

# 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. We conduct a series of policy experiments in which the tax deductibility of the corporate interest expense is eliminated. As expected, this results in a substantial decrease in the equilibrium level of leverage. However, contrary to conventional wisdom, we find that eliminating interest deductibility results in an *increase* in the default frequency and average credit spreads in the economy. The intuition for this lies in the fact that this policy change makes external financing more costly, resulting in riskier firms and higher credit spreads.

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# 1 Introduction

The recent financial crisis has sparked a discussion of how financial leverage affects fragility of the economy. Many have argued that a corporate sector with less financial leverage would result in a more stable economy with fewer defaults and less volatile business cycles. Furthermore, they view firms' accumulation of debt and the potential adverse consequences as resulting from the preferential treatment of debt in the tax code. By allowing interest expense to be deducted from a firm's tax bill, the current U.S. corporate tax code gives incentive for firms to finance with debt. The implication is that the tax policy was a key factor contributing to the recent financial crisis. Such a conclusion was reached in a recent IMF research paper Keen, Klemm, and Perry (2010):

*“Tax distortions are likely to have contributed to the crisis by leading to levels of debt higher than would otherwise have been the case. These distortions have mostly long been recognized, but few countries have acted on them decisively. There remains much to learn, but one lesson of the crisis may be that the benefits from mitigating them are far greater than previously thought.”*

In this paper, we quantitatively evaluate this claim regarding the benefits of mitigating the tax distortion favoring debt finance. Specifically, we use an equilibrium model with endogenous default and debt pricing to conduct a series of policy experiments in which we remove the tax deductibility of a firm's interest expense. By comparing the results of the simulated policy experiment economies with those of a benchmark model that captures the salient features of leverage, credit spreads, default rates, and macroeconomic quantities, we are able to measure the benefits to a change in the tax policy.

A long-standing literature in finance tries to estimate the response of firms' leverage to tax incentives. Furthermore, in light 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, e.g., Graham (2000) and Korteweg (2010)). While recent literature has made great progress along measured leverage and credit spreads (e.g., Bhamra, Kuehn, and Strebulaev (2010a,b), Chen (2009) Gomes and Schmid (2010)), 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 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 from investment and offer fairly stylized descriptions of the behavior of firms and investors. In 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.

We conduct policy experiments in which we remove the tax deductibility of the corporate interest expense. As expected, this results in a substantial reduction in firms' equilibrium level of financial leverage. Despite lower leverage, the policy experiment actually leads to an increase in the default frequency and average credit spreads in the economy. While removing the interest tax deduction reduces the incentive to issue debt and thus leads to lower leverage, it also increases firms' external cost of financing. With decreasing returns to scale in production and fixed operating costs, this increase in the cost of capital leads to a smaller optimal firm size and, as a result, higher operating leverage. In effect, firms end up substituting financial leverage for operating leverage: the reduction in financial leverage reduces firms' riskiness, while the increase in operating leverage increases it. We find that the latter effect quantitatively dominates, which results in an increase in the default frequency and equilibrium credit spreads, despite a reduction in firms' optimal leverage. Additionally, we consider a policy experiment with an investment tax credit where firms are able to deduct capital expenditures from their tax bill.

The remainder of the paper is organized as follows. Section 2 describes our general equilibrium model and some of its basic properties. Section 3 describes the properties of the implied cross-sectional distribution of firms and some basic macro aggregates as well as simulation results of the benchmark model. The results of three policy experiments are discussed in Section 4. In Section 6 we assess the robustness of the results of the policy experiments by considering an alternative model specification. Section 7 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 and 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. Lowercase variables denote firm-specific quantities and capitalized letter denote aggregate variables.

Firms produce using inputs of capital,  $k_t$ , and labor,  $n_t$ , subject to aggregate and idiosyncratic productivity shocks,  $X_t$  and  $z_t$ . 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 the firm's operating profits as

$$\Pi_t = \max_{n_t} \{ [1 - f(b_t/k_t)] X_t z_t k_t^{\alpha_k} n_t^{\alpha_n} - W_t n_t - C \} \quad (1)$$

We assume decreasing returns to scale in production, which implies

$$0 < \alpha_k + \alpha_n < 1.$$

The firm's debt outstanding is denoted by  $b_t$  and the function  $f(b_t/k_t)$ , which will be discussed in detail in a later section, represents the cost of financial leverage. Additionally, all firms face a fixed operating cost of  $C$ .

The processes driving aggregate and idiosyncratic productivity,  $X$  and  $z$ , respectively, 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  $\varepsilon_x$  and  $\varepsilon_z$  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

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

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

$$i_t = k_{t+1} - (1 - \delta)k_t, \tag{2}$$

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.

In addition to losses incurred in the event of default, we assume that financial leverage imposes a cost of the form

$$f(b_t/k_t) = \frac{1}{\nu} \left( \frac{b_t}{k_t} \right)^\nu$$

These costs, which are of a small magnitude in our parameterization, are meant to represent the costs associated with financial leverage outside of bankruptcy. We choose  $\nu = 3.5$ , which implies  $f(.25) = .0022$ . That is, for a leverage ratio of 25%, the firm incurs a cost of 22 basis points of earnings relative to a firm with zero leverage.

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:

$$\Lambda(e_t) = (\lambda_0 - \lambda_1 \times e_t) \mathbb{I}_{\{e_t < 0\}}, \quad (3)$$

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

$$e_t + i_t + \Phi_t = \Pi_t - T_t + b_{t+1} - (1 + c_t)b_t, \quad (4)$$

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:

$$d_t = e_t - \Lambda(e_t). \quad (5)$$

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 is 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,  $\tau$ , 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,  $\Pi$ . The key features of the corporate tax code can be summarized as follows. First, define the firm's taxable income in period  $t$  as

$$TI_t = \Pi_t - \delta k_t - \omega c_t b_t, \quad \omega \in [0, 1] \quad (6)$$

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  $\omega$  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

$$\tau_{c,\pi} = [\mathbb{I}_{\{TI>0\}}\tau_{c,\pi}^+ + (1 - \mathbb{I}_{\{TI>0\}})\tau_{c,\pi}^-], \quad (7)$$

where the indicator function is equal to 1 when taxable income is positive and zero otherwise. This assumes that positive taxable corporate income 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:

$$\tau_{c,int} = \omega \tau_{c,\pi}. \quad (8)$$

Total tax liabilities are then equal to

$$T_t = \tau_{c,\pi}(\Pi_t - \delta k_t) - \tau_{c,int} c_t b_t, \quad (9)$$

#### 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

$$\hat{b}_t \equiv (1 + c_t)b_t.$$

In addition, as 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

$$V(S) = \max\{0, \max_{k(S'), b'(S')} \{d(S) + E[M'V(S')]\}\} \quad (10)$$

where the expectation on the right-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 (10) 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

$$b_{t+1} = E \left[ M_{t,t+1} \left( (1 + c_{t+1}) b_{t+1} \mathbb{I}_{\{V_{t+1} > 0\}} + \theta_{t+1} (1 + c_{t+1}) b_{t+1} (1 - \mathbb{I}_{\{V_{t+1} > 0\}}) \right) \right], \quad (11)$$

where  $\theta(1 + c_{t+1})b_{t+1}$  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

$$\begin{aligned} b_{t+1} &= \frac{E \left[ M_{t,t+1} \left( \frac{1}{1-\tau} \hat{b}_{t+1} \mathbb{I}_{\{V_{t+1} > 0\}} + \theta b_{t+1} (1 - \mathbb{I}_{\{V_{t+1} > 0\}}) \right) \right]}{1 + \frac{\tau}{1-\tau} (E [M_{t+1} \mathbb{I}_{\{V_{t+1} > 0\}}])} \\ &= \mathbf{b}(k_{t+1}, \hat{b}_{t+1}, X_t, z_t). \end{aligned}$$

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

$$c_{t+1} = \frac{\hat{b}_{t+1}}{b_{t+1}} - 1.$$

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.

## 2.2 Optimal Firm Behavior

Before proceeding to describe the results of our policy experiments it is useful to gain some intuition by first exploiting some of the properties of the dynamic program (10). 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. 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.

### 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, not surprisingly, that 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 Bhamra, Kuehn, and Strebulaev (2010a,b) and Chen (2009): 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 and Zin (1989) 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:

$$u(C, N) = C^\alpha(1 - N)^{1-\alpha}. \tag{12}$$

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

$$U_t = \{(1 - \beta)u(C_t, N_t)^{1-1/\sigma} + \beta E_t[U_{t+1}^{1-\gamma}]^{1/\kappa}\}^{1/(1-1/\sigma)}. \quad (13)$$

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:

$$C_t + A_{t+1} = W_t N_t + R_t A_t + T_t \quad (14)$$

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:

$$A_t = \int V(S_t) + B(S_t) dG(S_t). \quad (15)$$

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 Benchmark Model Implications

In this section, we present simulation results from the benchmark model. For the results that follow, we adopt a partial equilibrium approach, ignoring the household sector presented in Section 2.3. Instead, we exogenously specify a pricing kernel that takes the following form:

$$\log(M_{t+1}) = \log(\beta) - \gamma \log(X_{t+1}/X_t). \quad (16)$$

As discussed below, the benchmark model captures many of the salient features of the data. In particular, it is able to jointly match financial leverage, credit spreads, and default rates.

### 3.1 Basic Methodology and Definitions

To assess the quantitative performance of the benchmark model, we begin by constructing an artificial cross-section of firms by simulating the investment and leverage rules implied by the model. 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  $BE/ME$ .

To match the current U.S. corporate tax code, in the benchmark model corporate interest expense is fully tax deductible ( $\omega = 1$ ) and we assume zero loss offsets ( $\tau_{c,\pi}^- = 0$ ). Changes to the variable  $\omega$ , which parameterizes the degree of the tax deductibility of interest, will be the focus of the policy experiments.

### 3.2 Benchmark Model Results

Table II presents simulation results for key quantities of the benchmark model. This table can thus be used to judge the ability of our model to fit basic empirical facts about the cross-section of firms. For each simulation, we compute a mean of the quantity of interest. The columns display the 25th, 50th, 75th, and mean values across simulations. All quantities reported are at an annual frequency and where applicable represent a cross-sectional average. As shown in the table, the benchmark model produces a mean book leverage ratio of just less than 25%, an annual default frequency of approximately 1%, and a mean credit spread of 130 basis points. Additionally, the mean market/book ratio and mean market leverage are roughly consistent with the data. Finally, note that, as in the data, equity issuance occurs



relatively infrequently.

## 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 model to address this question.

We consider two policy experiments and compare our results with the benchmark corresponding to the current U.S. tax code used in the calibration of our model in Sections 2 and 3. Both experiments involve the removal of the tax deductibility of the corporate interest expense. In the first experiment, we simply remove the tax deductibility of interest expense by setting  $\omega = 0$  and fixing the corporate tax rate. That is, we maintain a tax rate of 35% on positive profits and still assume zero loss offsets ( $\tau_{c,\pi}^+ = 0.35, \tau_{c,\pi}^- = 0$ ).

Note that this experiment is not tax revenue neutral in that firms now face a higher effective tax rate. Consequently, the government in the economy of the first policy experiment collects more tax revenue from the corporate sector than in the benchmark.

In the second policy experiment, we eliminate the deductibility of interest expense while reducing the corporate tax rate such that the government's corporate tax receipts are the same as in the benchmark. This allows us to cleanly identify the effect of removing the tax deductibility of interest distinct from a change in the effective corporate tax rate. As a final policy experiment, we implement an investment tax credit where firms are able to deduct capital expenditures from their tax bill.

## 4.1 No Interest Deductibility

In the first policy experiment, we set  $\omega = 0$  and fix all other parameters at their values from the benchmark economy. Recall that  $\omega = 0$  implies that corporate interest expense is not tax deductible. Note that depreciation of physical capital is still expensed and deducted from the firm's taxable income.

As in the benchmark model, we simulate the policy experiment economy a number of times and average the quantities of interest across simulations. The results from this policy experiment are presented in the second column of Table III, with the benchmark model results presented in the first column for comparison. Relative to the benchmark economy, the optimal equilibrium financial leverage is much less in this economy. In particular, the average book leverage, measured as  $b/k$ , is now only 0.047, compared to an average of 0.233 in the benchmark economy. This reduction in firms' optimal leverage is to be expected as there is no longer a tax incentive to issuing debt. Note, however, that due to equity issuance costs, it is still optimal for firms to issue some amount of debt, thus equilibrium leverage does not go to zero. Similarly, market leverage is much less than in the benchmark case.

Though the policy experiment produces an economy with much less leverage, it results in a much higher default rate. In fact, the average default rate increases from 1.2% in the benchmark economy to 3% in the zero deductibility economy. As a direct result of the increased default frequency, the average credit spread in this experiment economy is more than twice that in the benchmark. Thus, removing the tax deductibility of interest substantially reduces equilibrium leverage, but it actually increases the default rate and credit spreads.

The intuition for this result lies in the fact that removing the tax deductibility of interest has two effects. First, it reduces the incentive to finance investment with debt. This results in lower financial leverage, which *ceteris paribus*, results in a lower default probability and credit spread. But removing the tax deductibility of interest also has the effect of increasing firms' cost of capital. This second effect means that the required return on debt is higher, but firms' production technology has not changed. This suggests that debt is riskier in

the sense that the default probability is greater, which leads to an increased credit spread. Quantitatively, we find that this second effect dominates the first. Thus, while there is less debt than in the benchmark economy, the debt is actually riskier.

In the model, the key channel for this effect is through firms' operating leverage. Facing a higher cost of capital and with decreasing returns to scale in production, firms in the zero deductibility economy optimally choose a smaller firm size and thus are subject to more operating leverage. This effect can be seen in the first column of Table IV, where we show statistics for the cross-sectional distribution of size compared to the benchmark economy. The first line of the first column indicates that the average firm size, measured as the average capital stock,  $k$ , in the zero deductibility economy is approximately 85% of the average firm size in the benchmark economy. We see a similar pattern for the other cross-sectional statistics, indicating a shift to smaller size in the entire cross-sectional distribution of firm size when going from the benchmark to the zero deductibility economy.

The fifth line of the first column of Table IV displays an analogous statistic for the average equilibrium marginal productivity of capital (MPK), indicating that the average is higher in the zero deductibility economy than the benchmark. This suggests that the average cost of capital is higher in the zero deductibility economy than the benchmark. Again, looking at the other cross-sectional statistics, we see a shift to the right in the cross-sectional distribution of MPK in going from the benchmark to the zero deductibility economy.

Table V compares the size ( $k$ ) and marginal productivity of capital for the subset of defaults to the entire sample of firms for the benchmark and two policy experiment economies. The first line displays the ratio of firm size for defaulting firms to the average size for all firms. The value 0.1943 in the first row of the first column indicates that the average defaulting firm has a capital stock less than 20% that of the average firm. Thus, the model is consistent with the idea that smaller firms are more likely to default. The first line of the second column, shows that this effect becomes exacerbated when the tax deductibility of interest is removed. In fact, the average capital stock for defaulting firms in the zero deductibility economy is only 63% of the average capital stock for defaulting firms in the benchmark economy.

Taken together, the results of Tables IV and V show that in the model smaller firms tend to be more likely to default, due to the fact that these firms face higher operating leverage. This pattern exists separately in the benchmark and zero deductibility economies. But the effect can also be seen in comparing the two economies. Removing the interest deductibility increases firms' cost of capital, resulting in a reduction in optimal firm size and an increase in their operating leverage. In essence, firms end up substituting their lower financial leverage with higher operating leverage in the zero deductibility economy. The effect of the increase in the latter appears to dominate, which results in the higher default frequency and credit spreads observed in zero deductibility economy compared to the benchmark.

## **4.2 Tax Neutral Experiment with No Interest Deductibility**

The last row of Table III presents the average across simulations of the total taxes paid by the corporate sector relative to the benchmark economy. In the zero deductibility policy experiment, the government collects 5.3% more tax revenue than in the benchmark case. To consider a tax revenue neutral experiment, we eliminate the tax deductibility of interest while simultaneously reducing the corporate tax rate. The result is a tax revenue neutral experiment in which interest expense is not tax deductible and the total taxes paid by the corporate sector are equal to the taxes paid in the benchmark economy. The simulation results from this policy experiment are presented in the third column of Table III.

As in the case of the first policy experiment, the optimal book and market leverage ratios are substantially less than in the benchmark case. Also, the default frequency and average credit spread are larger than in the benchmark economy, though the magnitude of this increase is less than in the case of the first policy experiment. Moreover, nearly all the quantities are consistent with those of the first policy experiment, though in some cases the effect relative to the benchmark case is dampened. Thus, even a tax revenue neutral experiment has the result of reducing financial leverage while actually increasing the default frequency and credit spreads.

Additionally, in Tables IV and V we see patterns for the tax neutral zero deductibility

experiment similar to those found in the zero deductibility experiment discussed in Section 4.1. In particular, the tax neutral experiment still features a reduction in firm size and an increase in MPK compared to the benchmark, though these effects are much smaller than in the case of the zero deductibility experiment of the previous section. In the tax neutral experiment, the ratios of firm size and MPK of defaulting firms to all firms are lower and higher, respectively, than their counterparts in the zero deductibility experiment of the previous section.

### 4.3 Investment Tax Credit Experiment

We now consider a tax policy that subsidizes capital investment. Policies that give a temporary investment tax credit have been recently proposed as a means to spur corporate investment. Here we consider a permanent policy change where capital expenditure is fully tax deductible. Relative to the benchmark economy, we eliminate the tax deductibility of interest ( $\omega = 0$ ) but allow firms to deduct capital expenditures from their tax bill. For this case, we define taxable income as

$$TI_t = \Pi_t - \omega^I(k_{t+1} - (1 - \delta)k_t)$$

where  $\omega^I$  denotes the fraction of capital expenditure that is tax deductible. At present, we set  $\omega^I = 1$ . Note that compared to the benchmark case, we removed the tax deductibility of depreciation expense since the firm is now deducting capital when it is purchased rather than when it depreciates at a later date. Allowing for a deduction of the depreciation expense on top of the investment tax credit would amount to a double deduction. The simulation results for this policy experiment are presented in the last column of Table III.

The results in Table III show that the effect of this policy change on leverage, default, and credit spreads is qualitatively similar to the removal of the tax deductibility of interest. Relative to the benchmark economy, replacing the tax deductibility of interest with an investment tax credit results in a substantial drop in the average book and market leverage ratios. Despite the drop in leverage, however, default rates and credit spreads increase. Note, however, that this change in tax policy results in substantially less tax revenue collected by

the government. Thus, a revenue neutral policy change would require an increase in the tax rate on corporate earnings.

## 5 Operating Leverage

In this section, we further investigate the effects of operating leverage by recalibrating and simulating an alternative model in which fixed operating costs are removed. Intuitively, simply removing the fixed operating cost makes firms more profitable and less likely to default, all else equal. Therefore we recalibrate the model to be consistent with the default frequency observed in the data. Consequently, the results that follow do not provide a direct comparative static with respect to operating leverage due to the fact that other parameters in the model have been changed. Nonetheless, the simulated model results of this section serve two important purposes. First, they highlight the role that operating leverage plays in increasing the default frequency in our original policy experiment where tax deductibility is removed. Second, the results suggest that in the model framework we consider, a model without operating leverage is unable to match the data as well as a model in which firms face a fixed operating cost.

In Table VII, we present results from simulating the model without operating leverage. The first column displays simulated statistics for the case in which the interest expense is tax deductible. Note that in order for the zero operating leverage model to generate a default frequency consistent with the data, many of the other moments are far from their data counterparts. In particular, in the model with zero operating leverage, the average book leverage and market to book ratio, as well as the equity issuance frequency, are significantly higher than in the data. Taken together, the results of the first column of Table VII indicate that the model with zero fixed operating costs is unable to match the data as well as the previous benchmark model which included such a feature. While this need not be the case for every model setup, the results from our framework suggest that a model with operating leverage provides a closer match to the data.

Next, we conduct the policy experiment of removing the tax deductibility of interest

for the zero operating leverage model. The results from this experiment are displayed in the second column of Table VII. Comparing these results to the first column, we see that removing the tax deductibility has the opposite effect of the original model. That is, in the model without operating leverage, removing the tax deductibility results in a decrease in the default frequency and credit spreads in the economy. This makes clear that the result of an increase in defaults and credit spreads

This suggest that the previous result, that removing the tax deductibility of interest increases defaults and credit spreads, depends on the existence of operating leverage in the model. Indeed, Table VII, shows that without operating leverage this result is reversed. However, comparing the first column of Table VII to the first column of Table III, we see that the model with operating leverage does a significantly better job of matching the data in multiple dimensions.

## 6 Robustness

As shown in Section 4, removing interest deductibility results in an increase in the equilibrium default frequency and average credit spread in the economy, despite a large drop in average leverage. In this section, we investigate the robustness of this result with respect to our model specification. Specifically, we consider an alternative model specification in which we remove the pre-default distress costs of leverage as well as the fixed cost of issuing equity ( $\lambda_0 = 0$ ). We impose a linear cost of debt issuance of 1% and increase the linear cost of equity issuance to 4%. All other parameters are unchanged.

In Table VI we present simulations results from two cases of this alternative model specification. The first is a benchmark version in which, as before, we allow full deductibility of corporate interest expense ( $\omega = 1$ ). The second case is the zero deductibility policy experiment ( $\omega = 0$ ), analogous to the first policy experiment conducted in Section 4. In comparing the first column of Table VI to the first column of Table III, we see that this alternative specification results in somewhat higher average leverage, default frequency, and credit spreads. However, examining the second column of Table VI, we see that the effect of

the zero deductibility policy experiment is similar to the effect in the original specification presented in Table III.

In particular, when the tax deductibility of interest is removed the equilibrium average leverage drops significantly, while the default frequency and credit spreads both increase. This drop in leverage, accompanied by an increase in default frequency and credit spreads, is the same result observed for the original model specification. We take this as evidence that our main results do not depend on the functional form specification for the cost of leverage or the fixed cost of equity issuance that are used in main model specification.

## 7 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. As expected, eliminating the tax deductibility of interest results in a substantial decrease in the equilibrium level of leverage. However, contrary to conventional wisdom, we find that eliminating interest deductibility results in an increase in the default frequency and average credit spreads. The intuition for this lies in the fact that this policy change makes external financing more costly, which results in riskier firms and higher credit spreads.



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Table I: **Parameter Choices**

This table reports parameter choices for our general model. The model is calibrated to match quarterly data both at the macro level and in the cross-section. The persistence,  $\rho_x$ , and conditional volatility,  $\sigma_x$ , of aggregate productivity are set close to the corresponding values reported in Cooley and Hansen (1995). The persistence,  $\rho_z$ , and conditional volatility,  $\sigma_z$ , 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  $\delta$  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,  $\alpha$ , we use the evidence in Cooper and Ejarque (2003). Finally, the pricing kernel parameters  $\beta$  and  $\gamma$  are chosen to match the risk free rate and the average equity premium.

### Production Parameters

Parameter	Symbol	Value
Time Discount Factor	$\beta$	0.98
Capital Depreciation Rate	$\delta$	0.025
Aggregate Productivity Shock Persistence	$\rho_x$	0.95
Aggregate Productivity Shock Volatility	$\sigma_x$	0.008
Idiosyncratic Productivity Shock Persistence	$\rho_z$	0.8
Idiosyncratic Productivity Shock Volatility	$\sigma_z$	0.14
Fixed Operating Cost	$c$	0.42
Physical Capital Returns to Scale	$\alpha_k$	0.3
Labor Returns to Scale	$\alpha_n$	0.6

### Tax and Financing Parameters

Parameter	Symbol	Value
Deductibility of Interest Expense	$\omega$	1
Tax Rate on Positive Profits	$\tau_{c,\pi}^+$	0.35
Loss Offset for Negative Profits	$\tau_{c,\pi}^-$	0
Cost of Financial Leverage Parameter	$\nu$	3.5
Fixed Cost of Equity Issuance	$\lambda_0$	0.11
Proportional Cost of Equity Issuance	$\lambda_1$	0.025

Table II: **Benchmark Model: Simulated Moments**

This table reports simulation results from the benchmark model, with the data counterparts presented in the final column. All data are annualized. The model is simulated with a cross-section of 2000 firms at a quarterly frequency for 340 quarters and the first 100 quarters are dropped. The simulation is performed 50 times and a time series average is computed for each simulation. The columns refer to a percentile or mean value over the 50 simulations. The leverage, M/B, and credit spread measures are computed taking a cross-sectional average at each point in time and then computing a time series average of the cross-sectional mean.

	<b>25th</b>	<b>Mean</b>	<b>Median</b>	<b>75th</b>	<b>Data</b>
<b>Default Freq</b>	0.004	0.012	0.009	0.015	0.011
<b>Book Lev Mean</b>	0.226	0.233	0.235	0.243	0.27
<b>Mkt Lev Mean</b>	0.150	0.154	0.154	0.160	0.23
<b>M/B Mean</b>	1.327	1.341	1.339	1.351	1.59
<b>Equity Premium</b>	0.020	0.037	0.039	0.057	0.060
<b>Credit Spread</b>	0.004	0.013	0.009	0.015	0.010
<b>Equity Issue Freq</b>	0.161	0.171	0.174	0.186	0.15

Table III: **Experiment Comparison: Simulated Moments**

This table compares simulation results from the two policy experiments with the results of the benchmark economy. All data are annualized. As in the benchmark case, we perform 50 simulations for each economy, each of length 240 quarters (after dropping the first 100 quarters) with a cross-section of 2000 firms. The values reported are the means across the 50 simulations. As indicated in the bottom panel, the parameters  $\omega$  and  $\tau_{c,\pi}^+$  vary across the benchmark and policy experiment. All other parameters are fixed at their benchmark value.

	<b>Benchmark</b>	<b>Zero Deduct</b>	<b>ZeroDeduct Tax Neutral</b>	<b>Investment Tax Credit</b>	<b>Data</b>
<b>Default Freq</b>	0.012	0.030	0.020	0.035	0.011
<b>Book Lev</b>	0.233	0.047	0.044	0.022	0.27
<b>Mkt Lev</b>	0.154	0.025	0.021	0.029	0.23
<b>Credit Spread</b>	0.013	0.029	0.019	0.036	0.010
<b>M/B</b>	1.341	1.530	1.566	1.355	1.59
<b>Equity Premium</b>	0.037	0.032	0.032	0.016	0.060
<b>Equity Issue Freq</b>	0.171	0.149	0.153	0.045	0.15
<b>Corr(<math>X</math>, Def Freq)</b>	-0.393	-0.573	-0.490	-0.581	
<b>Corr(<math>X</math>, Book Lev)</b>	-0.588	0.636	0.645	0.432	
<b>Tax Paid/Bench</b>	1	1.053	0.996	0.796	
$\omega$	1	0	0	0	
$\tau_{c,\pi}^+$	0.35	0.35	0.3314	0.35	
$\tau_{c,\pi}^-$	0	0	0	0	

Table IV: **Size and MPK: Policy Experiments Relative to Benchmark**

This table displays cross-sectional statistics for the distribution of firm size (capital stock) and marginal productivity of capital for the policy experiment economies *relative* to the benchmark. Each cross-sectional statistic is computed at each simulated quarter and then averaged over time and across simulations. For example, the standard deviation is the average across simulated economies of the time series average of the cross-sectional standard deviation of capital stock at each quarter. The values reported in the table are relative to their respective statistics in the benchmark economy. Q1 and Q3 stand for the first and third quartiles, respectively.

		<b>Zero Deductibility</b>	
		<b>Zero Deductibility</b>	<b>Tax Neutral</b>
<b>Size</b>	Mean	0.853	0.981
	Median	0.840	0.979
	Std Dev	0.895	0.988
	Q1	0.828	0.974
	Q3	0.859	0.983
<b>MPK</b>	Mean	1.052	1.009
	Median	1.055	1.011
	Std Dev	1.040	1.008
	Q1	1.062	1.014
	Q3	1.060	1.010

Table V: **Size and MPK for Defaulting Firms**

This table displays statistics for firm size and marginal product of capital for defaulting firms in the benchmark economy and two policy experiment economies. The first line reports the average ratio of the size of defaulting firms to the cross-sectional average for the entire universe of firms. This ratio is computed at each date in the simulation and the value reported is averaged across time and simulations. The second line reports an analogous calculation for the marginal productivity of capital. The third line reports the average raw value of the MPK for defaulting firms. “ND” stands for the No Deductibility policy experiment, described in Section 4.1, where the tax deductibility of corporate interest expense is removed with the corporate earnings tax held constant. “NDTN” stands for the No Deductibility Tax Neutral policy experiment, described in Section 4.2, where the interest tax deductibility is removed along with a reduction in the tax rate on corporate profits such that the aggregate tax revenue collected is equal to the amount collected in the benchmark economy. ND/Bench and NDTN/Bench represent the ratios of the values for the “No Deductibility” and “No Deductibility Tax Neutral” policy experiment economies relative to the benchmark economy.

	<b>Benchmark</b>	<b>ND</b>	<b>NDTN</b>	<b>ND/Bench</b>	<b>NDTN/Bench</b>
$\mathbb{E}(\overline{K_D/K})$	0.1943	0.1675	0.1542	0.862	0.794
$\mathbb{E}(\overline{MPK_D/MPK})$	0.0836	0.0846	0.0941	1.012	1.126
$\mathbb{E}(\overline{MPK_D})$	0.0049	0.0052	0.0056	1.061	1.143

Table VI: **Alternative Model Specification: Benchmark and Policy Experiment**

This table compares simulation results for the alternative specification of the model that is described in Section 6. The simulation procedure is the same as that used in the primary model simulations. Values reported are means across simulations. Asset returns reported (i.e. equity premium and credit spread) are annualized. The parameter  $\omega$  refers to the fraction of interest expense that is tax deductible and  $\tau_{c,\pi}^+$  and  $\tau_{c,\pi}^-$  are the tax rates applied to positive and negative corporate taxable income, respectively.

	<b>Benchmark</b>	<b>Zero Deductibility</b>	<b>Data</b>
<b>Default Freq</b>	0.021	0.063	0.011
<b>Book Lev</b>	0.417	0.012	0.27
<b>Mkt Lev</b>	0.306	0.010	0.23
<b>Credit Spread</b>	0.021	0.062	0.010
<b>M/B</b>	1.017	1.385	1.59
<b>Equity Premium</b>	0.057	0.028	0.060
<b>Equity Issue Freq</b>	1.522	1.668	0.15
<b>Corr(<math>X</math>, Def Freq)</b>	-0.51	-0.65	
<b>Corr(<math>X</math>, Book Lev)</b>	0.81	-0.58	
<b>Tax Paid/Bench</b>	1	1.66	
$\omega$	1	0	
$\tau_{c,\pi}^+$	0.35	0.35	
$\tau_{c,\pi}^-$	0	0	

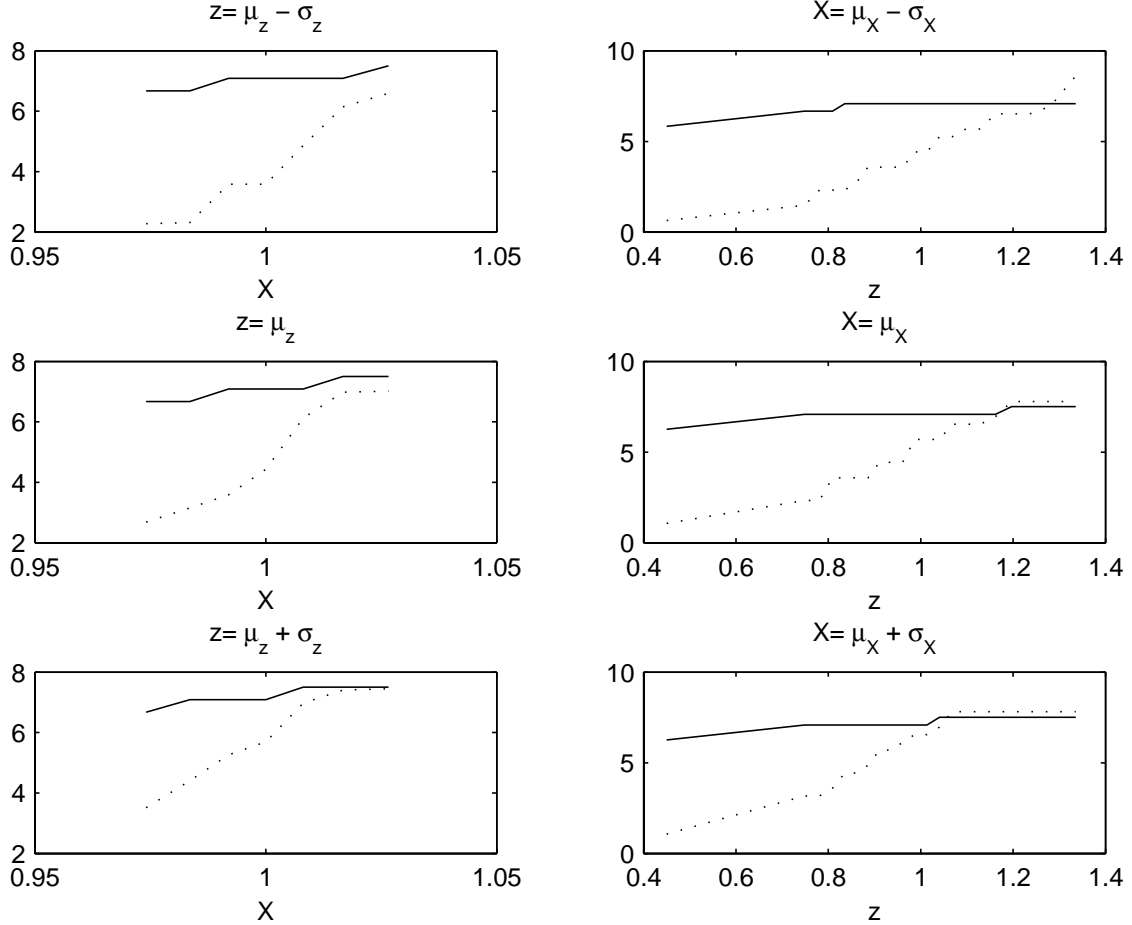


Table VII: Model with No Operating Leverage

This table compares simulation results for an alternative model specification in which firms have no fixed operating costs (zero operating leverage). The model parameterization differs slightly from the original benchmark economy as this alternative model is recalibrated so that the default frequency is consistent with the data. The first column represents a “benchmark” for this alternative model with zero operating leverage where the corporate interest expense is tax deductible. The second column displays results from a policy experiment of this alternative benchmark where the tax deductibility of interest is removed. For more details on this alternative model with zero operating leverage, see section 5. The simulation procedure is the same as that used in the primary model simulations. Values reported are means across simulations. Asset returns reported (i.e. equity premium and credit spread) are annualized. The parameter  $\omega$  refers to the fraction of interest expense that is tax deductible and  $\tau_{c,\pi}^+$  and  $\tau_{c,\pi}^-$  are the tax rates applied to positive and negative corporate taxable income, respectively.

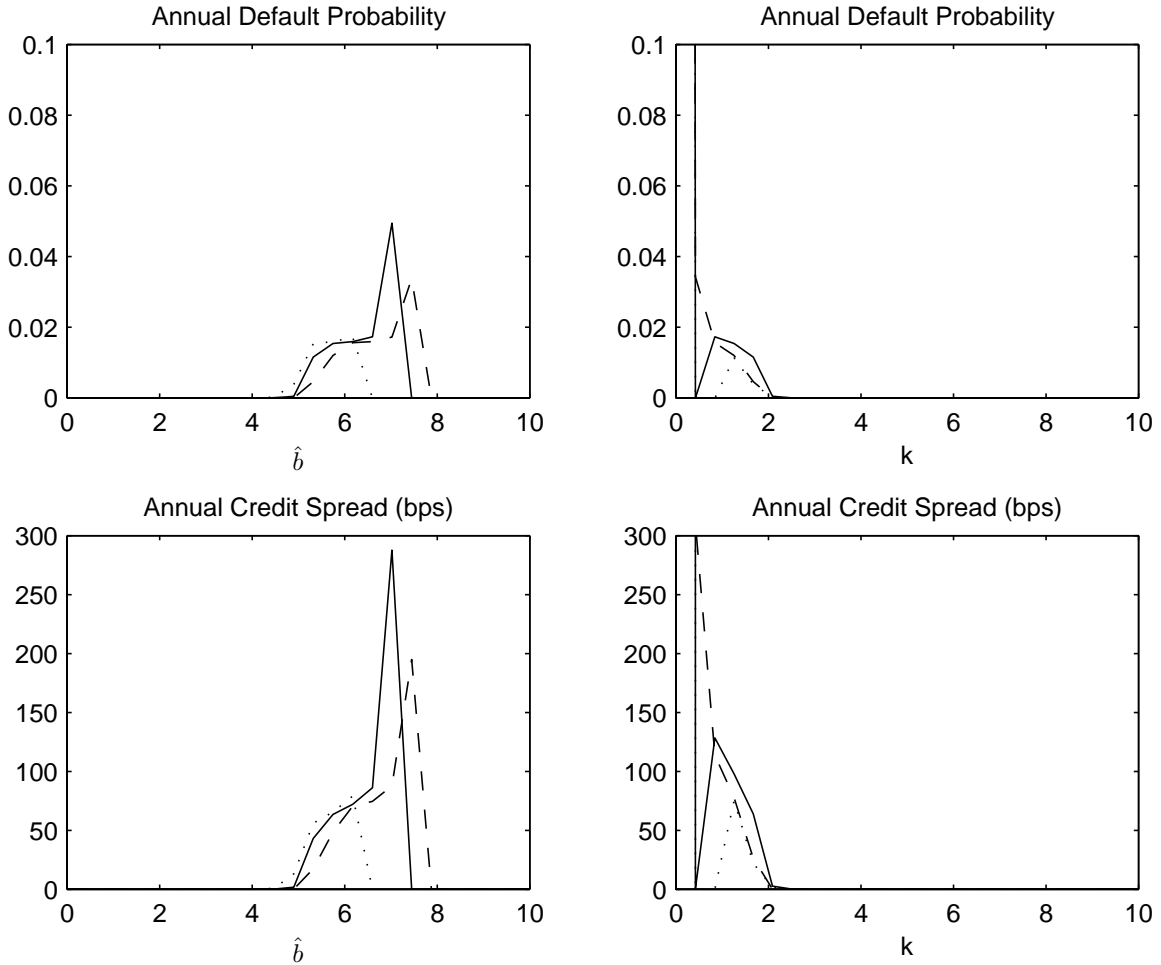
	<b>Benchmark</b>	<b>Zero Deductibility</b>	<b>Data</b>
<b>Default Freq</b>	0.009	2.52e-5	0.011
<b>Book Lev</b>	0.937	0.286	0.27
<b>Mkt Lev</b>	0.327	0.073	0.23
<b>Credit Spread</b>	0.005	5.1e-6	0.010
<b>M/B</b>	3.86	9.37	1.59
<b>Equity Premium</b>	0.062	0.041	0.060
<b>Equity Issue Freq</b>	0.295	0.093	0.15
<b>Corr(<math>X</math>, Def Freq)</b>	-0.488	-0.132	
<b>Corr(<math>X</math>, Book Lev)</b>	0.545	0.680	
<b>Tax Paid/Bench</b>	1	2.72	
$\omega$	1	0	
$\tau_{c,\pi}^+$	0.35	0.35	
$\tau_{c,\pi}^-$	0.15	0.15	

Figure 1



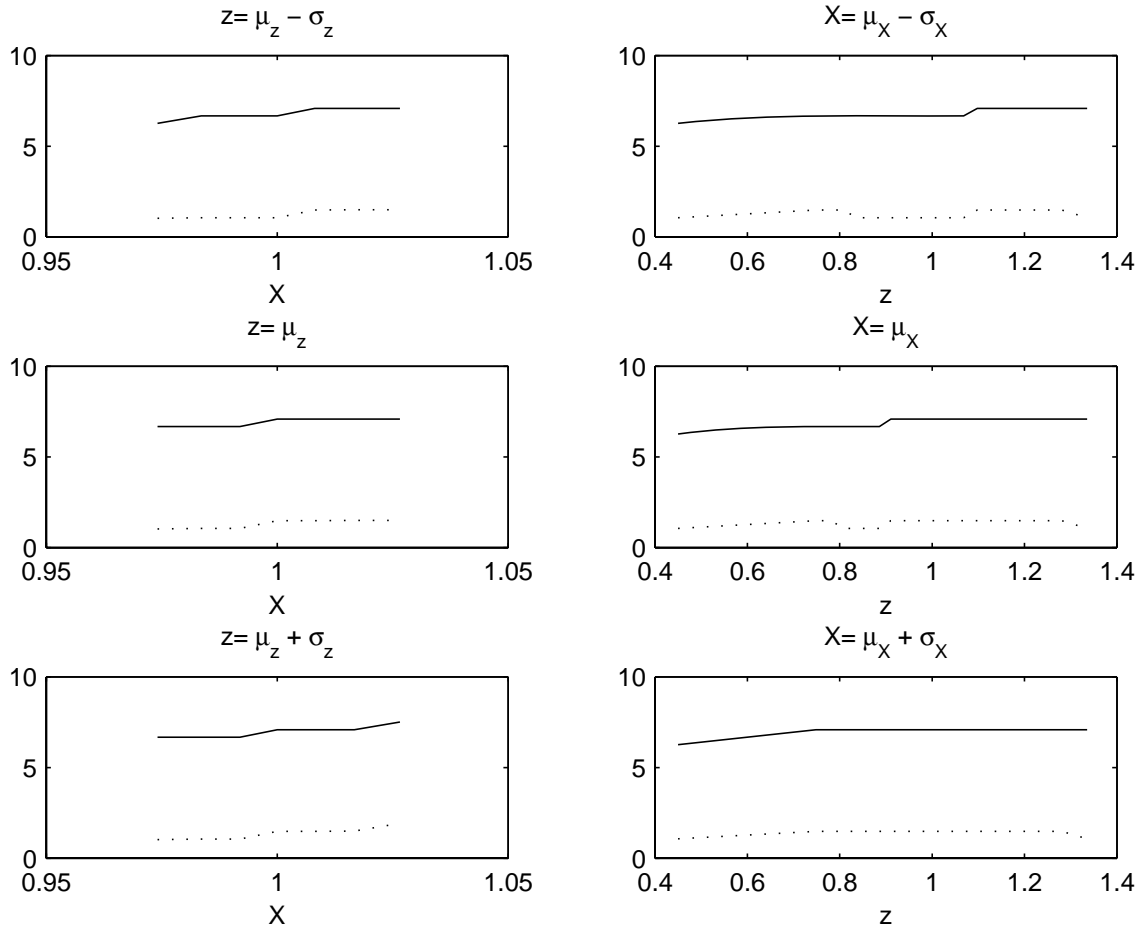
**Figure 1. Optimal Policies - Benchmark.** This figure plots the optimal policies for next period's capital,  $k$  (solid line), and debt,  $b$  (dashed line), as functions of the current states of aggregate and idiosyncratic productivity,  $X$  and  $z$  for the benchmark model. The three graphs in 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



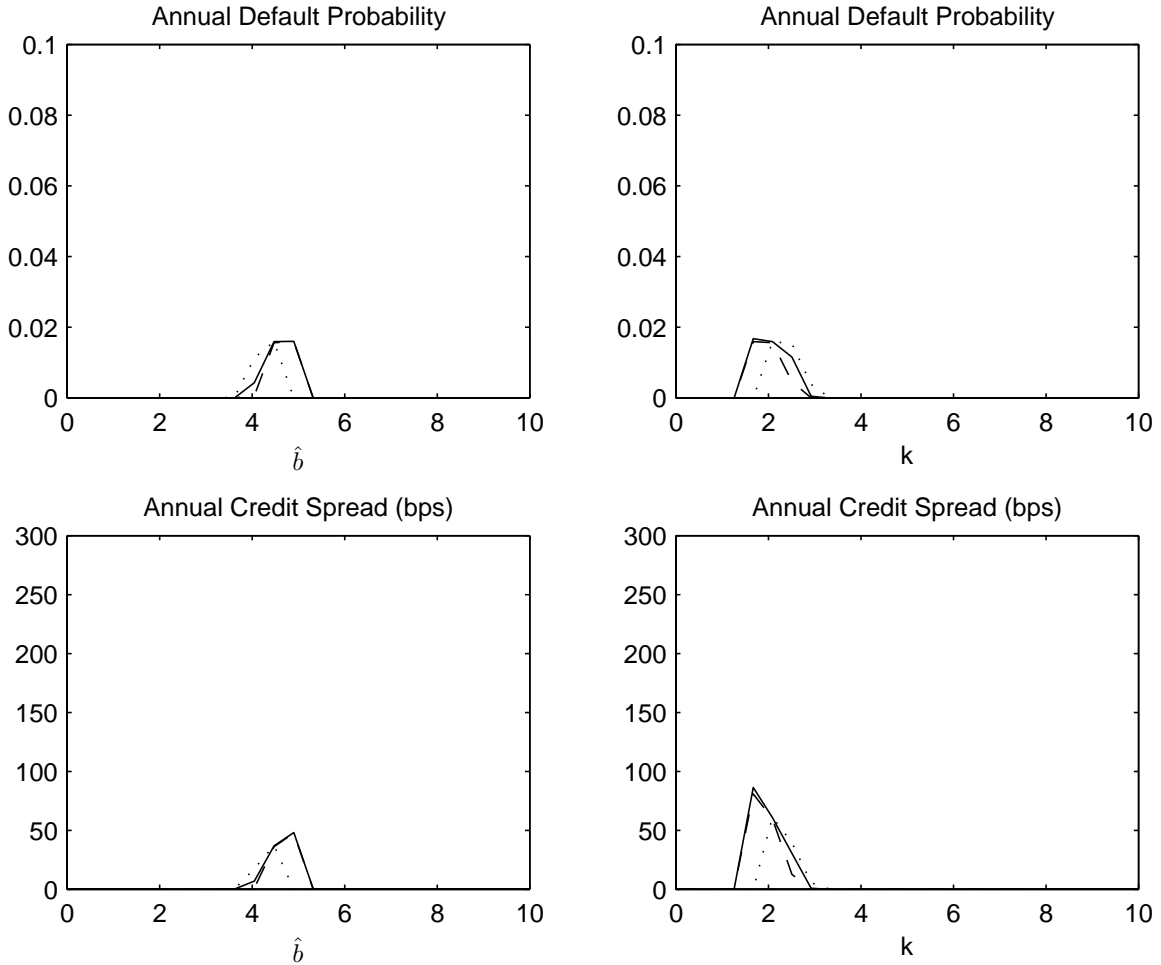
**Figure 2. Default Probabilities and Credit Spreads - Benchmark.** This figure plots the annualized credit spread (in basis points) and probability of defaulting in the next quarter as a function of current capital stock and current debt obligations for the benchmark model. Note that these spreads and 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



**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



**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 deductibility. 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.

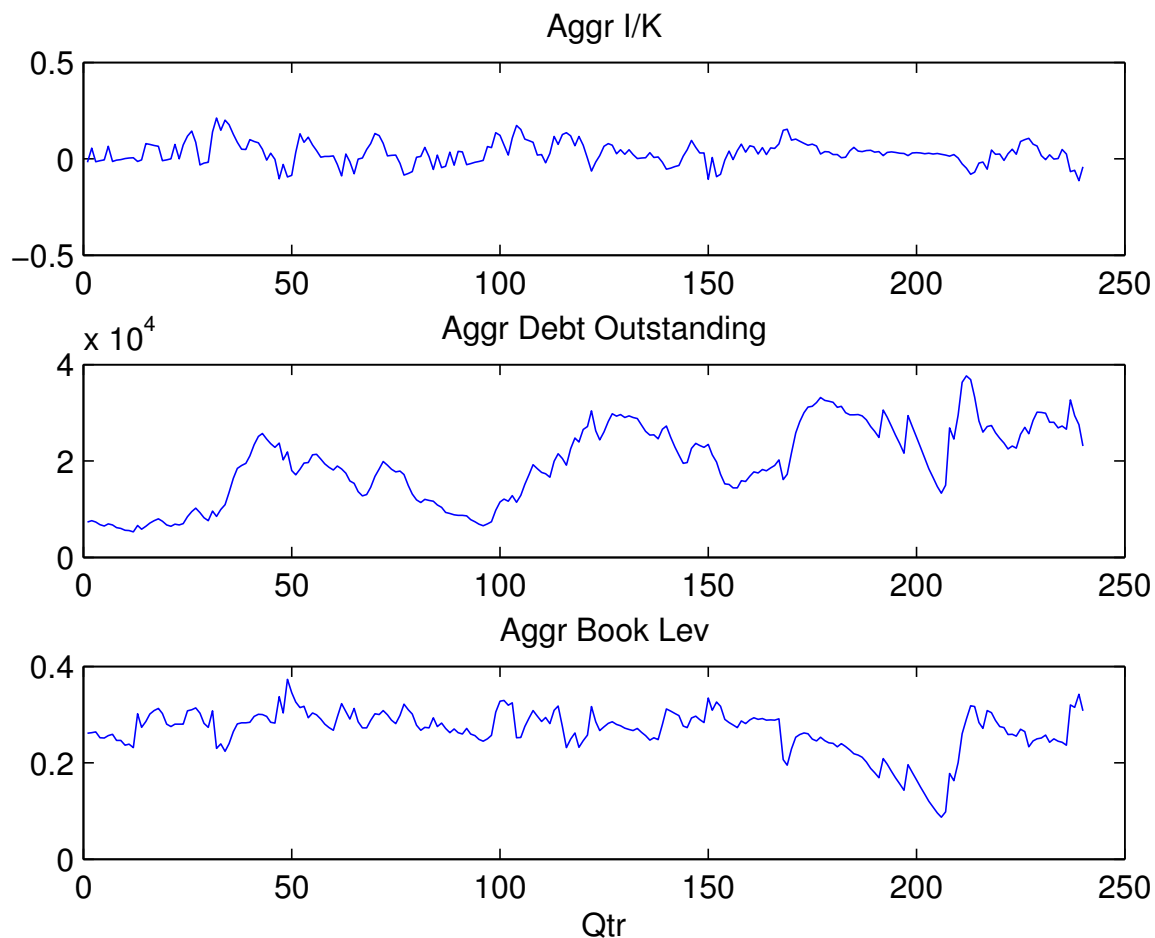
Figure 5



**Time Series of Book Leverage - Benchmark.**

This figure plots the sample paths of different measures of financial leverage from a single simulation of the benchmark model. The simulation length is 240 quarters (after dropping the first 100 quarters) and consists of a cross-section of 2000 firms. The top panel plots the time series paths of the 25th and 75th percentile values of book leverage in the cross-section. The second panel plots the time series of the cross-sectional standard deviation of book leverage. The third panel plots the time series evolution of the cross-sectional mean book leverage ratio.

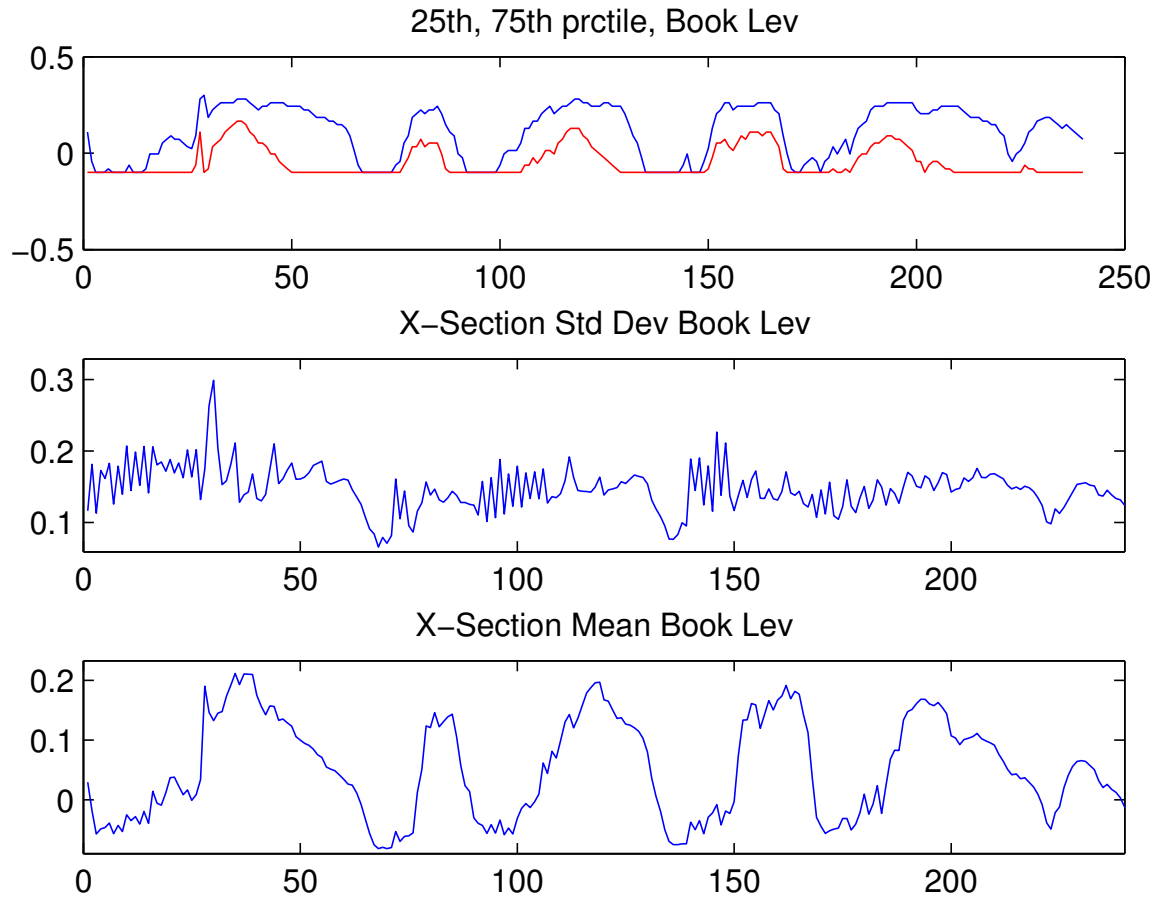
Figure 6



**Sample Simulation Default Frequencies - Benchmark.**

This figure plots sample paths of different aggregate quantities from a sample simulation of the benchmark model economy. The simulation length is 240 quarters (after dropping the first 100 quarters) and consists of a cross-section of 2000 firms. The top panel plots the time series of the (quarterly) investment/capital ratio. The middle panel presents the time series of the total corporate debt outstanding in the economy. The bottom panel plots the time series of the aggregate book leverage ratio, defined as total debt outstanding in the economy divided by the total capital in the economy.

Figure 7

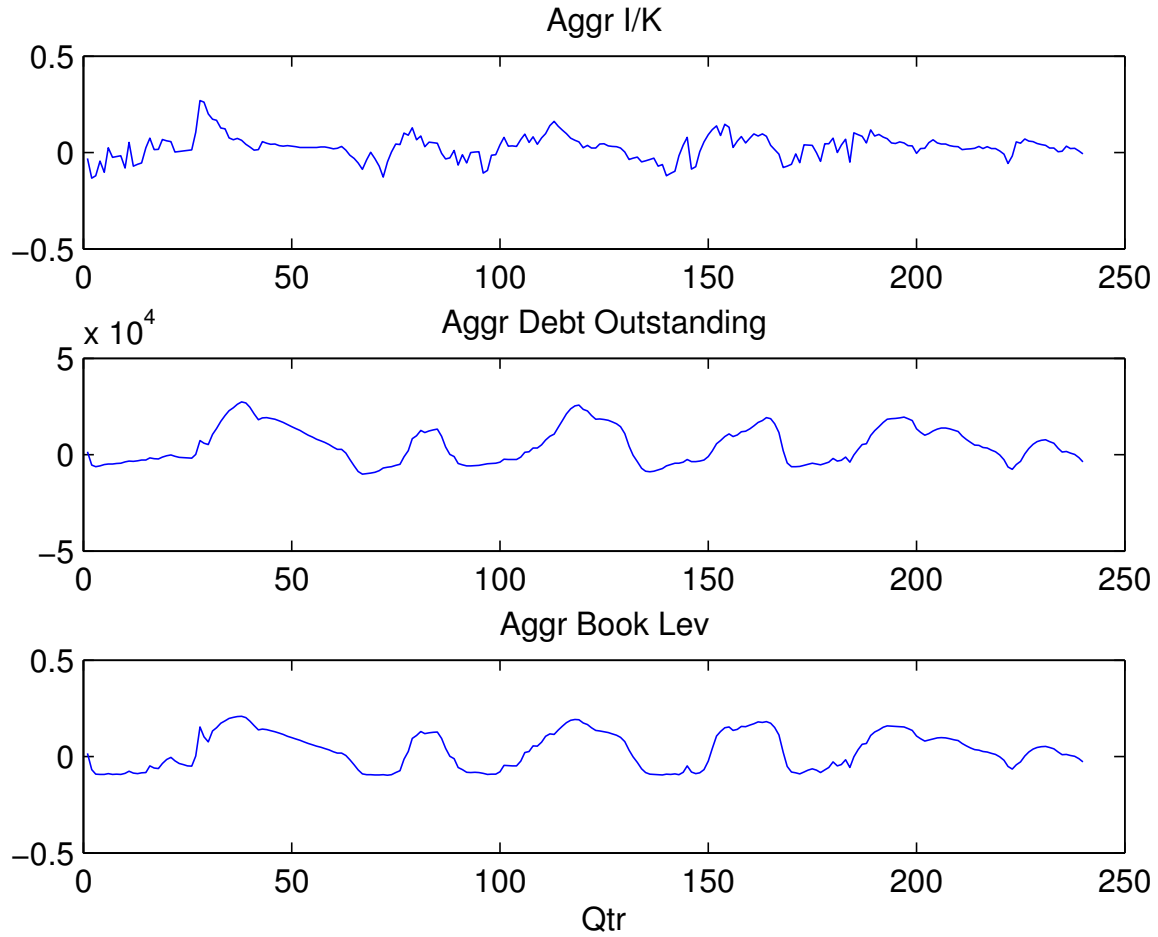


### Time Series of Book Leverage - Zero Deductibility.

This figure plots the sample paths of different measures of financial leverage from a single simulation of the policy experiment economy in which the tax deductibility of interest is removed ( $\omega = 0$ ) but the corporate tax rate is unchanged ( $\tau_{c,\pi}^+ = 0.35$ ). The simulation length is 240 quarters (after dropping the first 100 quarters) and consists of a cross-section of 2000 firms. The top panel plots the time series paths of the 25th and 75th percentile values of book leverage in the cross-section. The second panel plots the time series of the cross-sectional standard deviation of book leverage. The third panel plots the time series evolution of the cross-sectional mean book leverage ratio.



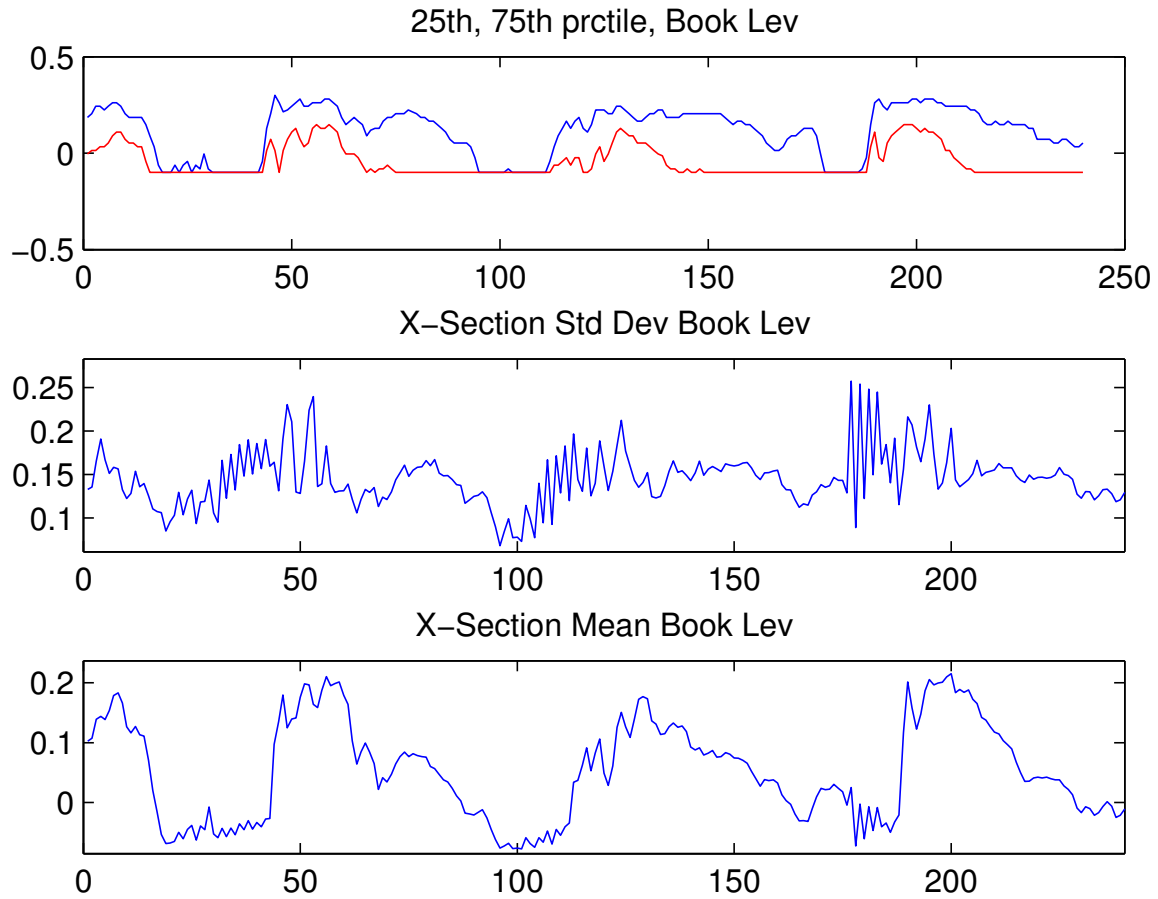
Figure 8



### Sample Simulation Default Frequencies - Zero Deductibility.

This figure plots sample paths of different aggregate quantities from a sample simulation of the policy experiment economy in which the tax deductibility of interest is removed ( $\omega = 0$ ) but the corporate tax rate is unchanged ( $\tau_{c,\pi}^+ = 0.35$ ). The simulation length is 240 quarters (after dropping the first 100 quarters) and consists of a cross-section of 2000 firms. The top panel plots the time series of the (quarterly) investment/capital ratio. The middle panel presents the time series of the total corporate debt outstanding in the economy. The bottom panel plots the time series of the aggregate book leverage ratio, defined as total debt outstanding in the economy divided by the total capital in the economy.

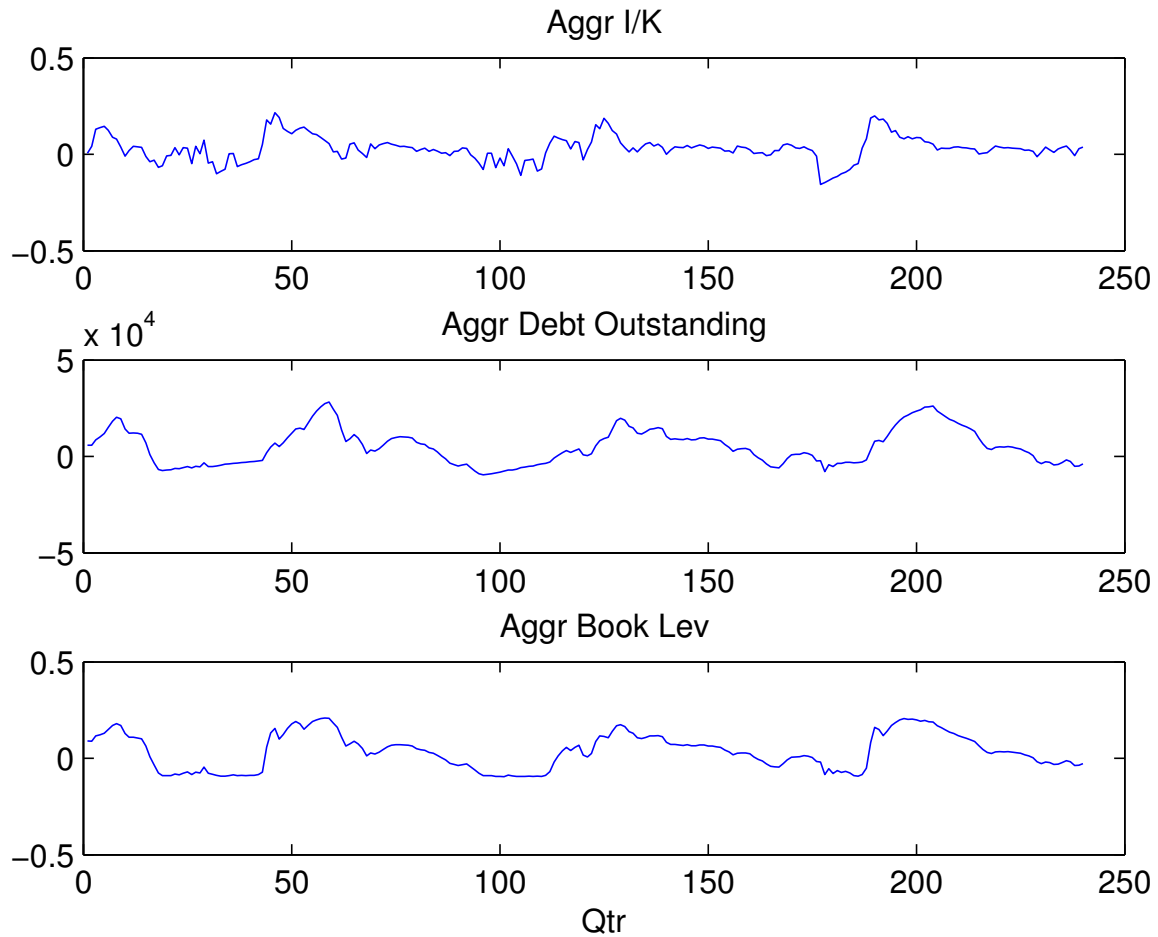
Figure 9



**Time Series of Book Leverage - Tax Neutral Experiment with Zero Deductibility.**

This figure plots the sample paths of different measures of financial leverage from a single simulation of tax revenue neutral policy experiment in which the tax deductibility of interest is removed ( $\omega = 0$ ) and the corporate tax rate is reduced to  $\tau_{c,\pi}^+ = 0.3314$ . The simulation length is 240 quarters (after dropping the first 100 quarters) and consists of a cross-section of 2000 firms. The top panel plots the time series paths of the 25th and 75th percentile values of book leverage in the cross-section. The second panel plots the time series of the cross-sectional standard deviation of book leverage. The third panel plots the time series evolution of the cross-sectional mean book leverage ratio.

Figure 10



### Sample Simulation Default Frequencies - Tax Neutral Experiment with Zero Deductibility.

This figure plots sample paths of different aggregate quantities from a sample simulation of the tax revenue neutral policy experiment economy in which the tax deductibility of interest is removed ( $\omega = 0$ ) and the corporate tax rate is reduced to  $\tau_{c,\pi}^+ = 0.3314$ . The simulation length is 240 quarters (after dropping the first 100 quarters) and consists of a cross-section of 2000 firms. The top panel plots the time series of the (quarterly) investment/capital ratio. The middle panel presents the time series of the total corporate debt outstanding in the economy. The bottom panel plots the time series of the aggregate book leverage ratio, defined as total debt outstanding in the economy divided by the total capital in the economy.