with the traditional estimates of the direct costs of bankruptcy obtained in the empirical corporate finance literature. We then choose ξ_0, the fixed cost of bankruptcy, such that we match average market-to-book values in the economy.

The costs of equity issuance λ_0 and λ_1 are chosen similarly as in Gomes (2001). Later empirical studies (Hennessy and Whited, 2007) have confirmed that these values are good estimates.

We choose the pure time discount factor β and the pricing kernel parameter γ so that the model approximately matches the mean risk-free rate and the equity premium. This implies that β equals 0.995 and γ is 15.

To assess the fit of our calibration, we report in Table II the implied moments generated by our parameterization for some key variables. Our calibration ensures that the simulated data match key statistics related to asset market data and firms' investment and financing decisions quite well. This strengthens our confidence in the inference procedure in the paper.

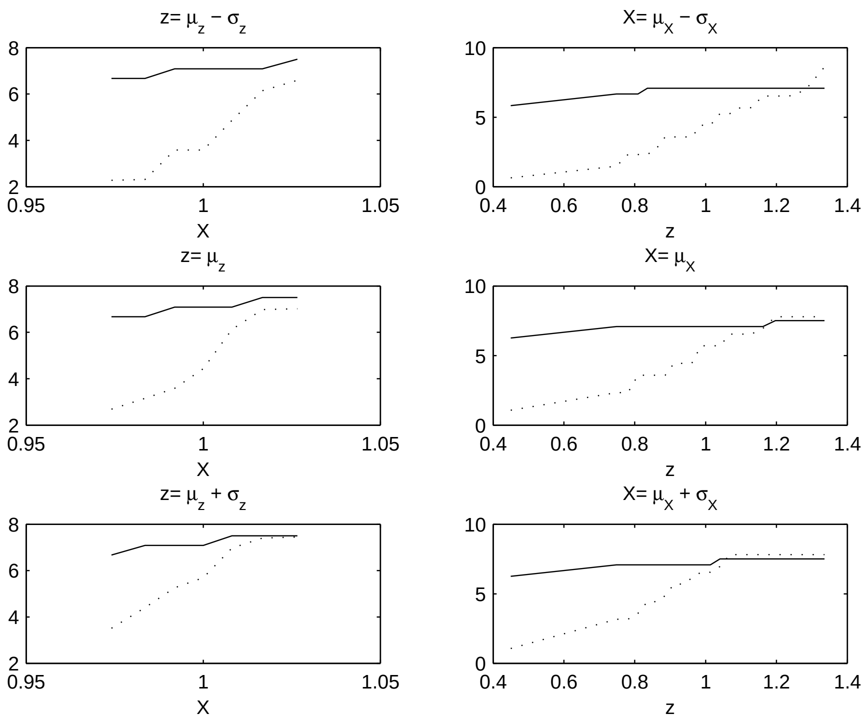

Figure 1. Optimal Policies - Benchmark. This figure plots the optimal policies for next period's capital, k (solid line), and debt, b (dashed line), as functions of the current states of aggregate and idiosyncratic productivity, X and z for the benchmark model. The three graphs in the left panel plot k and b on X for three values of z: its mean and one standard deviation above and below. The right panel is similarly k and b plotted on z for X equal to its mean and one standard deviation above and below. The current capital stock and outstanding debt obligations are fixed at their mean values for each plot.

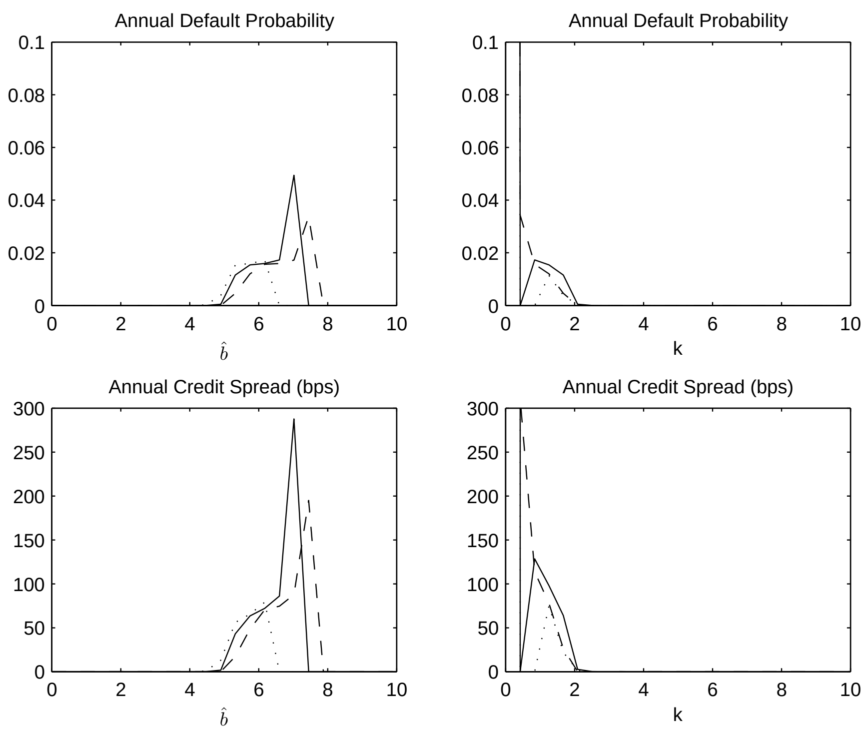

Figure 2. Default Probabilities and Credit Spreads - Benchmark. This figure plots the annualized credit spread (in basis points) and probability of defaulting in the next quarter as a function of current capital stock and current debt obligations for the benchmark model. Note that these spreads and default probabilities are consistent with the firm's optimal policies for investment and financing given the current level of capital stock and debt outstanding. The solid line corresponds to a realization of the aggregate productivity, X, equal to its mean. The dashed and dotted lines represent a realization of X that is one standard deviation above and below its mean, respectively.

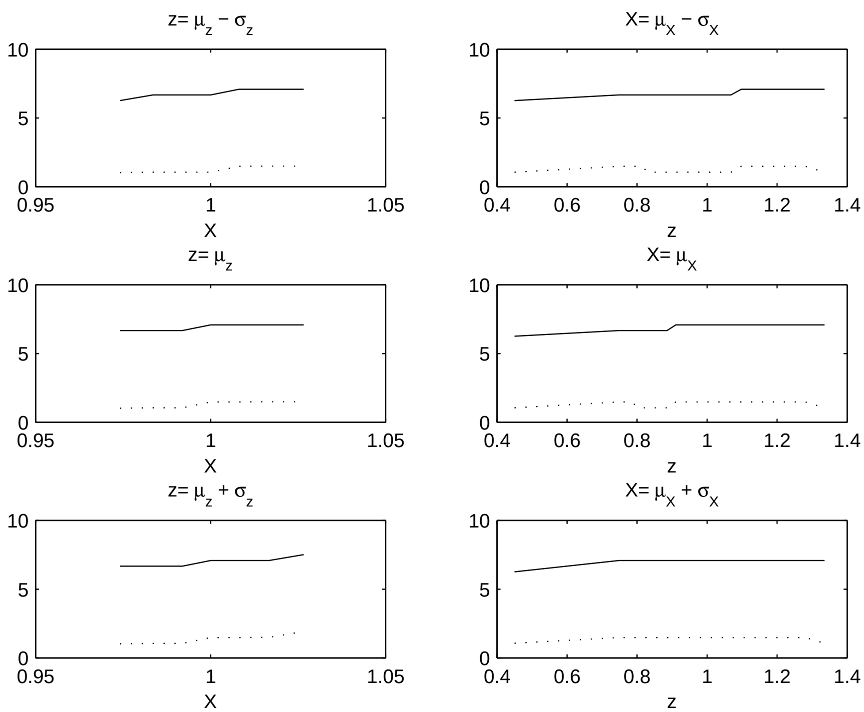

Figure 3. Optimal Policies - No Interest Deduction. This figure plots the optimal policies for next period's capital, k (solid line), and debt, b (dashed line), as functions of the current states of aggregate and idiosyncratic productivity, X and z for the case of no interest deductability. The three graphs in the left panel plot k and b on X for three values of z: its mean and one standard deviation above and below. The right panel is similarly k and b plotted on z for X equal to its mean and one standard deviation above and below. The current capital stock and outstanding debt obligations are fixed at their mean values for each plot.

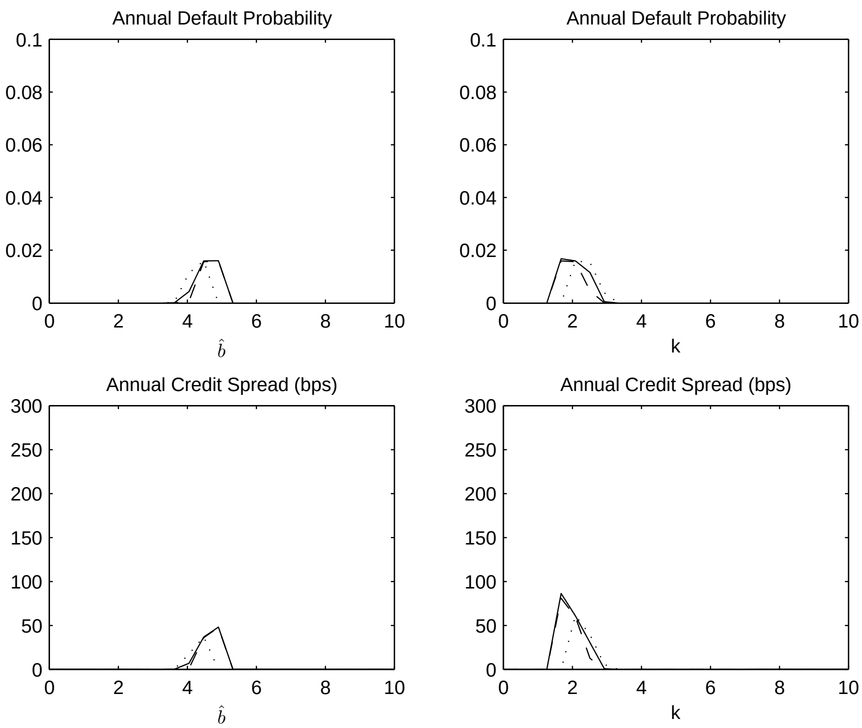

Figure 4. Default Probabilities and Credit Spreads - No Interest Deductions. This figure plots the annualized credit spread (in basis points) and probability of defaulting in the next quarter as a function of current capital stock and current debt obligations for the model with no interest deductability. Note that these spreads and default probabilities are consistent with the firm's optimal policies for investment and financing given the current level of capital stock and debt outstanding. The solid line corresponds to a realization of the aggregate productivity, X, equal to its mean. The dashed and dotted lines represent a realization of X that is one standard deviation above and below its mean, respectively.

Table I
Parameter Choices

This table reports parameter choices for our general model. The model is calibrated to match annual data both at the macro level and in the cross-section. The persistence, ρ_x, and conditional volatility, σ_x, of aggregate productivity are set close to the corresponding values reported in Cooley and Hansen (1995). The persistence, ρ_z, and conditional volatility, σ_z, of firm-specific productivity are close to the corresponding values constructed by Gomes (2001) to match the cross-sectional properties of firm investment and valuation ratios. The parameter δ is equal to the depreciation rate of capital and is set to approximate the average monthly investment rate. Equity issuance costs are set to values similar to those measured by Hennessy and Whited (2007). For the degree of decreasing returns to scale, α, we use the evidence in Cooper and Ejarque (2003). Finally, the pricing kernel parameters β and γ are chosen to match the risk free rate and the average equity premium.

Parameter	Benchmark Value
α	0.65
β	0.995
δ	0.01
γ	15
τ	0.2
λ_0	0.01
λ_1	0.025
ξ_0	0.1
ξ_1	0.75
f	0.01
ρ_x	0.983
σ_x	0.0023
ρ_z	0.92
σ_z	0.15

Table II
Sample Moments

This table reports unconditional sample moments generated from the simulated data of some key variables of the model. We compare our results for both the benchmark model calibrated to the current US corporate tax code and an alternative where interest expenses are not tax deductible. All data are annualized.

Variable	Benchmark	No Interest Deduction
Annual risk-free rate	0.0711	.0728
Annual Equity Premium	.32	.123
Credit Spread	.0478	.0459
Mean Market-to-Book	1.26	2.3
Book Leverage	0.82	.0567
Market Leverage	0.37	.0373
Default Rate	0.0102	0.0001