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Should Interest Expenses Be Tax Deductible?*

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Abstract

This paper analyzes how shareholder wealth, firm characteristics, and public finance would be impacted if tax deductibility of interest expenses were eliminated. We find that shareholder value would decrease by 3.5%. Under the new regime, firms would be smaller and less levered, would have less productive capital, and would feature lower default probabilities. The effects on aggregate output and employment would be negative. However, the government's revenues from corporate income tax would increase by 3% in the long-run and could be used to partially offset the negative side effects of the reform. The current period of historically low corporate bond yields is probably the best time to change the treatment of interest expenses.

Key words: Corporate income tax; Tax deductibility; Interest expenses.

JEL classifications: C68; G32; G38; H25; H32.

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"*We need to know whether these incentives*[1] *cause businesses to become overleveraged in a way that hurts our economy.*" US Senate Finance Committee Chairman Max Baucus (D-Mont.), March 8, 2011.

1 Introduction

Firms have been allowed to deduct interest expenses from their tax liabilities since 1918 in the USA (Warren Jr., 1974). However, dividends are not tax deductible. Tax deductible interest expenses mean that the government subsidizes debt financing. Thus, firms are encouraged to take more debt compared to the environment without taxes. In other words, the financing decision of firms is biased toward the use of debt instead of equity financing. Should interest expenses be tax deductible?

The concept of net income provides a justification for the preferable debt treatment (Johnson, 1986; Warren Jr., 1974). According to the concept, interest expenses are seen as production costs like any other, such as raw materials or labor. Therefore, interest expenses are subtracted from earnings before tax as they were operating expenses. Dividends, on the contrary, are seen as a vehicle of profit distribution rather than a part of operating expenses. However, from the modern finance perspective, debt holders and equity holders are capital suppliers. Interest expenses are the compensation to debt holders, but not a part of operating expenses. For example, interest expenses as well as dividends are included in the cash flow resulting from financing activities rather than in the cash flow resulting from operating activities. Following this idea, debt financing is tax preferred since interest expenses are deducted from taxable income while dividends are paid from the profit after tax.

In the USA, the rule allowing for the unlimited deductibility of interest expenses was introduced in 1918 "*as a temporary measure designed to equalize the effects of the World War I excess profits tax*" (Warren Jr., 1974). Three years later, the excess profits tax was

[1] Allowing firms to deduct interest expenses from their tax liabilities (authors' comment).

removed with no effect on the unlimited deductibility of interest expenses (Warren Jr., 1974). In 2011 – that is, almost a century later – there was a debate in the US Senate Committee on Finance about the current tax system. The Chairman Max Baucus (D-Montana) raised the question of whether tax-deductible interest expenses "*encourage unhealthy risk-taking and investing in underperforming assets*" (Baucus, 2011).

In this paper, we address this issue by analyzing the impact on firms and public finance, if tax deductibility of interest expenses is fully or partially eliminated. Specifically, the goals of this paper are: *a*) to analyze the impact of the change in the treatment of interest expenses on firm characteristics, in particular financial leverage and default frequency; *b*) to measure the negative effect on shareholder loss; *c*) to analyze the impact of the change in the treatment of interest expenses on public finance and the macroeconomy; *d*) and to find the optimal policy regarding the proportion of interest expenses that could be tax-deductible. We expect that firms would reduce their leverage if tax deductibility of interest expenses is fully or partially eliminated. As a result, probability of firm default should decrease. The reform is likely to improve government revenues from corporate income taxes due to increased tax revenues per firm and lower default frequency of firms.

The topic is important as preferable debt treatment might impact firms' incentives and choices in not only financing policy but also in investment and operating policies. The changes will ultimately lead to a change in the firm values and aggregate level of the economy. For example, firms might take more debt and become riskier than optimal for society. Further, firms might become too large or choose to invest too much into productive capital. This could lead to inefficient resource allocation in the economy. Debtholders are economically important providers of capital and; thus, it is necessary to gain insights into how the removal of the deductibility of interest expenses would impact firm solvency risk, reliance on debt, the cost of debt, and firm value.

In 1992, the US Department of the Treasury prepared a comprehensive study of how individual and corporate income taxes could be integrated in order to eliminate double taxation of corporate income and reduce the economic distortions (US Department of the Treasury, 1992). The study develops the comprehensive business income tax (CBIT) concept which allows deductions for neither dividends nor interest paid by corporations.[2] US Department of the Treasury (1992) finds that CBIT would lead to 6.6 p.p. lower firm leverage (leverage would decrease from 36.6% to 30.0%). Radulescu and Stimmelmayr (2007) and De Mooij and Devereux (2011) analyze the consequences on the German and European Union economies if CBIT were introduced. Both studies report the negative impacts on gross domestic product, employment, and investments. De Mooij and Devereux (2011) also find that firms would reduce their leverage by 6.8 p.p. Glover et al. (2011) use a dynamic general equilibrium model to analyze the economic consequences of allowing firms to deduct interest expenses from their tax liabilities. They find that the change in tax treatment would substantially reduce the equilibrium level of leverage. Glover et al. (2011) argue that the default frequency and average credit spreads in the economy would increase as external financing would become more expensive. The previous papers mainly focused on main economic aggregates. In contrast, our key focus is on the impact on firm-level variables. Such analysis is superior as it lets us focus on corporate policies of a representative firm and deepens our understanding of how and why the deductibility (or non-deductibility) of interest expenses impact firm behavior and value. In the analysis, we use a utility maximization model that replicates the life and simplified behavior of a representative firm in a dynamic world with a changing environment.[3]

The direct effect of elimination of tax deductibility is the increase in effective borrowing costs for firms. As a result, it is very likely that firms would rebalance their capital structure by reducing the leverage. Consistent with our expectations, we find that the elimination of interest deductibility leads to lower leverage. Optimal debt-to-assets ratio decreases from 0.213 to 0.060. The result is consistent with previous studies (Glover et al., 2011; US

[2] Hasen (2013) recommends that CBIT could be improved by introducing a tax on distributions to high-income individuals and deducting the distributions that are immediately reinvested.

[3] Glover et al. (2011) also model the behavior of an individual firm. The model used in our paper is based on a different set of assumptions that, we believe, can better replicate firm behavior. For example, our model assumes that, in each period, to respond to the changes in the environment, the manager makes several interrelated decisions regarding production volume, investment, debt level, and share issues/repurchases, whereas Glover et al. (2011) assume that firms decide only how much labor to hire, and shareholders choose optimal capital level and debt ratio.

Department of the Treasury, 1992).[4]

Economists identified the significant impact of taxes on the firm's financial policy a long time ago.[5] In their seminal paper, Modigliani and Miller (1958) argue that in the environment with taxes, but without bankruptcy costs, the optimal capital structure of the firm is 100% debt. Miller (1977) argues that the value of the tax shield due to tax-deductible interest expenses is much lower than shown in Modigliani and Miller (1958, 1963), if personal income taxes on interest payments are introduced.[6] More recent empirical studies estimate that the value of net benefits of debt – that is, the difference between the value of the tax shield and bankruptcy costs – is around 4% of firm value (van Binsbergen et al., 2010; Korteweg, 2010). Our calibrated model suggests that shareholders would lose approximately 3.5% of their investment. This is equivalent to 2.7% of the firm's value; thus, the result is close to those in previous studies. We find that the loss is twice as small as the value of the initial debt tax shield, due to the changes in the corporate policies; that is, firms would become less levered, would rely less on fixed assets, and would make increased use of other production inputs.

The empirical literature provides strong evidence on the impact of debt level on firm risk. Christie (1982) finds some evidence that stock return volatility is positively impacted by the firm's financial leverage. Molina (2005) reports that firms with higher leverage are more likely to have a higher default probability proxied by the credit rating. Mandelker and Rhee (1984) find that higher financial leverage increases the systematic risk of the firm measured by the firm's common stock beta. To show the impact of the hypothetical change in the treatment of interest expense on the firms' riskiness, we generate an artificial dataset with heterogeneous firms. Using the same shock patterns, we run 1,000 simulations

[4] In addition, Buettner et al. (2012) find that subsidiaries of multinational firms use less foreign internal debt if there are restrictions on tax deductibility of interest expenses (i.e., thin-capitalization rules). Panier et al. (2012) investigates the impact on the capital structure of Belgian firms when notional interest deduction (NID) was introduced in Belgium. NID eliminates the discriminatory treatment of equity by allowing firms to deduct from their taxable income the product of book value of equity and benchmark interest rate. Panier et al. (2012) find that firms significantly reduce their leverage ratios.

[5] This view is also supported by US CFOs' opinions. According to the survey, the tax advantage of interest expenses is of average importance in the corporate financing decisions (Graham and Harvey, 2001).

[6] It is hard to summarize the large amount of literature available on the effects of taxes on corporate financial policy. Excellent surveys on the topic include Auerbach (2002) and Graham (2006).

for both cases: when interest expenses are tax deductible and when interest expenses are not tax deductible. The results show that the number of defaults decreases if the tax deductibility of the interest expense is eliminated. The results show that the elimination of the deductibility of interest expenses leads to lower leverage (0.213 vs. 0.060) which decreases the firm cumulative default rate by 3.90 p.p. over the 25-year time period. The finding is in contrast to Glover et al. (2011), who argue that the number of defaults increases, as the change in tax policy would make external financing more costly.

The impact of the change in the treatment of interest expenses on public finance is likely to be positive. The reform would improve government revenues from corporate income taxes by approximately 3% in the long run, if the portion of interest expenses that can be tax deductible does not exceed 75%. The government's revenues would increase due to the reduced number of firm insolvencies. However, the results show that there would be an adverse impact on the optimal firm size and optimal production level due to this hypothetical tax reform. This would lead to lower aggregate production and employment levels.[7,8]

Lastly, we analyze what could be the optimal policy on tax deductibility for government. In the short run (first 10 years), the government's revenues from corporate income tax are maximized if firms are not allowed to deduct interest expenses from their tax bills. This does not depend on the reduced number of firm insolvencies. In the long run, the optimal portion of interest expenses that are tax deductible is 0.66 if we assume that the number of firms in the economy remains constant; otherwise, the optimal deductibility ratio is between 0 and 0.25. However, if the government wants to maximize economic growth and employment, then, according to the model, interest expenses should be fully tax deductible.

[7]The analysis using the stationary model implies that the economy would slightly shrink. In reality, this would be equivalent to lower growth of the economy.

[8]This suggest that the reform would have a negative impact on employment. The result is consistent with Ahmad and Xiao (2013) who analyze the outcome of the potential elimination of double taxation of dividends. However, Michaelis and Birk (2006) find that the reduction in double taxation (i.e., when the cut in capital income tax rate is financed by a higher payroll tax rate) would lead to higher employment and growth. Gómez and Sequeira (2014) report that the long-run growth rate would not change and welfare would increase by 3% if double taxation is eliminated in the USA (the tax rate on capital income (dividends) increases from 0.213 to 0.397 in order to compensate the elimination of the corporate income tax and maintaining the intertemporal government budget balance.

The rest of the paper is structured as follows. Section 2 describes a dynamic stochastic partial equilibrium model. Obtained results are detailed in Section 3. Finally, Section 4 concludes.

2 The model

In this section, we firstly describe the model that is used in the analysis. Then we define the equilibrium conditions and calibrate the model's parameters. In this paper, we use a modified version of the dynamic stochastic partial equilibrium (DSPE) model developed in Karpavičius (2014b).[9] The model replicates the performance of a representative firm in a dynamic world with a changing environment which is defined by stock price and productivity shocks. The model is stationary; that is, there is no growth.

2.1 A firm

We consider a firm with an infinite life span in discrete time. Following Karpavičius (2014b), we assume that the utility function of the firm's manager depends on shareholder value. In other words, the firm's manager maximizes shareholder value subject to her time and risk preferences. An intertemporal objective function of the firm's manager is as follows:

$$\mathbb{E}_0\left(\sum_{t=0}^{\infty}\beta^t\mathbb{U}_t\right), \tag{1}$$

where β is the subjective discount factor. The instantaneous objective function, $\mathbb{U}_t$, is given by:

$$\mathbb{U}_t=\frac{(P_t^m N_t)^{1-\sigma}}{1-\sigma}, \tag{2}$$

where P_t^m is market value of equity per share at time t and N_t is the number of shares outstanding.[10] σ is the coefficient of constant relative risk aversion (the inverse of elasticity

[9] In this section, the description of the model is broadly similar to one in Karpavičius (2014b).

[10] The model implies that the market value of equity per share is equal to the present value of future dividends (see p. 21 of this paper or Karpavičius (2014b) for more details).

of substitution).

The firm's manager maximizes the objective function subject to two constraints:

$$
\begin{aligned}
P_t^b N_t = {} & P_{t-1}^b N_{t-1} + P_{t-1}^m N_t - P_{t-1}^m N_{t-1} - \Phi_N \frac{(N_t - N_{t-1})^2}{N_{t-1}} - d_t N_{t-1} + \pi_t \\
& - \Phi_D \frac{(D_t - D_{t-1})^2}{D_{t-1}} - \Phi_K \frac{(K_t - K_{t-1})^2}{K_{t-1}},
\end{aligned} \tag{3}
$$

$$
K_t = \kappa(D_t + P_t^b N_t). \tag{4}
$$

Equation (3) is the evolution of book value of equity and Equation (4) shows the asset composition of the firm. P_t^b denotes book value of equity per share at time t. The left hand side of Equation (3) is the book value of equity. As one can see equity value originates from both the number of shares outstanding and share price. The following equation relates market value of equity to book value of equity:

$$
P_t^m = P_t^b \exp(q_t), \tag{5}
$$

where q_t is shock to market-to-book ratio and follows the AR(1) process:

$$
q_t = \rho_q q_{t-1} + \eta_t^q, \text{ where } \eta_t^q \sim \mathbb{N}(0, \sigma_q^2). \tag{6}
$$

q_t proxies the information asymmetry between the firm's manager and investors. Positive q_t means that stock is overvalued, and vice versa.

d_t is dividends at time t. We assume that dividends are paid to investors who purchased shares at time $(t-1)$. π_t denotes net income. A firm can use short-term debt to finance its activities. D_t is new borrowing. D_{t-1} is debt a firm repays in period t. K_t is capital stock at time t. To make the model more realistic, the quadratic number of shares outstanding, debt, and capital adjustment costs, $\Phi_N \frac{(N_t - N_{t-1})^2}{N_{t-1}}$, $\Phi_D \frac{(D_t - D_{t-1})^2}{D_{t-1}}$, and $\Phi_K \frac{(K_t - K_{t-1})^2}{K_{t-1}}$ are included in the model. $\Phi_N \geqslant 0$, $\Phi_D \geqslant 0$, and $\Phi_K \geqslant 0$ are the number of shares outstanding, debt, and capital adjustment cost parameters.[11] Equation (3) implies that it is costly for a firm to increase or decrease its capital stock, the number of shares outstanding, and debt. Empirical evidence suggests that equity issue costs are approximately 7% and debt issue costs are around 2% (Lee et al., 1996). The quadratic number of share outstanding and debt adjustment costs take this into account. Similarly, if firms purchase new machinery, they need to install it and train employees how to appropriately use it. The quadratic capital adjustment costs reflect both installation and training costs.

Equation (4) implies that a firm can invest only the κ fraction of its financial assets into capital stock. This assumption is introduced in order to make the model more realistic. For example, a mean (median) of fixed assets-to-total assets ratio for all Compustat firms was 0.246 (0.160) in 2009. The rest of the financial capital, $(1-\kappa)(D_t + P_t^b N_t)$, can be interpreted as working capital. Stock of physical capital, K_t, evolves according to:

$$K_t = (1-\delta)K_{t-1} + I_t, \tag{7}$$

where δ is the capital depreciation rate. I_t stands for investment.

Firm's net income is calculated using the following formula:

$$\pi_t = (S_t - C_t - \delta K_{t-1})(1-\tau) - D_{t-1}r_{t-1}(1-\mathbb{D}\tau), \tag{8}$$

where S_t is sales revenue. C_t is an amount of production input (for example, labor and raw materials). It is assumed that the unit cost of C_t is one. $\mathbb{D}$ is a variable that equals to one if interest expenses are tax deductible, zero otherwise. τ is corporate income tax rate. r_t is the interest rate for a debt obtained in time t, D_t. The interest rate at which a firm can borrow increases with firm's leverage:

$$r_t = r^* \left(1 + \Phi_r \frac{D_t}{D_t + P_t^b N_t}\right), \tag{9}$$

[11] Quadratic debt adjustment costs make short-term debt similar to long-term debt with variable interest rates.

where r^* is a constant and equals to the hypothetical interest rate on corporate bonds for unlevered firms. The last term in Equation (9) is the risk premium related to a firm's financial leverage. $\Phi_r > 0$ is the parameter of risk premium.

Firm's tax liability at time t is T_t:

$$T_t = (S_t - C_t - \delta K_t)\tau - D_{t-1} r_{t-1} \mathbb{D}\tau. \tag{10}$$

Sales revenue, S_t, is the product of output volume, Y_t, and the price per output unit, p_t:

$$S_t = Y_t p_t. \tag{11}$$

A firms sells its products in a competitive market. The price per output unit decreases with the output volume and is given by the following function:

$$p_t = \bar{p} \left(\frac{\bar{Y}}{Y_t} \right)^{\eta}, \tag{12}$$

where $\bar{Y}$ and $\bar{p}$ are the demand for a firm's products and market price in the steady state, respectively.[12] Parameter η is price elasticity of demand.

A firm produces a single tradable good according to Cobb-Douglas function:

$$Y_t = \exp(A_t) K_{t-1}^{\alpha} C_t^{1-\alpha}, \tag{13}$$

where A_t is the productivity shock that follows the AR(1) process:

$$A_t = \rho_a A_{t-1} + \eta_t^a, \text{ where } \eta_t^a \sim \mathbb{N}(0, \sigma_a^2). \tag{14}$$

α is capital share. According to Equation (13), output volume increases with capital stock and other production inputs.

[12] The term "steady state" refers to the deterministic steady state. Throughout this paper, variables with bars denote steady-state values.

We assume that dividends per share, d_t, consist of constant and variable parts. The constant part is equal to the steady-state dividends per share, $\bar{d}$, multiplied by ψ. It is equivalent to a certain amount of cash per share distributed to shareholders at the end of each period. The variable part of dividends per share is net income per share multiplied by its weight, $(1-\psi)$:

$$d_t = \psi \bar{d} + (1-\psi)\frac{\pi_t}{N_{t-1}}, \tag{15}$$

where ψ is the weighting parameter.

2.2 The equilibrium

In each period, the firm's manager observes the values of the shocks and parameters and chooses strategy $\{C_t, K_t, N_t, D_t\}_{t=0}^{t=\infty}$ to maximize her expected lifetime utility subject to constraints (Equations (3) and (4)), initial values of debt, capital stock, share price, the number of shares outstanding and a no-Ponzi scheme constraint of the form:

$$\lim_{j\to\infty} \mathbb{E}_t \frac{D_{t+j}}{\prod_{i=1}^{j}(1+r_i)} \leq 0. \tag{16}$$

In other words, to respond to the changes in the environment that are defined by stock price and productivity shocks, the firm's manager needs to makes several decisions; namely, to choose how much capital to raise in the external equity and debt markets, how much to produce, and how much to invest in productive capital stock. The firm's manager has rational expectations about the future, does not know the timing of future shocks but knows their distributional properties. Thus, the decisions of the manager are made knowing that the future value of innovations is random but will have zero mean.

To simplify the firm's manager's optimization problem, we assume that the firm's manager does not consider an option of strategic default while running a firm. We admit that, in some cases, it could be optimal from the shareholder perspective to liquidate a firm in order to avoid further losses. However, in reality, we do not observe (at least, we are not familiar with) cases where a manager liquidated a firm with positive net assets;

that is, when a firm's assets exceeded its liabilities. Usually, managers try to run a firm as long as possible; thus, creditors initiate bankruptcy procedure. However, this occurs when a firm's net assets are negative. The potential explanations for why managers do not file for bankruptcy when firms' net assets are still positive include agency-related reasons (managers do not want to lose their jobs and thus salaries – important source of their income), information asymmetry (managers are more likely to have better information regarding the firm's prospects than other stakeholders), and behavioral reasons (managers might be overconfident about their firm's prospects and their abilities). Thus, without loss of generality, we assume that the firm's manager does not foresee the possibility that a firm might default.

Maximization of objective function (Equation (1)), subject to the evolution of shareholder value and asset composition of a firm (Equations (3) and (4)), yields the following first-order conditions:

$$\frac{\partial}{\partial C_t} : C_t = (1-\alpha)(1-\eta)S_t, \tag{17}$$

$$\begin{aligned} \frac{\partial}{\partial K_t} &: \frac{[\exp(q_t)]^{1-\sigma}}{\kappa}\left(\frac{K_t}{\kappa} - D_t\right)^{-\sigma} + \lambda_t\left[-\frac{1}{\kappa} - 2\Phi_K\left(\frac{K_t}{K_{t-1}} - 1\right)\right] \\ &+ \beta\mathbb{E}_t\left\{\lambda_{t+1}\left[\frac{1}{\kappa} + \frac{\exp(q_t)}{\kappa}\left(\frac{N_{t+1}}{N_t} - 1\right) + \Phi_K\left(\frac{K_{t+1}}{K_t}\right)^2 - \Phi_K\right.\right. \\ &\left.\left. + \psi\left(1-\tau\right)\left[\alpha(1-\eta)\frac{S_{t+1}}{K_t} - \delta + \Phi_r r^* \kappa\left(\frac{D_t}{K_t}\right)^2\right]\right]\right\} = 0, \end{aligned} \tag{18}$$

$$\begin{aligned} \frac{\partial}{\partial N_t} &: \lambda_t\left[\frac{\exp(q_{t-1})}{N_{t-1}}\left(\frac{K_{t-1}}{\kappa} - D_{t-1}\right) - 2\Phi_N\left(\frac{N_t}{N_{t-1}} - 1\right)\right] \\ &= \beta\mathbb{E}_t\left\{\lambda_{t+1}\left[\exp(q_t)\frac{N_{t+1}}{(N_t)^2}\left(\frac{K_t}{\kappa} - D_t\right) - \Phi_N\left(\frac{N_{t+1}}{N_t}\right)^2 + \Phi_N + \psi\bar{d}\right]\right\}, \end{aligned} \tag{19}$$

$$\frac{\partial}{\partial D_t} : -\left[\exp(q_t)\right]^{1-\sigma}\left[\frac{K_t}{\kappa} - D_t\right]^{-\sigma} + \lambda_t\left[1 - 2\Phi_D\left(\frac{D_t}{D_{t-1}} - 1\right)\right]$$
$$= \beta\mathbb{E}_t\left\{\lambda_{t+1}\left[1 + \exp(q_t)\left(\frac{N_{t+1}}{N_t} - 1\right) - \Phi_D\left[\left(\frac{D_{t+1}}{D_t}\right)^2 - 1\right]\right.\right.$$
$$\left.\left. + \ \psi\exp(\psi_{t+1})\left(1 - \mathbb{D}\tau\right)r^*\left[1 + 2\Phi_r\kappa\frac{D_t}{K_t}\right]\right]\right\}, \tag{20}$$

where λ_t is a Lagrange multiplier. Equation (17) defines the optimal level of production input, C_t, and Equations (18)-(20) are Euler conditions.

The managerial decisions reflect two trade-offs. Firstly, there are two production inputs (C_t and K_t) that can substitute each other. The optimal amount of capital stock, K_t, depends on variable production costs, C_t. To take this into account, it is necessary to derive the first-order conditions of the Lagrangian with respect to C_t and capital stock, K_t (Equations (17) and (18), respectively). The optimal levels of C_t and K_t are those where the marginal utility (of the manager) obtained by spending a monetary unit on C_t is equal to the marginal utility obtained by spending a monetary unit on K_t. Secondly, the manager needs to decide how to finance the acquisition of productive capital stock. The manager can choose between debt and equity. To take this into account, it is necessary to derive the first-order conditions of the Lagrangian with respect to the number of shares outstanding, N_t, and debt, D_t (Equations (19) and (20), respectively). As both equations hold, the first-order conditions imply that the marginal utility obtained by raising one monetary unit is the same regardless of whether a firm conducts equity or debt issue.

The equilibrium of the model is defined by the evolution of shareholder value, asset composition constraint, first-order conditions, several variable definitions (in total 15 equations), and two shocks.[13] The number of endogenous variables is equal to the number of equations; thus, the model can be solved. First of all, we analyze the properties of the model assuming a non-stochastic environment. It would help to understand long-term equi-

[13] Specifically, the equilibrium of the model is defined by Equations (3)-(5), (7)-(13), (15), (17)-(20) and two exogenous processes: Equations (6) and (14).

librium relations among the model's variables. To do so, we solve for the non-stochastic steady state of the model by using the following procedure: all shocks are set to zero, the time subscripts are dropped, and the steady-state values of each endogenous variable are expressed in terms of parameters.

When all shocks are set to zero and the time subscripts are dropped, the model reduces to 13 equations: Equation (12) cancels out and the steady-state expressions of Equations (3) and (15) are identical. To express the steady-state values of each endogenous variable in terms of parameters and constants, the number of endogenous variables must be equal to the number of equations. Thus, we assume that steady-state values of the number of shares outstanding, $\bar{N}$, and dividends, $\bar{d}$, are known.[14]

2.3 Calibration

The model is calibrated mostly as in Karpavičius (2014b). We assume that the variables are measured quarterly. The steady-state values for the number of shares outstanding, $\bar{N}$, and dividends, $\bar{d}$, are normalized to one.

The quarterly discount factor, β, calibrated to 0.98 is equivalent to an 8% annual discount rate (see Table 1). The coefficient of manager's risk aversion, σ, is 1.8. We assume that ψ is 0.8. It implies that the weight of the constant part of the dividends is 0.8. Following macroeconomic literature, quarterly capital depreciation rate, δ, is 0.025 and capital share in the production function, α, is set to 0.3. Further, we assume that a firm can invest 28.5% of its financial resources in productive capital ($\kappa = 0.285$).

The steady-state quarterly interest rate on corporate bonds, r^*, is set equal to 0.01. It implies that the hypothetical annual interest rate for unlevered firms is 4%. It is approximately equal to Moody's Seasoned Aaa Corporate Bond Yield during the 2011-2013 period.[15] The corporate income tax rate, τ, is 0.3, which is approximately equal to an

[14]The results are not impacted if we assume that steady-state value of sales revenues, $\bar{S}$, instead of dividends, $\bar{d}$, are known.

[15]Source: `https://research.stlouisfed.org/fred2/series/AAA`.

Table 1: Calibration of the parameters and steady-state values of some variables
This table presents the calibrated parameter values and steady-state values of some variables.

Coefficient	Description	Value
$\bar{N}$	Shares outstanding in the steady state	1
$\bar{d}$	Dividends in the steady state	1
κ	Fixed assets-to-capital ratio	0.285
τ	Corporate income tax rate	0.3
r^*	Interest rate for unlevered firm	0.01
α	Capital share	0.3
η	Price elasticity of demand	0.2
β	Subjective discount factor	0.98
ψ	Weight of the constant part of dividends	0.8
Φ_D	Debt adjustment cost parameter	2
Φ_K	Capital adjustment cost parameter	6
Φ_N	Number of shares outstanding cost parameter	10
Φ_r	Parameter of risk premium	1
δ	Capital depreciation rate	0.025
σ	Coefficient of constant relative risk aversion	1.8
ρ_q	Autocorrelation coefficient of stock price shock	0.5
σ_q	Standard deviation of stock price shock	0.15
ρ_a	Autocorrelation coefficient of productivity shock	0.5
σ_a	Standard deviation of productivity shock	0.05

average value of corporate marginal tax rate simulated in Graham and Mills (2008). We assume that price elasticity of demand, η, is 0.2. It implies that if the production supply increases by 10%, the sale price decreases by 2%, and vice versa. The parameter of risk premium, Φ_r, is set equal to one. It implies that if a firm's leverage increases by one percentage point, the quarterly interest rate will increase by one basis point if r^* is 0.01.

To introduce some persistence in the artificially-generated time series, we calibrate debt and capital adjustment cost parameters, Φ_D and Φ_K, to two and six, respectively. To reduce the volatility of simulated series for the number of shares outstanding, Φ_N is set to ten. The values of adjustment cost parameters imply that half-life of capital accumulation and half-life of leverage convergence are slightly greater than six years which is consistent with the recent literature. For example, Keuschnigg and Keuschnigg (2012) assume that half-life of capital accumulation is 6-10, Radulescu and Stimmelmayr (2010) use the value of eight. The empirical corporate finance studies suggest that it takes firms 2-7 years to reduce the effect of a shock to target capital structure by half (see Table 8 on page 267 in Huang and Ritter (2009)).

We assume that a firm operates in the competitive and dynamic environment; thus, the AR(1) coefficients for both shocks are calibrated to 0.5. It implies that the magnitude of shocks diminishes over time, and two years (eight quarters) later it is less than 1% of its initial value. The standard deviation of shock to market-to-book ratio is set to 0.15 and is approximately equal to the standard deviation of quarterly stock returns over the 2000-2014 period for firms with market capitalization greater than $50 million. Further, the standard deviation of the technology shock is set to 0.05.[16]

The calibrated parameter values imply quite reasonable firm characteristics in the steady state. Book (market) leverage is 0.213. Quarterly dividend yield is 0.026, implying that shareholders earn 10.6% per year on their investment.[17] Thus, equity financing is more expensive than debt financing. Net profit margin (net income, $\bar{\pi}$, over sales, $\bar{S}$) is equal to 0.23.

In the analysis, we assume that market interest rate is unaffected by the hypothetical change in the regulatory environment. In other words, we assume that the supply of funds in the external credit market is flat and does not depend on interest rate. As it is more likely that market interest rate would decrease if tax deductibility of interest expenses is eliminated, our analysis represents the extreme case. As a robustness check, we consider various scenarios.

3 Results

In this section, we present the results. First of all, we analyze the hypothetical impact on firm characteristics, default rates, and government tax revenues if interest expenses were not tax deductible. Further, we investigate the convergence path of variables towards the

[16]It corresponds to the assumption that there is a probability of approximately 68% that the *unexpected* change in the productivity in any given period will be between –0.05 and 0.05.

[17]The model is stationary; therefore, capital gains are zero.

Table 2: The steady-state values
This table presents the steady-state values of the variables under different treatment of interest expenses.

		Interest expenses are tax deductible	
Variable	Description	Yes	No
Gross profit margin	$\frac{\bar{S}-\bar{C}}{\bar{S}}$	0.440	0.440
Net profit margin	$\frac{\bar{\pi}}{\bar{S}}$	0.230	0.250
Leverage	$\frac{\bar{D}}{\bar{D}+\bar{P}^b\bar{N}}$	0.213	0.060
Interest rate	$\bar{r}$	0.012	0.011
Dividend yield	$\frac{\bar{d}}{\bar{P}^m}$	0.026	0.026
Fixed assets	$\bar{K}$	14.2	11.5
Share price	$\bar{P}^b$, $\bar{P}^m$	39.2	39.2
The number of shares outstanding	$\bar{N}$	1	0.965
Firm value	$\bar{D}+\bar{P}^b\bar{N}$	49.8	40.3
Sales	$\bar{S}$	4.347	3.869
Price per output unit	$\bar{p}$	1.052	1.083
Production	$\bar{Y}$	4.132	3.572
Sales/Capital	$\frac{\bar{S}}{\bar{K}}$	0.306	0.337
Production/Capital	$\frac{\bar{Y}}{\bar{K}}$	0.291	0.311
Costs/Capital	$\frac{\bar{C}}{\bar{K}}$	0.171	0.189
Profit	$\bar{\pi}$	1	0.965
Taxes paid	$\bar{T}$	0.429	0.425

new steady state after the announcement of the hypothetical elimination to deduct interest expenses from tax liabilities. Next, we present the effects of the pre-announcement. Finally, we analyze the government's optimal policy.

3.1 Long-run effects

To analyze the changes in the equilibrium levels of firm characteristics and tax liabilities, we compare steady-state values of the variables under different treatment of interest expenses; that is, the steady state values when interest expenses are tax deductible and new steady state values to which variables converge after the policy has changed.[18] Table 2 presents the results. The most significant change is the decrease in financial leverage. We measure

[18]The outcomes of the elimination of preferable debt treatment are not equivalent to those of the income tax rate of zero. Though the tax shield vanishes in either case and firms would have less or no incentives to have debt, net income after taxes is different under the two scenarios. Net income after taxes would be higher if the income tax rate is zero and, therefore, would impact a firm's operating, financing, and investment decisions.

leverage using book leverage (debt over book value of assets). We find that, if interest expenses are not tax deductible, optimal leverage decreases substantially: from 0.213 to 0.060. The result is consistent with Glover et al. (2011) who find that book leverage would decrease from 0.233 to 0.047. However, US Department of the Treasury (1992) forecasts a substantially lower impact, that is, from 0.366 to 0.300. The decreased debt is not replaced by the newly issued equity. Due to the lower debt level, the significant reductions in firm size and capital stock are observed. Firm value reduces by 19.2% (from 49.8 to 40.3). Since a firm can invest only a fixed fraction of its financial assets into capital stock, the latter decreases also by 19.2% (from 14.2 to 11.5) in the new equilibrium. Smaller capital stock results in lower production level and sales. Despite total net income, $\bar{\pi}$, is lower in the new equilibrium, relative measures of profitability are not negatively affected. Earnings per share ($\frac{\bar{\pi}}{\bar{N}}$), dividend yield ($\frac{\bar{d}}{\bar{P}^m}$), and gross profit margin ($\frac{\bar{S}-\bar{C}}{\bar{S}}$) are unaffected.[19] This is consistent with US Department of the Treasury (1992). Net profit margin ($\frac{\bar{\pi}}{\bar{S}}$) slightly increases due to lower interest payments.

The model implies that share price is unaffected by the treatment of interest expenses. However, the number of shares outstanding decreases by 3.5%. Thus, shareholder value decreases by the same percentage. In Section 3.3, we will show that this is the effective loss to shareholders if government stops subsidizing the corporate debt.[20] The calibration of the model suggests that the tax shield of the debt, scaled by either market or book value of equity, is 8.1%:

$$\frac{\tau\bar{D}}{\bar{N}\bar{P}^b} = \frac{0.3 \times 10.63}{1 \times 39.2} = 0.081 = 8.1\%.$$

The value shows the loss to shareholders if a firm does not change its investment, production, and financing policies. In the model, the firm's manager makes rational decisions to maximize shareholder value. Due to managerial decisions, shareholders lose less than half

[19] By re-arranging equations in the steady state, one can derive that $\frac{\bar{\pi}}{\bar{N}} = \bar{d}$, $\frac{\bar{d}}{\bar{P}^m} = \frac{1-\beta}{\beta\psi}$, and $\frac{\bar{S}-\bar{C}}{\bar{S}} = \alpha + \eta \times (1-\alpha)$. Thus, these profitability measures do not depend on the treatment of interest expenses.

[20] According to the model, share price is the sum of discounted constant parts of dividends (see Equation (21) on p. 21 of this paper or p. 296 in Karpavičius (2014b)). Thus, dividend yield is also not affected by tax reform (though both total dividends paid and total equity decrease by 3.5%).

of the amount that would be lost if the firm's manager does nothing.

From the macroeconomic perspective, the change in treatment of interest expenses would be controversial. Due to smaller optimal firm size, lower profit and leverage, the government would collect slightly less tax *from each firm*. In the absence of changes in corporate policies, the government's income from corporate income taxes from each firm would be higher by 9.0%:

$$\frac{(\bar{S}-\bar{C}-\delta\bar{K})\tau}{(\bar{S}-\bar{C}-\delta\bar{K}-\bar{D}\bar{r})\tau}-1=$$
$$\frac{4.347-2.434-0.025\times 14.2)\times 0.3}{4.347-2.434-0.025\times 14.2-10.6\times 0.012)\times 0.3}-1=0.090=9.0\%.$$

However, due to the managerial actions, the government receipts from corporate income taxes paid by each firm would reduce by approximately 1%. Smaller optimal firm size and optimal production level suggest the change in the treatment of interest expenses would have a negative impact on the economy (due to lower sales) and employment (due to lower production input), if the number of firms remains unchanged in the economy. A lower production level leads to the higher price of the final product; thus, the change in the treatment of interest expenses increases the inflationary pressure. To conclude, the policy change would result in smaller, less leveraged firms.

To shed some light on which parameters have the biggest impact on the changes in shareholder value and taxes paid, we conduct the sensitivity analysis of these variables with respect to all parameters, except for the managerial constant relative risk aversion, σ. The latter does not impact the values of endogenous variables in the steady state.

Sensitivity analysis of the number of shares outstanding, $\bar{N}$, (or shareholder value) reveals that all considered parameters impact the variable of interest; however, the most influential parameters are the hypothetical interest rate for unlevered firm, r^*, price elasticity of demand, η, the managerial discount factor, β, and capital share, α (see Table 3). We find that the impact on $\bar{N}$ increases with r^*, η, and β but decreases with α.

Table 3: Sensitivity analysis of the number of shares outstanding, $\bar{N}$, and taxes paid, $\bar{T}$

This table presents the sensitivity analysis of the number of shares outstanding, $\bar{N}$, and taxes paid, $\bar{T}$, with respect to all parameters, except for the managerial constant relative risk aversion, σ. The latter does not impact the values of endogenous variables in the steady state. The actual values of $\bar{N}$ and $\bar{T}$ are highlighted. Columns "Ded." and "Non-ded." show the results if interest expenses are tax deductible and non-deductible, respectively.

	Interest rate for unlevered firm, r^*									
	0.002		0.005		0.01		0.02		0.03	
	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.
$\bar{N}$	1	0.904	1	0.912	**1**	0.965	1	1.046	1	1.116
$\bar{T}$	0.429	0.481	0.429	0.450	**0.429**	0.425	0.429	0.405	0.429	0.392
	Capital share, α									
	0.1		0.2		0.3		0.4		0.5	
	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.
$\bar{N}$	1	1.020	1	0.999	**1**	0.965	1	0.925	1	0.881
$\bar{T}$	0.429	0.412	0.429	0.420	**0.429**	0.425	0.429	0.425	0.429	0.421
	Subjective discount factor, β									
	0.96		0.97		0.98		0.985		0.99	
	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.
$\bar{N}$	1	0.866	1	0.907	**1**	0.965	1	1.003	1	1.053
$\bar{T}$	0.429	0.455	0.429	0.439	**0.429**	0.425	0.429	0.416	0.429	0.401
	Price elasticity of demand, η									
	0.1		0.15		0.2		0.25		0.3	
	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.
$\bar{N}$	1	0.800	1	0.914	**1**	0.965	1	0.991	1	1.005
$\bar{T}$	0.429	0.407	0.429	0.424	**0.429**	0.425	0.429	0.422	0.429	0.418
	Weight of the constant part of dividends, ψ									
	0.6		0.7		0.8		0.85		0.9	
	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.
$\bar{N}$	1	0.926	1	0.947	**1**	0.965	1	0.973	1	0.981
$\bar{T}$	0.429	0.434	0.429	0.429	**0.429**	0.425	0.429	0.423	0.429	0.421
	Corporate income tax rate, τ									
	0.1		0.2		0.3		0.4		0.5	
	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.
$\bar{N}$	1	0.996	1	0.985	**1**	0.965	1	0.932	1	0.880
$\bar{T}$	0.111	0.112	0.250	0.251	**0.429**	0.425	0.667	0.642	1.000	0.914

(*continued on next page*)

Table 3 – continued from previous page

	Parameter of risk premium, Φ_r									
	0.01		0.5		1		2		3	
	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.
$\bar{N}$	1	0.914	1	0.949	**1**	0.965	1	0.979	1	0.985
$\bar{T}$	0.429	0.428	0.429	0.424	**0.429**	0.425	0.429	0.426	0.429	0.427
	Fixed assets-to-capital ratio, κ									
	0.1		0.2		0.285		0.3		0.4	
	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.
$\bar{N}$	1	0.936	1	0.953	**1**	0.965	1	0.967	1	0.978
$\bar{T}$	0.429	0.424	0.429	0.425	**0.429**	0.425	0.429	0.425	0.429	0.424
	Capital depreciation rate, δ									
	0.01		0.02		0.025		0.03		0.04	
	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.	Ded.	Non-ded.
$\bar{N}$	1	0.939	1	0.958	**1**	0.965	1	0.972	1	0.984
$\bar{T}$	0.429	0.425	0.429	0.425	**0.429**	0.425	0.429	0.424	0.429	0.423

Table 3 shows that the change in taxes paid per firm, $\bar{T}$, is most impacted by the managerial discount factor, β, and hypothetical interest rate for unlevered firm, r^*. The impact on taxes paid if interest expenses become non-tax-deductible decreases with both factors. In general, those parameters that are the key determinants of the financial leverage have the highest impact on the outcome of the reform. For brevity, the discussion of the sensitivity analysis covers only the most influential parameters.

According to the model, the most important factor of leverage is the hypothetical interest rate for unlevered firm, r^*. Its lower value leads to higher leverage, and vice versa. The changes in firm leverage impact firm risk and taxes paid per firm. Therefore, any changes in interest rate would impact firm risk and taxes paid. If $r^* = 0.002$, the change in the policy would lead to 9.6% lower $\bar{N}$ (from 1 to 0.904) and if $r^* = 0.03$, $\bar{N}$ would increase by 11.6% (from 1 to 1.116).[21] If $r^* = 0.002$, the change in the policy would result

[21] If $r^* = 0.002$, firm leverage would decrease from 0.711 to 0.651, and if $r^* = 0.03$, firm leverage would change from –0.185 to –0.263. A firm with negative leverage is a net lender. It lends rather than borrows financial resources. The model of this paper treats interest income and interest expense symmetrically; that is, interest income is a negative interest expense, and vice versa. If interest expenses are tax deductible, then interest income is treated in the same way as sales revenue. This view is generally consistent with the

in 12.3% higher taxes paid by each firm (from 0.429 to 0.481), and if $r^* = 0.03$, taxes paid would decrease by 8.6% if interest expenses become non-tax-deductible. The results suggest that firms with higher level of debts would pay more taxes; however, taxes paid from less levered firms would not increase.

The model implies that higher capital share, α, leads to greater capital stock, $\bar{K}$. Re-arranged Equations (4), (5) and (19) in the steady state imply the following relation:

$$\bar{P}^m = \bar{P}^b = \frac{\beta\psi\bar{d}}{1-\beta}. \tag{21}$$

Thus, in the steady state, equity value is only determined by the present value of future dividends. Equations (4) and (21) in the steady state lead to the following relation:

$$\bar{D} = \frac{\bar{K}}{\kappa} - \bar{P}^b\bar{N} = \frac{\bar{K}}{\kappa} - \frac{\beta\psi\bar{d}\bar{N}}{1-\beta}. \tag{22}$$

In Equation (22), κ, β, ψ, $\bar{d}$, and $\bar{N}$ are constant (i.e., they do not depend on α); therefore, any increase in $\bar{K}$ (due to higher α) leads to greater $\bar{D}$. The empirical studies support the model's prediction that firm's leverage is higher for firms with more tangible assets (Frank and Goyal, 2009). More levered firms would lose more from the reform. According to the current calibration, firms with low capital share ($\alpha = 0.1$) have negative financial leverage. As the result, they benefit from the reform. If $\alpha = 0.1$, the change in the policy would lead to 2.0% higher $\bar{N}$ (from 1 to 1.020) and if $\alpha = 0.5$, $\bar{N}$ would decrease by 11.9% (from 1 to 0.881).

A lower subjective discount factor, β, implies that a manager is less patient. Thus, a firm will generate more earnings in the earlier periods. Karpavičius (2014a) finds that firms with more patient managers (i.e., managers with a higher subjective discount factor, β) have proportionally less debt. Such manager prefers smaller risk exposure; thus, he or she chooses less risky corporate strategies such as lower debt levels. Lower leverage leads

current US tax regulations. However, if interest expenses cannot be used to reduce a firm's tax liabilities, then according to our model, interest income is tax-free; that is, interest income is taxed at zero tax rate.

to lower reduction in shareholder value and taxes paid if the reform is implemented. If β is 0.96 (implying the managerial subjective discount rate of 4%), shareholders would lose 13.4% of their investment following the change in the treatment of interest expenses ($\bar{N}$ changes from 1 to 0.866).[22] If β is 0.99, shareholders would gain 5.3% ($\bar{N}$ would increase from 1 to 1.053).[23] To conclude, the shareholders of more levered firms would lose more if interest expenses become non-tax-deductible. If $\beta = 0.96$, the change in the treatment of interest expenses would increase taxes paid by each firm by 6.1% (from 0.429 to 0.455). However, if $\beta = 0.99$, taxes paid would decrease by 6.4% (from 0.429 to 0.401) following the change in tax policy.

A higher price elasticity, η, implies that the price per output unit, p_t, is more responsive to the changes in production volume, Y_t. Similarly, low η means that changes in the price per output unit, p_t, would lead to small changes (in the opposite direction) in the optimal production volume. If a volatility in the demand of the final product is small, then a firm has incentives to increase its production output. To achieve this, the firm would acquire more capital stock. Similarly as in the case of capital share, α, the additional capital is financed by debt. The opposite is true for higher values of η. If $\eta = 0.3$, a firm's leverage is 0.027 if a firm is allowed to deduct interest expenses; however, the leverage is –0.088 if interest expenses are not tax deductible, *ceteris paribus*. This leads to the positive impact on shareholder value. Assuming that $\eta = 0.1$, $\bar{N}$ would decrease by 20.0% (from 1 to 0.800) if interest expenses become non-tax-deductible; however, if we assume that $\eta = 0.3$, $\bar{N}$ would increase by 0.5% following the change in policy (from 1 to 1.005).[24] We observe the concavity in tax revenues when η changes. It appears because production costs, C_t, decrease slightly more than sales proceeds, S_t, when $\eta > 0.1$. The relation between the variables is defined by Equation (17).

[22] If $\beta = 0.96$, firm leverage is 0.595 and 0.448 *ceteris paribus* if interest expenses are tax deductible and non-deductible, respectively.

[23] Under this scenario, firm leverage is negative *ceteris paribus*: –0.129 and –0.217 if interest expenses are tax deductible and non-deductible, respectively. Negative leverage implies that a firm lends financial resources to others.

[24] If $\eta = 0.1$, firm leverage would decrease from 47.1% to 27.3% following the change in the treatment of interest expenses.

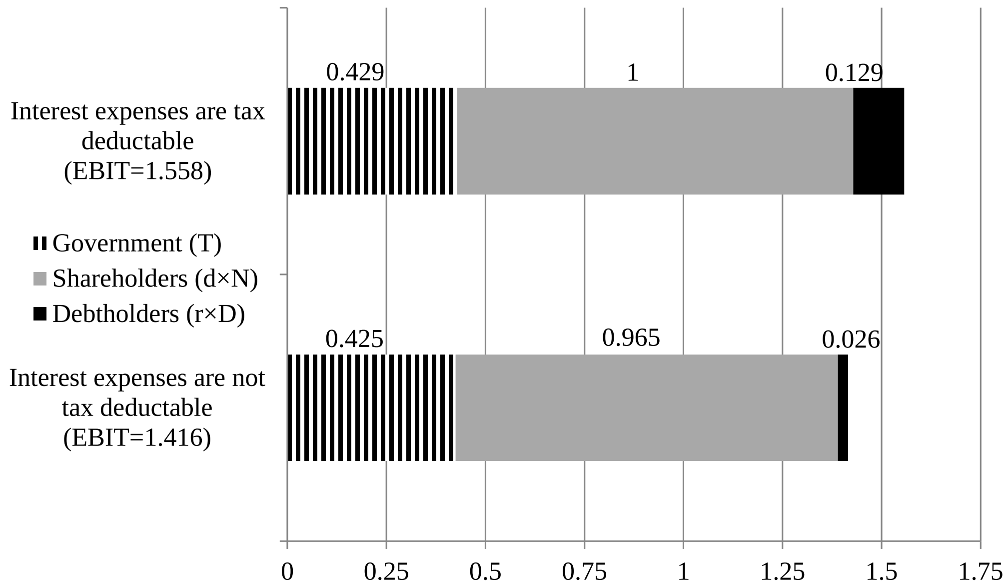


Figure 1: The distribution of earnings before interest and taxes (EBIT) to different stakeholders.

Next, we look at how the distribution of a firm's income is changed. Figure 1 shows the distribution of earnings before interest and taxes (EBIT) to stakeholders under a different treatment of interest expenses. In the benchmark case (when interest expenses are tax deductible), shareholders receive 64.2% of EBIT. The government's share is 27.5%. The debt holders receive the smallest portion of EBIT (8.3%). Eliminating the tax deductibility of interest expenses redistributes the debt holders' part of EBIT to shareholders and government. In this case, shareholders receive 68.2% of EBIT; government and debt holders get 30.0% and 1.8%, respectively. The results do not mean that shareholders and the government benefit from the change in policy. If the treatment of interest expenses is changed, the EBIT decreases by 9.1%. Government income in monetary unit terms decreases only from 0.429 to 0.425 (see Table 2). The total income of shareholders decreases from 1 to 0.965.

3.2 The impact on the default probability of firms

In this section, we analyze the impact of the hypothetical policy change on default rates. Table 2 suggests that the elimination of an asymmetric treatment of debt and equity would reduce the financial leverage of a firm. Such firms have a smaller financial risk (see, for example, Christie, 1982; Mandelker and Rhee, 1984; Molina, 2005). Thus, we expect that if interest expenses were not tax deductible, the probability of default would reduce, as we will show numerically by using simulations. In order to analyze this issue numerically, we solve the model using the same procedure as in Karpavičius (2014b).

We use simulated data and count the number of cases when firms default. We assume that a firm defaults if its share price, or the number of shares outstanding, becomes non-positive. To generate an artificial dataset with heterogeneous firms, we use the following procedure. We first simulate 1,000 firms for 2,100 time periods and then drop the first 100 time periods. In each simulation, shocks are random. Thus, these 1,000 time series should be unique. Then we compute in how many cases firms go bankrupt. Using the same shock patterns, we run 1,000 simulations when interest expenses are tax deductible, when interest expenses are non-tax-deductible, and when interest expenses are partially tax deductible. The final results are proportionally adjusted to the number of defaults in the first 100 time periods.

Table 4 presents the results. As expected, we find that the number of defaults is greater if interest expenses are tax deductible. In period 2,000, there are 662 defaults if interest expenses are tax deductible ($\mathbb{D} = 1$) and 196 defaults when interest expenses are not tax deductible ($\mathbb{D} = 0$). Further, we find that the number of defaults increases monotonically with the portion of interest expenses that can be tax deductible. The results are in contrast to Glover et al. (2011), who find that the number of defaults increases if the tax deductibility of the interest expense is eliminated. Glover et al. (2011) argue that the change in tax policy would make external financing more costly and would increase the operating leverage of firms. Our model does not include fixed costs; thus, we cannot

Table 4: Firm defaults

This table presents the number of firm defaults under different treatment of interest expenses. The sample includes 1,000 simulated firms for 2,000 time periods. We run 1,000 simulations using the same shock patterns when interest expenses are tax deductible ($\mathbb{D} = 1$), when interest expenses are not tax deductible ($\mathbb{D} = 0$), and several cases where interest expenses are partially tax deductible. The final results are proportionally adjusted to the number of defaults in the 100 time periods.

	$\mathbb{D}$				
Time period	1	0.75	0.5	0.25	0
100	55	37	30	20	12
200	107	74	54	34	23
300	172	117	88	57	37
400	217	147	103	67	43
500	256	180	125	80	53
600	295	207	140	89	62
700	325	226	152	99	69
800	355	246	168	113	79
900	395	276	194	125	91
1,000	423	299	213	141	103
1,100	444	319	226	151	109
1,200	474	345	254	173	126
1,300	502	367	279	185	135
1,400	530	385	292	201	149
1,500	551	403	306	211	157
1,600	573	426	322	225	167
1,700	599	448	341	239	176
1,800	621	467	358	248	183
1,900	641	485	372	260	189
2,000	662	505	387	269	196

assess the impact on operating leverage. However, Table 2 shows that if interest expenses are not tax deductible, financial leverage decreases and cost-to-capital ($\frac{\bar{C}}{K}$) ratio increases, meaning that firms would rely less on debt and fixed assets. Instead, firms would use proportionally more equity to finance their capital needs and more variable production input, C_t, to produce goods.

In the untabulated simulations, we find that the number of defaults depends on the covariance matrix of shocks. If the standard deviations of shocks increase, the number of defaults rises, and vice versa. However, in all cases the number of defaults is greater when interest expenses are tax deductible.

The results presented in Tables 2 and 4 suggest that shareholders lose 3.5% of their investment; however, the rest of the investment becomes less risky. Thus, positive risk-return relation is observed. Nevertheless, the change in policy would be a loss to shareholders, as they are the ultimate receivers of the debt subsidies from the government. Since the change in policy is a systematic shock, its impact cannot be eliminated through diversification.

We find that the change in policy would lead to lower firm insolvencies. This suggests that the static effects for a single firm in Table 2 do not reflect the impact on the economy. The total taxes paid would be higher due to the higher number of firms in the economy. We address this issue in detail in Section 3.5.

3.3 Convergence towards new equilibrium

In this section, we analyze the convergence of variables if tax deductibility of interest expenses is eliminated. We model this situation as deterministic shock. We assume that at time $t = 1$, $\mathbb{D}$ changes from one to zero, and then we compute the impulse responses of variables. Figure 2 presents the results. The responses are expressed in levels.

As the model contains several adjustment costs, the convergence is quite slow. The calibration of the model implies that it would take approximately 80 periods (or 20 years) for most variables to reach a new steady state. However, for example, the number of shares outstanding converges to the new steady state in more than 200 periods. In the steady state, the share price is equal to the discounted sum of constant parts of dividends (see Equation (21) on p. 21 of this paper or p. 296 in Karpavičius (2014b)) and we set the steady-state dividend per share to one. Therefore, the steady-state share price is constant as well (see Table 2), market values of equity per share, P_t^m, book values of equity per share, P_t^b, and dividends per share, d_t (i.e., variables closely related to dividends) converge to the initial steady state, and the change in the number of shares outstanding would reflect any impact on shareholder value (as shareholder value is the product of the number of shares outstanding and share price which is constant).

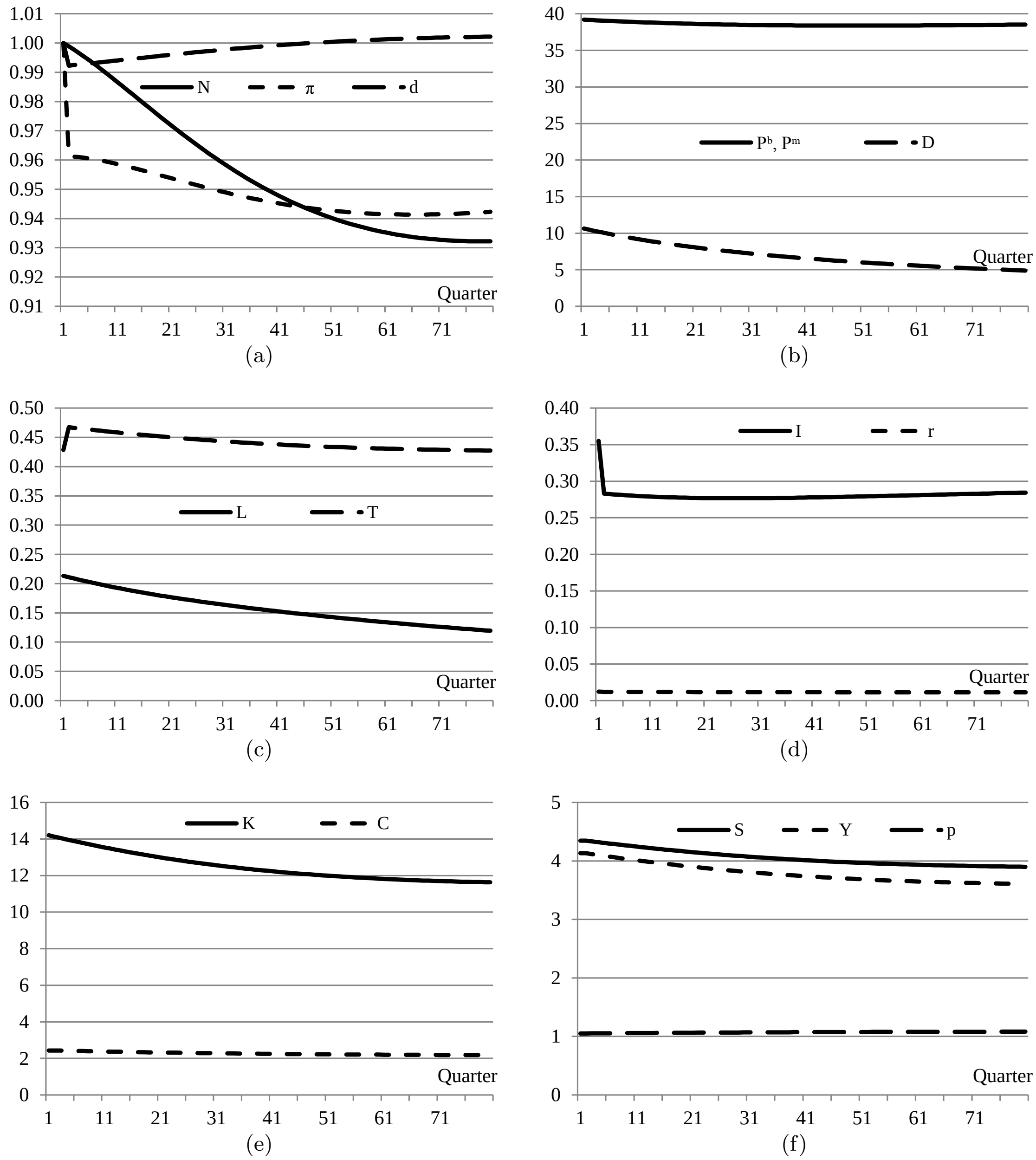


Figure 2: The impact of the elimination of tax deductibility of interest expenses. The responses are expressed in levels.

Figure 2 shows that, if interest expenses cannot be used to reduce a firm's tax liabilities, then the debt tax shield vanishes and the number of shares outstanding is negatively impacted (see Figure 2a). Further, a firm reduces debt level and leverage in order to decrease the effective interest rate (see Figures 2b and 2c). As firm size shrinks, a firm needs to reduce its capital stock (see Equation (4)); therefore, a firm disinvests certain portions of its capitals stock (see Figures 2d and 2e). As a firm uses Cobb-Douglas technology, it is optimal to reduce the amount of production input, C_t. Since both production factors decrease, the production volume also decreases, which leads to greater price per output unit (see Figure 2f). However, the impact of lower production volume offsets a higher price, and the sales revenues slightly decrease. The change in the treatment of interest expense increases firm's tax liability, T_t, in the short-term as a firm is not able to instantly rebalance its capital structure. Smaller sales revenues and higher tax liability negatively impact net income, π_t, (see Figure 2a). Since dividends are sticky and decrease less than net income, retained earnings are negative and slightly reduces share price (see Figure 2b). However, the negative impact on share price is temporal.

In the analysis above, we assume that the payout policy is not impacted by the change in the treatment of interest expenses. It would be more realistic to assume that shareholders or the board of directors understand that shareholder value would be negatively impacted if the government stops subsidizing debt. The rational response to the lower shareholder value would be to reduce the payout per share. Suppose the board of directors decides to cut the constant part of dividends by 5%: from $\bar{d}\psi = 1 \times 0.8 = 0.8$ to $\bar{d}\psi \times 0.95 = 1 \times 0.8 \times 0.95 = 0.76$. This leads to lower dividends per share in the steady state (0.95).

Figure 3 compares the impact on selected variables under a benchmark case (variables without primes) and under an altered payout scheme (variables with primes). The dynamic of variables is impacted if the constant part of dividends is cut. The book (market) value of equity per share decreases to 37.29. In a benchmark case, the share price is unaffected by the change in the treatment of interest expenses. Further, the number of shares outstanding converges to 1.015 if the board of directors adjusts the payout policy. Thus, the total shareholder value is the same in both cases (book (or market) value of equity: $39.2 \times 0.965 = 37.8 = 37.29 \times 1.015$). This example shows that the decrease in total shareholder value can be seen as a loss to equity owners, if interest expenses become non-tax deductible. Further, we analyze the dynamic of variables if the elimination of the

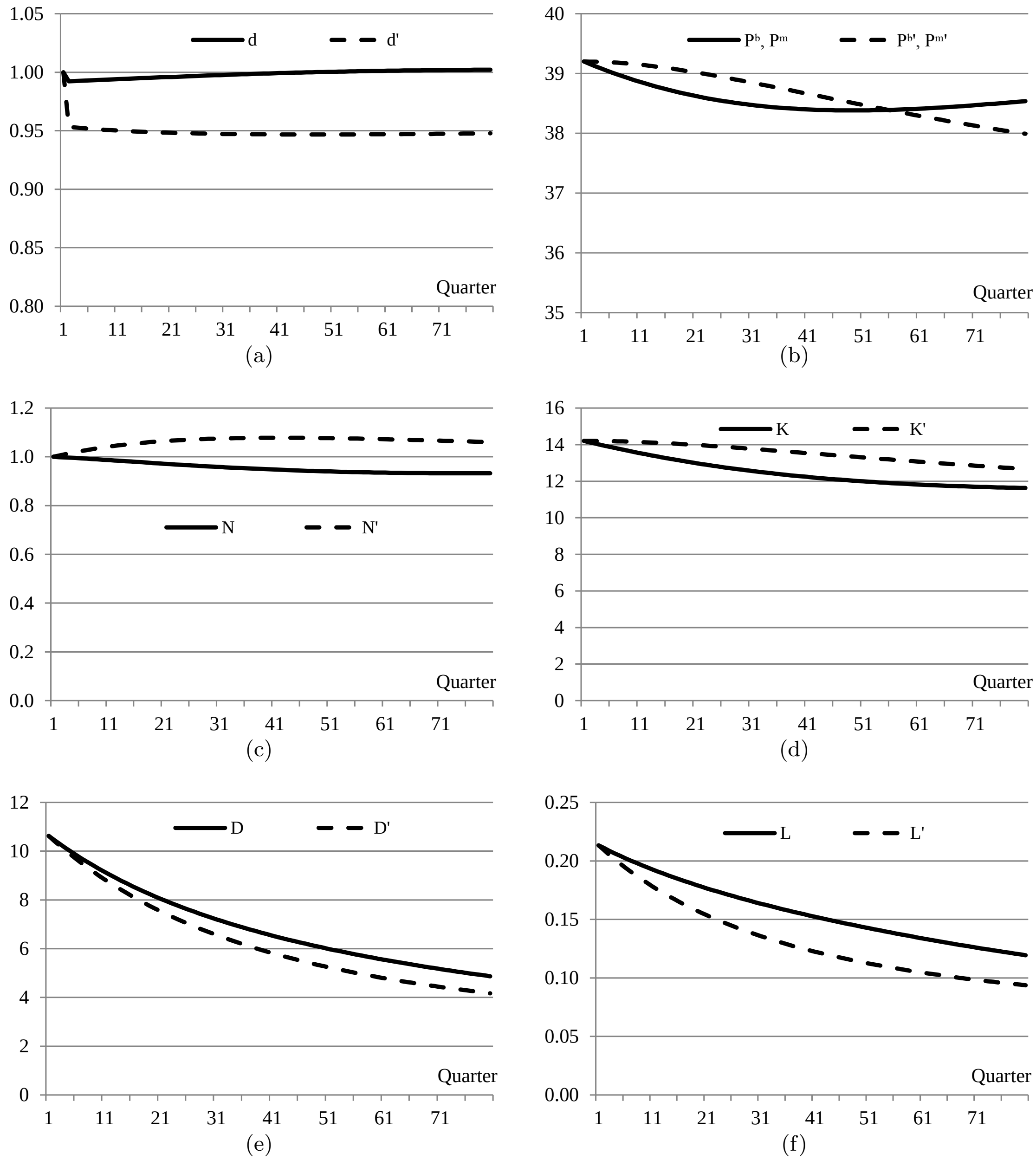


Figure 3: The impact of the elimination of tax deductibility of interest expenses under different payout scheme. The responses are expressed in levels. Variables without primes show the performance under benchmark case. Variables with primes show the performance when the constant part of dividends is cut by 5%.

tax advantage of debt is announced four periods (or one year) before it becomes effective; that is, we investigate the role of pre-announcement.

3.4 Impact of pre-announcement

To analyze the impact of the pre-announcement of a hypothetical policy change, we assume that the announcement of the change in tax-code treatment of interest expenses is credibly received by the firms. We assume that the interest expenses will not be tax deductible for four periods (or one year) after the announcement is made. Untabulated results imply that the pre-announcement has no impact in the long term. In this section, we focus on short- and medium-term effects. Figure 4 compares the results of the previous section (benchmark case) with pre-announcement effects ("pre-ann." denotes the convergence path for variables when the tax reform is pre-announced). We find that, if the tax reform is announced four periods (or one year) in advance, then the convergence is slightly slower; however, the difference is very small (in most cases, less than 1%). The result is expected as firms have one additional year to prepare for the policy change. To conclude, the pre-announcement of the hypothetical tax reform does not significantly impact firm behavior.

3.5 Optimal policy

Lastly, we investigate what the government's optimal policy could be. We compute the new steady state values for key variables under various policy scenarios. Each of them features a different portion of interest expenses that can be tax deductible (i.e., $\mathbb{D} = \{0, 0.25, 0.5, 0.75, 1\}$). Panel A in Table 5 presents the results for *a representative firm* for five scenarios. We find that the impact on tax revenue ($\bar{T}$) is not monotonic. The level of tax revenue is the highest if a firm can deduct 75% of their interest expenses from its tax bills.[25] If government aims to maximize economic growth and employment then, according to the model, interest expenses should be fully tax deductible ($\mathbb{D} = 1$). The impact of $\mathbb{D}$ on

[25] There are two sources of the non-monotonicity in tax revenues. Equation (10) on page 9 shows that firm's tax liability can be decomposed into two components: EBIT$\times\tau$ (i.e., $(S_t - C_t - \delta K_t)\tau$) and debt tax shield ($D_{t-1} r_{t-1} \mathbb{D}\tau$). They both increase with $\mathbb{D}$ but at different rates. When $\mathbb{D} = 0$, the debt tax shield increases at a lower rate. When $\mathbb{D} = 0.75$, the rates are the same, and afterwards, the change in the debt tax shield exceeds the change in EBIT$\times\tau$. Such dynamic is driven by the fact that firm size increases at a lower rate than debt level with $\mathbb{D}$ (because equity value does not depend on $\mathbb{D}$ (see Equation (21))), leading to more levered firms. Further, debt tax shield is magnified by the higher values of $\mathbb{D}$.

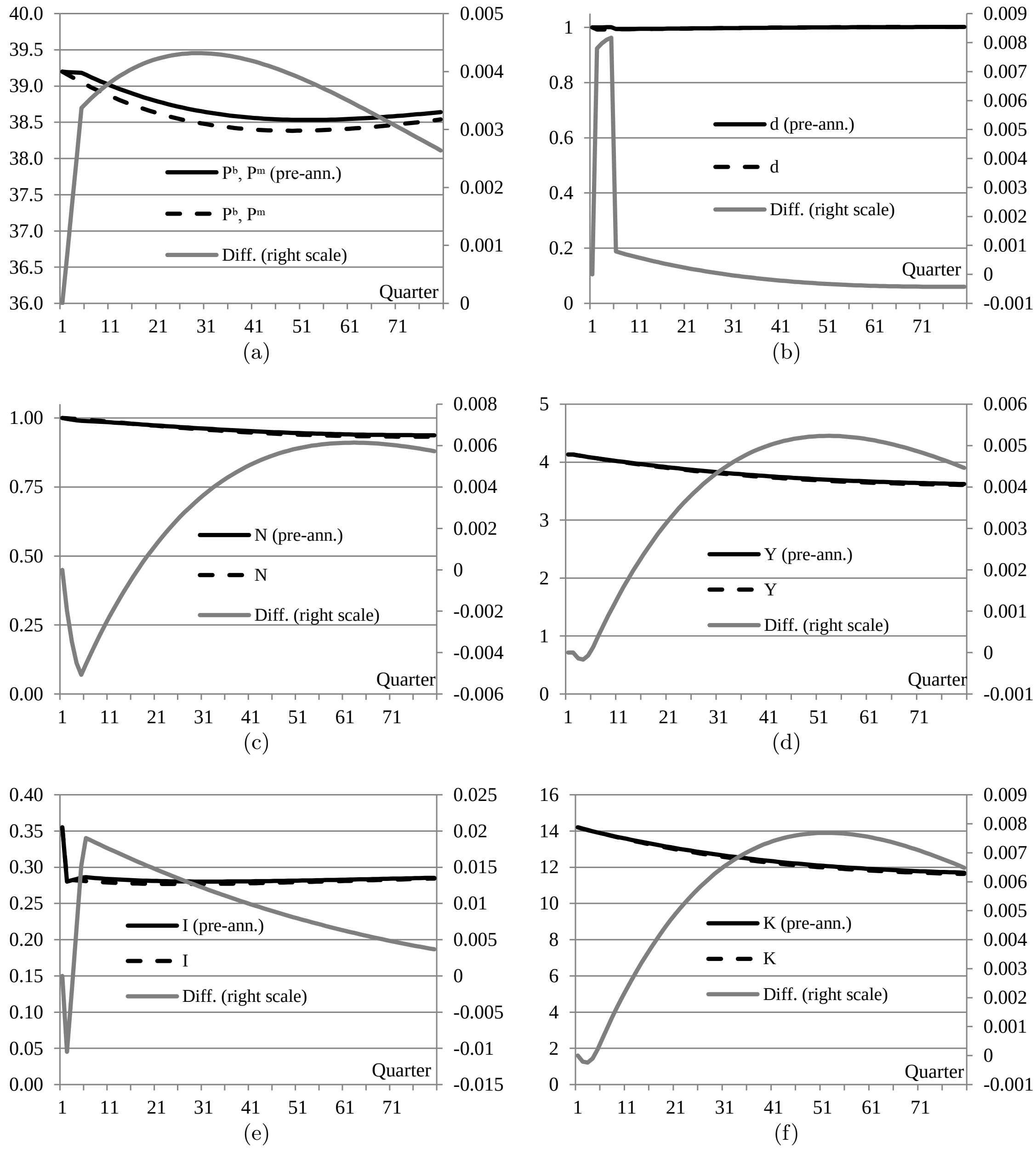


Figure 4: The impact of pre-announcement of the hypothetical policy change. This figure compares the responses of selected variables when the elimination of tax advantage of debt is announced four periods (or one year) before interest expenses become not tax deductible and when the policy change is effective immediately. "Pre-ann." shows the convergence path for variables when the tax reform is pre-announced. The responses are expressed in levels. "Diff." shows the difference in decimals between the value of a variable when the tax reform is pre-announced and when the policy change is effective immediately (e.g, for any variable X, Diff. $= \frac{\text{X (pre-ann.)}}{\text{X}} - 1$).

Table 5: Impact of different values of $\mathbb{D}$ on main variables

This table presents the impact of the portion of interest expenses that can be tax deductible ($\mathbb{D}$) on key variables in the new steady state. The value for $\bar{C}$, $\bar{Y}$, $\bar{S}$, and $\bar{T}$ in Panel B are adjusted for the increase in the number of firms (the second column in Panel B).

Panel A. Impact on characteristics of individual firm

$\mathbb{D}$	$\bar{P}^b$, $\bar{P}^m$	$\bar{N}$	$\bar{C}$	$\bar{Y}$	$\bar{S}$	$\bar{T}$	$\bar{\pi}$	$\bar{L}$	$\bar{p}$
0	19.4	0.965	2.167	3.572	3.869	0.425	0.965	0.060	1.083
0.25	19.4	0.970	2.214	3.670	3.953	0.429	0.970	0.092	1.077
0.5	19.4	0.977	2.272	3.790	4.057	0.432	0.977	0.128	1.070
0.75	19.4	0.986	2.344	3.941	4.185	0.433	0.986	0.168	1.062
1	19.4	1	2.434	4.132	4.347	0.429	1	0.213	1.052

Panel B. Economy-wide impact at $t = 100$

$\mathbb{D}$	Increase in the number of firms	$\bar{C}$	$\bar{Y}$	$\bar{S}$	$\bar{T}$
0	3.90%	2.260	3.730	4.036	0.443
0.25	3.37%	2.303	3.823	4.112	0.444
0.5	2.46%	2.343	3.916	4.184	0.443
0.75	1.48%	2.390	4.023	4.268	0.439
1		2.434	4.132	4.347	0.429

other variables is monotonic. All of them (except $\bar{p}$) increases with the portion of interest expenses that can be tax deductible.

To find the deductibility rate, $\mathbb{D}$, which maximizes firm's tax liability, $\bar{T}$, we estimate the model for the deductibility rates ranging between 0.64 and 0.82 with the increment of 0.01. We find that the tax revenues per firm is maximized when the deductibility rate is 0.66 (see Figure 5).

Table 4 reports that probability of firm default increases with the portion of interest expenses that can be tax deducted. This suggests that the static effects for a single firm in Panel A of Table 5 do not reflect the impact on the economy. For example, the total corporate income taxes collected by the government would be higher, due to the higher number of firms in the economy. Thus, the values of variables in Panel A of Table 5 should be adjusted in order to take into account the reduced number of firm insolvencies. Unreported results show that it takes approximately 100 periods (i.e., 25 years) for C_t, Y_t, S_t, and T_t to fully converge to the new steady state under different values of $\mathbb{D}$. Thus,

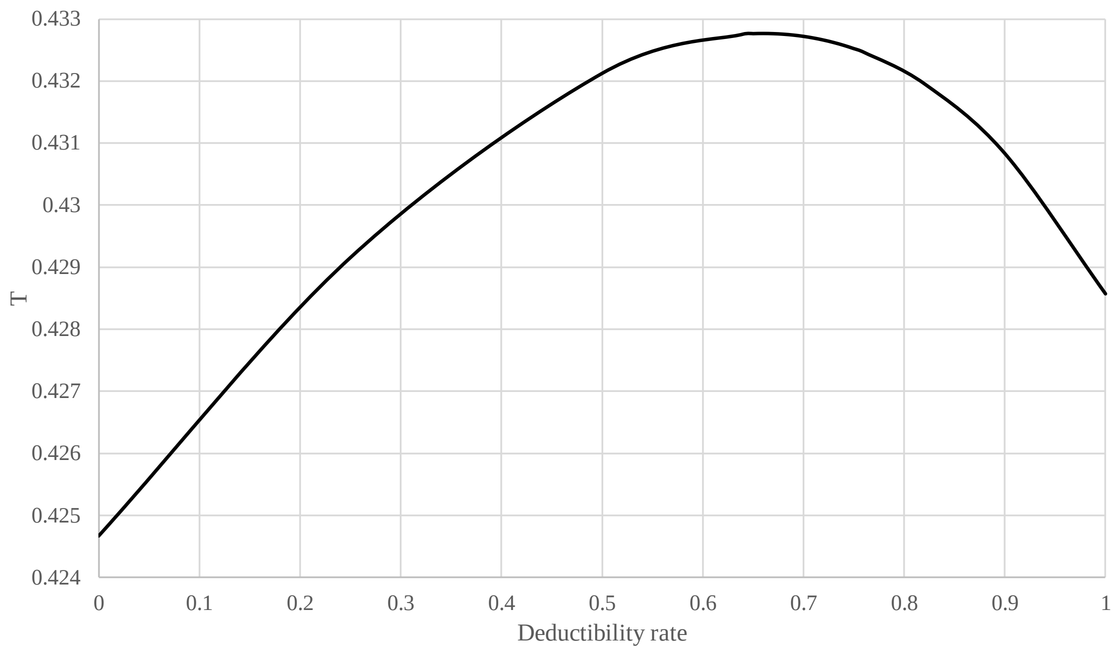


Figure 5: Firm's tax liability, $\bar{T}$, and the deductibility rate, $\mathbb{D}$, in the steady state.

we adjust the values of the variables at $t = 100$ (they are approximately equal to those in Panel A of Table 5) by the increased number of firms in the economy over 100 periods.

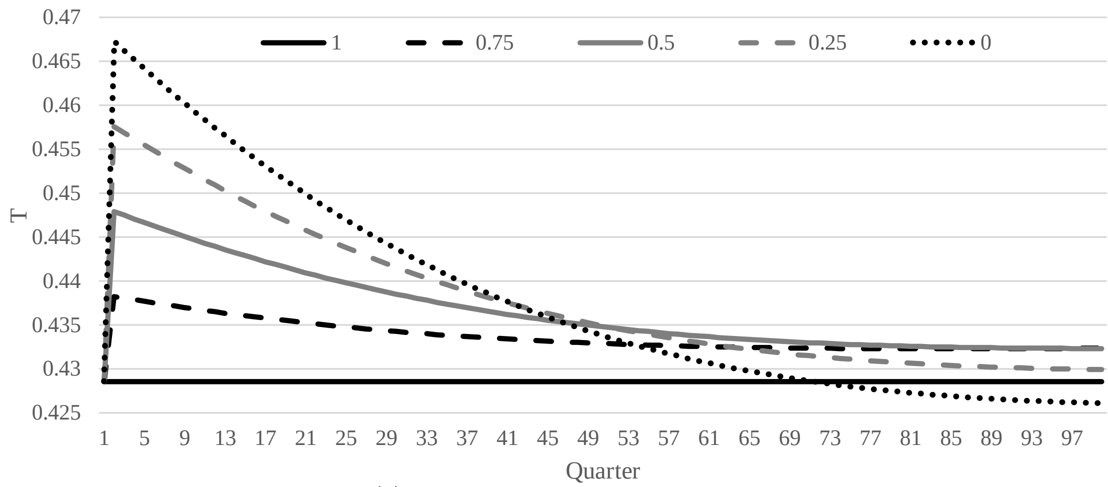
We compute the geometric average of the decrease in the default rate of incumbent firms *per period* by using the number of defaults in the 2,000$^{\text{th}}$ period in Table 4.[26] Then we compute the decrease in the cumulative default rate of incumbent firms over 100 periods. Without loss of generality, one can assume that the rate of creation of new firms remain unchanged following the change in tax-code treatment of interest expenses. Therefore, the increase in the number of firms in any scenario is equal to the respective decrease in the default rate. The second column in Panel B of Table 5 shows the increase in the number of firms for different scenarios. Then we multiply the values of variables at $t = 100$ by one plus the increase in the number of firms to get the impact on the economy. Columns 3-6 in Panel B of Table 5 show the economy-wide impact if the treatment of interest expenses is changed. Consistent with results in Panel A, we find that the largest levels of output, $\bar{Y}$, sales, $\bar{S}$, and production input, $\bar{C}$, are observed when interest expenses are fully tax-

[26] We find that the default rate decreases by 0.00038 p.p. per period (one quarter) which is equivalent to the decrease in the cumulative default rate by 3.90 p.p. over 100 periods (25 years) if $\mathbb{D} = 0$.

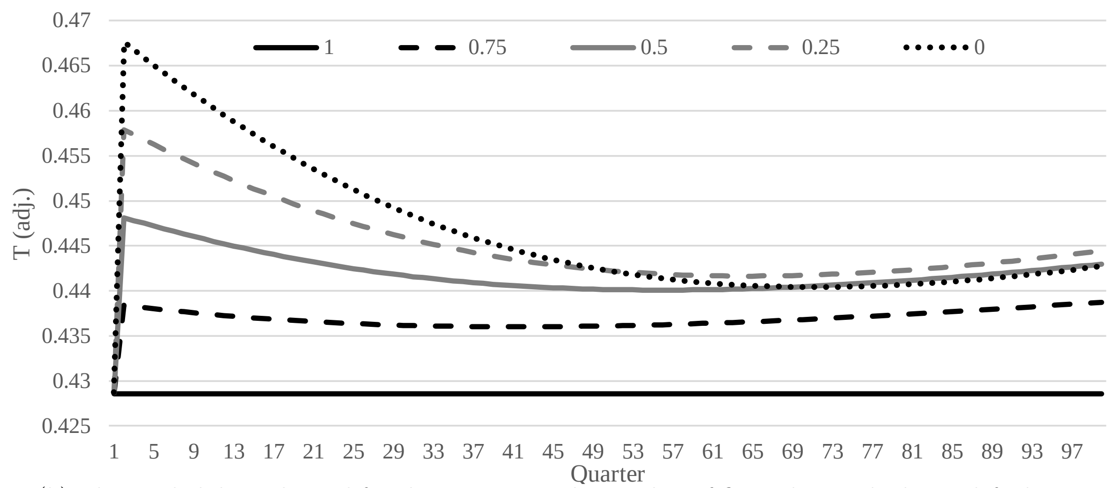
deductible (i.e., $\mathbb{D} = 1$). However, unreported results show that if the treatment of interest expenses is changed then in the long run (e.g., $t = 500$), the values of aggregate output, $\bar{Y}$, sales, $\bar{S}$, and production input, $\bar{C}$, exceed their initial values due to the reduced number of firm insolvencies. The values are maximum if the tax deductibility of interest expenses is eliminated (i.e., $\mathbb{D} = 0$).

The results show that abolishing the tax deductibility of interest expenses would lead to higher government revenues; however, the government revenues are maximized if firms can deduct 25% of their interest expenses. The last column in Panel B of Table 5 shows that government's income would increase by approximately 3%, if the portion of interest expenses that are tax deductible is between 0% and 75%: 3.3% if the portion is 0% and 50%, 3.7% if the portion is 25%, and 2.7% if the portion is 75%. De Mooij (2012) argues that the disadvantage of limiting the deductibility of interest expense is the additional complexity. If this is the case, then the government's second-best decision would be not to allow firms to deduct interest expenses from their taxable income.

It is entirely conceivable that short-term effects on the government's income, T_t, are different from those in the long run (see the last column in Panel B of Table 5). Thus, we analyze the convergence of T_t if tax deductibility of interest expenses is partially or fully eliminated. Figure 6 compares the responses of firm's tax liability, T_t, across different values of the deductibility rate, $\mathbb{D}$, (i.e., $\mathbb{D} = \{0, 0.25, 0.5, 0.75, 1\}$). Figure 6a shows that the tax liability of the representative firm decreases with $\mathbb{D}$ and is the highest if $\mathbb{D} = 0$ in the short run (if $t \geqslant 42$). Afterwards, the tax liability is the highest if the portion of interest expenses that are tax deductible is 50% or 75%. The responses in Figure 6b take into account the lower default rates when interest expenses are not fully tax deductible. The default rates are adjusted in each period and are based on the geometric average of the decrease in the default rate of incumbent firms *per period* by using the number of defaults in the 2,000$^{\text{th}}$ period in Table 4. Thus, the results in Figure 6b can be interpreted as the impact of the partial or full elimination of tax deductibility of interest expenses on the government's income from all firms in the economy. Consistent with the results in Figure 6a, we find that



(a) The tax liability of a single firm.



(b) The tax liability adjusted for the increase in the number of firms due to the lower default rate.

Figure 6: Firm's tax liability, T_t, and the deductibility rate, $\mathbb{D}$. This figure compares the responses of firm's tax liability, T_t, across different values of the deductibility rate, $\mathbb{D}$.

the aggregate government's revenues from corporate income tax decrease with $\mathbb{D}$ and are the highest if $\mathbb{D} = 0$ in the short run (if $t \geqslant 50$). Unreported results show that until $t = 167$, the aggregate government's income is maximized if $\mathbb{D} = 0.25$; however, the difference is marginal compared to the case when $\mathbb{D} = 0$. Afterwards, the aggregate tax revenues are the highest if $\mathbb{D} = 0$. The results in Figures 6a and 6b are similar in the short run because firms cannot adjust their capital structures quickly and because the changes in the default rates are rather moderate in early periods.

One can argue that Figure 6a shows the worst case scenario and Figure 6b shows the best case scenario from the government's perspective because we assume that the rate of creation of new firms remain unchanged following the change of the treatment of interest expenses. However, if fewer firms default then it is likely that fewer new firms would be established due to scarce availability of labor and other resources, even whether consumers would be able to afford (if willing) to purchase products of the newly established firms. We believe that the long-term effects on the aggregate government's income would be similar to those in Figure 6b, suggesting that the aggregate government's income is higher for lower values of $\mathbb{D}$; however, the response functions would be less steep.

For robustness, we replicate the results in Panel A of Table 5 by assuming that the quadratic adjustment costs for debt, capital stock, and the number of shares outstanding (Φ_D, Φ_K, and Φ_N) are zero. The obtained results are identical to those in Panel A of Table 5 and suggest that the long-term effects do not depend on the adjustment costs. They only impact the dynamics of variables in the short term. For example, half-life of capital accumulation is approximately one year if there are no quadratic adjustment costs.

If tax deductibility of interest expenses is eliminated, the demand by firms for debt would be lower, and there would be a surplus of capital at the original interest rate in the corporate bond market. The exact impact on market interest rate is ambiguous as it depends on a number of factors. First of all, elasticities of demand and supply of debt instruments matter, as they would determine how the additional costs are split between capital suppliers and firms. As it is more likely that neither demand nor supply is perfectly elastic or inelastic, the change in the treatment of interest expenses would reduce market interest rate. However, it will be higher than the product of the original interest rate and one minus tax rate ($r(1-\tau)$). Another important factor is availability of other capital markets such as the Eurobond market, the volume of which exceeded the volume of the US bond market in 2006 (Peristiani and Santos, 2010). Capital suppliers who do not want to lend at lower rates in the US market might decide to invest their funds in the Eurobond market. Alternatively, they might even choose different assets classes, such as stocks or government bonds. Thus, it is unlikely that capital suppliers would fully absorb all the additional costs. The results presented in Panel A of Table 5 are equivalent to different scenarios for the impact on market interest rate of the elimination of tax deductibility of interest expenses. For example, if $\mathbb{D} = 0$, market interest rate is unaffected by the hypothetical change in the regulatory environment, implying that firms bear all the costs. Similarly, if $\mathbb{D} = 1$, market interest rate reduces to $r(1 - \tau)$, and capital suppliers would fully absorb all the additional costs. The scenarios with $0 < \mathbb{D} < 1$ are less extreme and more plausible. Panel A in Table 5 shows that if $\mathbb{D} \neq 1$ then in all cases, optimal leverage and shareholder value decrease.

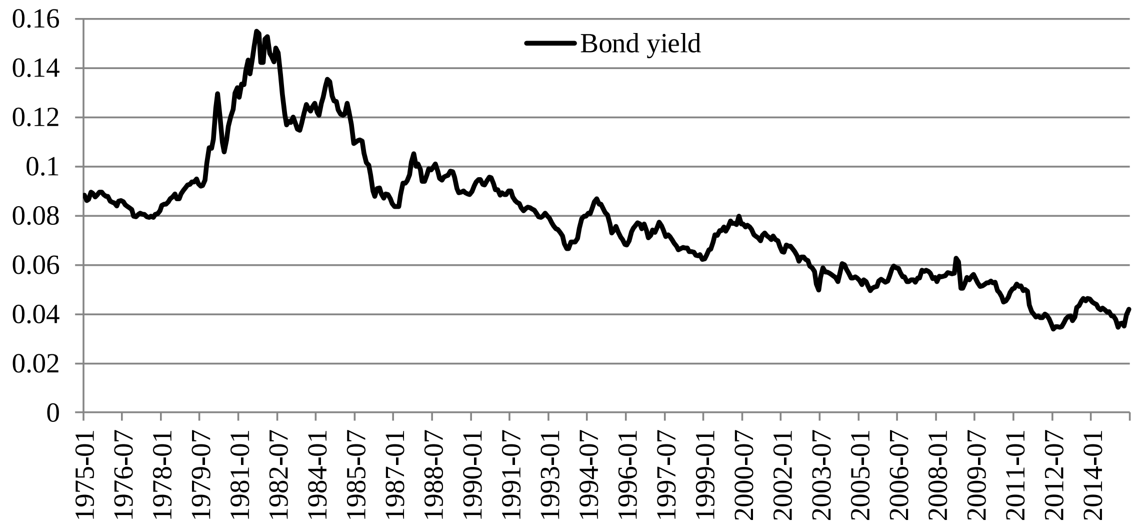
4 Conclusion

This paper analyzes the impact on shareholder wealth, firm characteristics, and public finance if tax deductibility of interest expenses is eliminated. In the analysis, we use the DSPE model developed in Karpavičius (2014b).

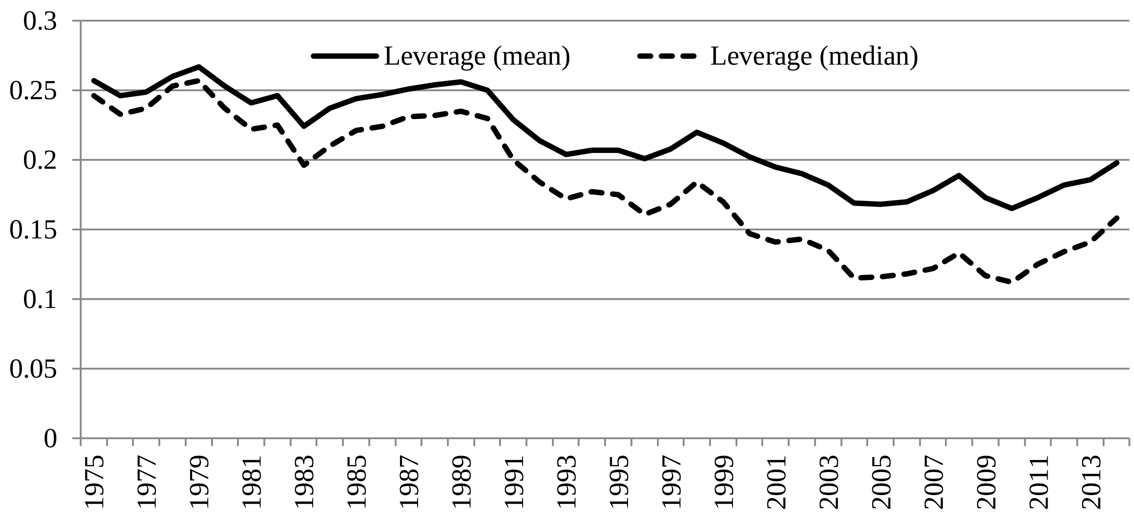
The study makes several novel contributions to the existing literature. First of all, the government's revenues from corporate income tax would increase if interest expenses are not tax deductible or if firms are allowed to only partially deduct interest expenses from the pre-tax profit. In the short run (first 10 years), the government's revenues from corporate income tax are maximized if firms are not allowed to deduct interest expenses from their tax bills. The result does not depend on the reduced number of firm insolvencies. In the long run, the optimal portion of interest expenses that are tax deductible is 0.66 if we assume that the number of firms in the economy remains constant; otherwise, the optimal deductibility ratio is between 0 and 0.25. Secondly, we show that shareholder value would decrease by 3.5%. The loss is twice as small as the value of the initial debt tax shield, due to the changes in corporate policies. Sensitivity analysis reveals that the impacts on taxes paid per firm and shareholder value are mainly driven by the subjective managerial discount factor and market interest rate; that is, the parameters that heavily affect firm leverage. Thirdly, we show that firms would adjust their operating, financing, and investment decisions if they are not allowed to deduct interest expenses from the pre-tax profit; that is, firms would become less levered, would rely less on fixed assets, and would make increased use of other production inputs. This suggests that firms would become more labor intensive. As a result, the number of defaults would be lower in this environment. Fourthly, we find that optimal firm size and optimal production output are smaller under the new tax regime. Despite the reduced number of firm insolvencies, the impact on aggregate output and employment is likely to be negative. Lastly, the model used in this paper can be further extended by other researchers to investigate how existing or proposed fiscal and monetary policy reforms could impact corporate policies, firm valuations and riskiness, and the associated macroeconomic variables.

Given the positive and negative outcomes of the potential change in the treatment of interest expenses, it is hard to say whether the reform would be beneficial for society in the long term or not. However, the current corporate bond yields are historically low (see Figure 7a). Leverage of US industrial firms decline until 2010 and afterwards starts increasing (see Figure 7b). According to the empirical literature, it takes firms 2-7 years to move halfway towards their target capital structure (see Table 8 on p. 267 in Huang and Ritter (2009)). This suggests that firms are likely to be underlevered now; that is, given the slow speed of adjustment toward target leverage, it is unlikely that firms have already reached their target capital structures. Table 3 shows that shareholder loss is higher in the steady-state environment with low interest rates. Thus, the current period of historically low corporate bond yields is probably the best time to change the treatment of interest expenses. Otherwise, firms continue increasing their debt levels in the current environment of low interest rates, and the tax reform, if implemented later, would result in higher loss to shareholders. In this case, government revenue from corporate income taxes *per firm* would increase more. However, this is not a purpose of the reform.

The limitation of this study is that the results might not hold if there are any changes in the values of calibrated parameters under the new tax regime. For example, the board of directors observe the changes in tax laws; therefore, they amend the CEO compensation



(a) The evolution of Moody's Seasoned Aaa Corporate Bond Yield.



(b) The evolution of mean and median leverage of US industrial firms.

Figure 7: The evolution of Moody's Seasoned Aaa Corporate Bond Yield and firm leverage. Source: `https://research.stlouisfed.org/fred2/series/AAA` and Compustat. Leverage is computed as the sum of long-term debt (Compustat item DLTT) and debt in current liabilities (Compustat item DLC) over *book value of assets* (Compustat item AT) and is winsorized at the tails of 0.5% and 99.5%.

package that impacts the risk and time preferences of the firm's manager. For example, if a firm's manager is provided with riskier incentives, it is likely that the manager would increase the firm's debt level.

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