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Taxation and Asset Pricing in a Production Economy

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Abstract

This paper studies the asset pricing implications of dividend and corporate income taxes in a stochastic general equilibrium model with production similar to Jermann (1998). In particular, we ask whether those two types of taxes introduce additional tax-related risk factors in the economy, and how the equity premium may be affected. We find that proportional dividend taxes introduce no additional risk factors and, as a result, have no impact on the equity premium. By contrast, corporate income taxes have strong implications for asset pricing. Key economic variables, including consumption, dividends, and investment, are more volatile in a general equilibrium model with corporate income taxes. Thus, a larger equity premium is required to compensate for the risk brought about by such taxes.

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1 Introduction

In the United States, taxes on shareholders (dividend taxes) are levied independently of the taxes on the corporations they own (corporate income taxes). Such "double taxation" of capital income has always generated interest in the respective impact of dividend and corporate income taxes on economic decisions.

In this paper, we find that those two types of capital income taxes have different implications for both the real economy and the financial market, and those differences are theoretically and quantitatively important.

Our theoretical framework generalizes Jermann's (1998) production-based asset pricing model. The model, embedded with habit formation in preferences and capital adjustment costs in production, is able to match salient features of the real business cycle and obtain a reasonable equity premium. We generalize the model by introducing dividend taxes and then corporate income taxes and identify the tax-related components of the equity premium. We calibrate the model and compare the quantitative asset pricing implications of the two types of taxes with those in a benchmark economy with no taxes.

In our framework, taxes are fully capitalized into the value of the firm. In that type of environment, proportional dividend taxation affects the marginal cost and benefit of investment symmetrically, thus not altering the firm's marginal investment decisions. Consequently, proportional dividend taxes have no impact on the equity premium.

By contrast, corporate income taxes have distinctively different implications for asset pricing. Because corporate income taxes are levied on procyclical profits, the tax liabilities increase during an expansion and decrease in a recession. For that reason, corporate income taxation is often considered an automatic stabilizer. Indeed, the procyclical corporate tax burden tends to be negatively correlated with the stochastic discount factor, thus generating a possibly negative tax-burden premium and acting as an insurance mechanism. However, we find that this potential stabilizing component of corporate income taxes is more than offset by other forces in our general equilibrium setup. Quite surprisingly, corporate income taxes turn out to be destabilizing.

The rationale for that finding is as follows. Corporate income taxes discourage investment. Compared to an economy without taxes, investment constitutes a smaller share of the aggregate output in the steady state of an economy with corporate income taxes. A lower investment-output ratio implies that investment has to respond more to a technology shock in order to smooth consumption. A strong preference for consumption smoothing, such as habit formation assumed in our model, while indispensable for obtaining a reasonable equity premium, also implies that the response of investment has to be even more pronounced. However, the presence of capital adjustment costs limits the ability of investment to smooth consumption, thus leading to more volatile consumption. We find that almost all the macro variables including consumption, investment, dividends, and the stochastic discount factor are more volatile in an economy with corporate income taxes. As a result, a larger equity premium is required to compensate for the risk brought by corporate income taxes. The increase in the equity premium dominates the insurance component attributed to the procyclical tax burden of corporate income taxes.

This paper relates to three strands of literature. It relates to the literature on production-based asset pricing models, including Jermann (1998) and Boldrin, Christiano, and Fisher (2001). Those papers do not consider any type of capital income taxes. Our paper shows that including such taxes can have a significant impact on both the real economy and asset prices.

This paper also relates to the literature on taxation and asset pricing in an endowment economy. Brennan (1970), Lai (1989) and Sialm (2007) analyze the asset pricing implications of different taxes. However, they all assume exogenously given dividends or stock prices. In our model, both dividends and stock prices are endogenously determined as a result of the endogenous responses of investment to taxation. That feature is crucial for understanding the asset pricing implications of dividend and corporate income taxes and, in particular, the implications for the equity premium. McGrattan and Prescott (2005) derive the quantitative implications of the changing tax rates on corporate distributions and corporate income on U.S. corporate valuations in a production economy. However, their deterministic model is not equipped to discuss the implications of those taxes for the equity premium.

This paper is also closely related to the literature on dividend taxes and investment. Hasset and Hubbard (2002) survey the research on the impact of dividend taxes on investment. This paper extends the analysis to the financial market.

The organization of the paper is as follows. Section 2 describes the model. Section 3 compares the asset pricing implications of the two types of taxes. In Section 4, we parameterize the model and conduct a quantitative analysis of the real and financial statistics. Section 5 concludes.

2 Model

In this section, we extend Jermann (1998) by introducing dividend and corporate income taxes. There is a continuum of infinitely-lived identical households and a representative firm owned by the households. The government levies taxes and rebates them in a lump sum to the households. The economy grows at a constant trend g.

2.1 Households

The representative household maximizes expected lifetime utility:

$$\max_{a_{t+1}, f_{t+1}, c_t} E_0 \sum_{t=0}^{\infty} \beta^t \frac{(C_t - bC_{t-1})^{1-\gamma}}{1-\gamma}$$

subject to a sequential budget constraint:

$$C_t + a_{t+1}V_t + f_{t+1}V_t^f = a_t \left[V_t + (1-\tau_D)\widehat{D}_t \right] + f_t(V_t^f + D_t^f) + W_t L_t + \psi_t. \quad (1)$$

Here β is the subjective discount factor and C_t is real consumption at time t. The coefficient γ measures the curvature of the representative agent's utility function. When $b > 0$, the utility function allows for habit persistence based on the household's own consumption in the previous period.

In the budget constraint, a_t represents shares of the representative firm held from period $t-1$ to t. V_t is the firm's value and τ_D is the proportional dividend tax rate.[2] $\widehat{D}_t$ are the firm's dividends per share after corporate income taxes. The vector f_t represents the vector of other financial assets held at period t and chosen at $t-1$, including private bonds and possibly other assets. V_t^f and D_t^f are vectors of asset prices and current period payouts, respectively. W_t represents the real wage and L_t is the labor supply at time t. Each household faces a (normalized) time constraint 1. Given that

[2] Santoro and Wei (2008) study the case of progressive dividend taxation. They find that the quantitative impact of a progressive dividend tax system on key economic variables is very similar to that of a proportional system for an income tax system as weakly progressive as in the United States.

leisure does not enter the utility function, agents will allocate their entire time endowment to productive work. All the tax revenue is rebated back to the household as a a lump-sum transfer, ψ_t.[3]

2.2 Production

The production in the economy takes place in a representative firm operating in perfectly competitive markets using a constant returns to scale technology. We assume that the representative firm does not issue new shares and finances its capital stock solely through retained earnings. In each period, the representative firm maximizes the present value of a stream of after-tax dividends

$$\max_{I_t} E_0 \sum_{t=0}^{\infty} \beta^t \frac{\Lambda_t}{\Lambda_0} \left[(1-\tau_D)\widehat{D}_t \right]. \tag{2}$$

Here $\beta^t \frac{\Lambda_t}{\Lambda_0}$ is the marginal rate of substitution of the owner, where Λ_t represents the marginal valuation of consumption (as a numeraire) at time t. The dividends after corporate income taxes, $\widehat{D}_t$, are defined as follows:

$$\widehat{D}_t = D_t - \tau_c \Pi_t \tag{3}$$

where the before-tax dividends, D_t, are given by

$$D_t = Y_t - W_t L_t - I_t. \tag{4}$$

Here I_t represents investment and $\tau_c \Pi_t$ represents the corporate income taxes on corporate profits Π_t, which is given by

$$\Pi_t = Y_t - W_t L_t. \tag{5}$$

Alternatively the after-tax dividends, $\widehat{D}_t$, can also be written as:

$$\widehat{D}_t = (1-\tau_c)\,\Pi_t - I_t. \tag{6}$$

In the theoretical analysis, we assume that investment is not exempt from corporate income taxes.[4]

[3] We assume that the government rebates all of the tax revenues to the household in a lump-sum fashion. By doing that we abstract from the income effect of the tax system and focus on the distortionary aspect of the tax system.

[4] Allowing partial expensing does not change our main results.

The output Y_t is produced using Cobb-Douglas production technology:

$$Y_t = Z_t K_t^{\alpha} L_t^{(1-\alpha)}, \tag{7}$$

where K is the capital stock, and the logarithm of the stochastic productivity level, Z_t, follows a first-order autoregressive process given by

$$z_t = \rho z_{t-1} + \sigma \xi_t. \tag{8}$$

The firm's capital stock follows an intertemporal accumulation equation with adjustment costs:

$$K_{t+1} = (1-\delta) K_t + \Phi\left(\frac{I_t}{K_t}\right) K_t, \tag{9}$$

where δ is the depreciation rate and the function $\Phi(\bullet)$ takes the following form:

$$\Phi\left(\frac{I_t}{K_t}\right) = \frac{(g+\delta)^{\eta}}{1-\eta}\left(\frac{I_t}{K_t}\right)^{1-\eta} + \frac{\eta(g+\delta)}{\eta-1}. \tag{10}$$

The capital supply is inelastic when η approaches infinity. As in Jermann (1998) and Boldrin, Christiano, and Fisher (2001), the parameters that govern the function $\Phi(\bullet)$ are set so that the model with adjustment costs has the same steady state as the model without adjustment costs and that near the steady state: $\Phi > 0$, $\Phi' > 0$, $\Phi'' < 0$.[5] The concavity of that function captures convex costs of adjustment.

2.3 Equilibrium

In equilibrium, all produced goods are either consumed or invested:

$$Y_t = C_t + I_t. \tag{11}$$

Labor is supplied inelastically at 1. Financial markets equilibrium requires that a_t equals 1 for all t and that all other assets are in zero net supply. In our model, the representative household cannot vary its labor supply or shareholdings to avoid income taxes. That allows us to isolate the impact of distortionary taxation on dynamic investment decisions.[6]

[5] The functional form implies that $\Phi\left(\frac{I}{k}\right) = g + \delta$ and $\Phi'\left(\frac{I}{K}\right) = 1$ when evaluated at the steady state.

[6] Inelastic labor supply implies that the household cannot adjust its labor supply to smooth consumption, a feature necessary for obtaining a reasonable equity premium in a Jermann-type model.

3 Asset Pricing with Taxes

In this section, we examine the asset pricing implications of dividend taxes and corporate income taxes, respectively. The economy without those two types of taxes is that of Jermann (1998). As he has shown, such a model generates reasonable magnitude of equity premium, risk-free interest rate, and equity return. It also generates an excessively volatile risk-free interest rate. Using a Jermann-type tax-free economy as our benchmark economy, we now examine how incorporating those two types of taxes might alter Jermann's (1998) results regarding the equity premium.

3.1 Asset Pricing: Proportional Dividend Taxes Only

We proceed to examine investment decisions and the corresponding implications for asset pricing in an economy with dividend taxes only. That is accomplished simply by setting τ_c to zero.

3.1.1 Investment Decisions

The first-order condition with respect to investment is:

$$\frac{1-\tau_D}{\Phi'\left(\frac{I_t}{K_t}\right)} = \beta E_t \left\{ \frac{\Lambda_{t+1}}{\Lambda_t}(1-\tau_D)\left[\alpha \frac{Y_{t+1}}{K_{t+1}} + \frac{(1-\delta)+\Phi\left(\frac{I_{t+1}}{K_{t+1}}\right)-\Phi'\left(\frac{I_{t+1}}{K_{t+1}}\right)\frac{I_{t+1}}{K_{t+1}}}{\Phi'\left(\frac{I_{t+1}}{K_{t+1}}\right)}\right]\right\}. \tag{12}$$

The left-hand side of equation (12) represents marginal q, the shadow price of the installed capital in terms of the consumption good. Compared with the benchmark economy, marginal q is lower since investment can be used as a tool to avoid a dividend tax burden. The right-hand side represents the marginal benefit of investment, which is also lower because of the dividend tax burden. The proportional dividend taxes have a symmetric impact on the marginal cost and benefit of investment, which can be canceled out on both sides of the investment equation. That is the essence of the so-called "new view", which argues that dividend taxation is not relevant for marginal investment decisions.[7]

Because taxes are rebated as a lump sum to the household, the economy with only dividend taxes shares the same equilibrium consumption, investment, capital stock, and output as an economy without taxes. As a result, those two economies share the same Λ_t and D_t, two variables instrumental for asset pricing implications.

3.1.2 Asset Pricing Implications

The equilibrium value of the firm, however, is modified by the introduction of dividend taxes. The household's first-order condition with respect to the real equity holding describes the value of the firm as the present discounted value of after-tax dividends. We add superscript D to underscore that the corresponding variables are derived in an economy with dividend taxes only.

The value of the firm is given by

$$V_t^D = \beta E_t \left\{ \frac{\Lambda_{t+1}^D}{\Lambda_t^D} \left[(1-\tau_D) D_{t+1}^D + V_{t+1}^D \right] \right\}, \tag{13}$$

where the before-tax dividends, D_{t+1}^D, are defined in equation (4).

The risk-free rate is reciprocal of the value of claim to one unit of consumption good in the next period:

$$R_{t,t+1}^{f,D} = \frac{1}{\beta E_t \left(\frac{\Lambda_{t+1}^D}{\Lambda_t^D} \right)}$$

The gross return to the firm's equity–a claim to the infinite sequence of after-tax dividends–is given by

$$R_{t,t+1}^D = \frac{V_{t+1}^D + (1-\tau_D) D_{t+1}^D}{V_t^D}, \tag{14}$$

where V_t^D is defined in equation (13).

Proposition 1 *If two economies are identical except that (i) the dividend tax rate, τ_D, is zero in the first economy but positive in the second, and (ii)*

[7] Poterba and Summers (1985) formalize the "old view" and the "new view" of dividend taxation in the public economics literature.

the difference in lump-sum transfers offsets the difference in revenues from dividend taxes, then the equilibrium outcome, asset returns, and the equity premium are the same in both economies except for the firm's value.

Proof. The stand-in firm in the two economies faces the same maximization problem except for a multiplicative factor, $1 - \tau_D$, in the objective function. Moreover, the budget constraints of households place the same constraints on consumption provided that condition (ii) holds. Labor is supplied inelastically in both economies. As a result, the two economies have the same equilibrium outcome, as demonstrated in the first-order condition with respect to investment in equation (11).
The firm's value is reduced proportionally by $(1 - \tau_D)$ in the economy with a positive dividend tax rate. Since the after-tax value and dividends of the firm are proportional to their respective before-tax counterparts, the equity return in the economy with a positive dividend tax rate is the same as that in the economy without dividend taxes. Similarly, the risk-free interest rates are determined by the equilibrium dynamics of the marginal rates of substitution, which are the same in the two economies. As a result, the equity premium are the same in the two economies. ■

Proposition 1 implies that the log-deviations of the firm's value from its steady state are the same in the two economies. The solution of the model can be approximated by a log-linear state space system. For asset pricing, that system provides us with the log-deviations of dividends and the marginal utility from their steady-state values, denoted by d^D and λ^D, as linear combinations of the log-deviations of the state variables.

Following Jermann (1998), we decompose the equity premium of a single-payout asset using log-linear approximation. The decomposition sheds light on how the fundamental factors, including taxes, determine the equity premium. The value of the single-payout asset is a claim to the after-tax dividends in the $n-$th period only. Given that the firm's value, V_t^D, is the sum of the value of claims to $n-$period payouts with n going from 1 to ∞, the equity premium will just be a composite of such strip premiums.

Proposition 2 *If two economies are identical except that (i) the dividend tax rate, τ_D, is zero in the first economy but positive in the second, and (ii) the difference in lump-sum transfers offsets the difference in revenues from dividend taxes, the following results about the equity premium hold:*

The risk premium for the asset with a single-period payout, $EPM_t^{D,n}$, can be decomposed into the following three components:

$$\begin{aligned} EPM_t^{D,n} &= \exp\left[-cov_t\left(E_{t+1}\lambda_{t+n}^D - \lambda_{t+1}^D, \lambda_{t+1}^D\right)\right] \\ &\quad \times \exp\left\{-cov_t\left[\left(1+\theta^D\right)E_{t+1}d_{t+n}^D, \lambda_{t+1}^D\right]\right\} \\ &\quad \times \exp\left[cov_t\left(\theta^D E_{t+1}d_{t+n}^D, \lambda_{t+1}^D\right)\right], \qquad (15) \\ \text{where } \theta^D &= \frac{\tau_D}{1-\tau_D}. \end{aligned}$$

After consolidating the last two terms, equation (15) becomes

$$\begin{aligned} EPM_t^{D,n} &= \exp\left[-cov_t\left(E_{t+1}\lambda_{t+n}^D - \lambda_{t+1}^D, \lambda_{t+1}^D\right)\right] \\ &\quad \times \exp\left[-cov_t\left(E_{t+1}d_{t+n}^D, \lambda_{t+1}^D\right)\right]. \qquad (16) \end{aligned}$$

Proof. See Appendix B. ■

The first term in equation (15) represents the term premium which compensates the household for the uncertainty attached to the valuation of given dividends. The second term compensates the household for risk related to uncertain before-tax dividends. The third term compensates the household for risk related to stochastic dividend tax liabilities. Since the dividend tax liabilities are proportional to before-tax dividends, the last two terms can be collapsed into one single term which represents both before- and after-tax dividend uncertainty premiums.

Because the economy with dividend taxes only has the same equilibrium outcome as an economy without taxes, the term and dividend uncertainty premiums in equation (16) are the same in those two economies.

In all, dividend taxes reduce the firm's value proportionally but have no impact on the equity return or the equity premium.

3.2 Asset Pricing: Corporate Income Taxes Only

Now we consider an economy with corporate income taxes only, which we do by setting τ_D to zero. We show that corporate income taxes have nontrivial implications for investment decisions and asset pricing.

3.2.1 Investment Decisions

The first-order condition with respect to investment is

$$\frac{1}{\Phi'\left(\frac{I_t}{K_t}\right)} = \beta E_t \left\{ \frac{\Lambda_{t+1}}{\Lambda_t} \left[\alpha(1-\tau_c)\frac{Y_{t+1}}{K_{t+1}} + \frac{(1-\delta) + \Phi\left(\frac{I_{t+1}}{K_{t+1}}\right) - \Phi'\left(\frac{I_{t+1}}{K_{t+1}}\right)\frac{I_{t+1}}{K_{t+1}}}{\Phi'\left(\frac{I_{t+1}}{K_{t+1}}\right)} \right] \right\}. \quad (17)$$

In the absence of an investment tax credit, investment is made after the corporate income taxes are paid. As compared with dividend income taxes, investment no longer has the benefit of avoiding taxes. In other words, corporate income taxes affect the marginal benefit, but not the marginal cost, of investment, which is different from what we have obtained from dividend income taxes. This leads to different investment dynamics in response to technology shocks.

The equilibrium of the economy with only corporate income taxes is different from that of the benchmark economy and, as a result, is different from the economy with dividend taxes only. In equilibrium, corporate income taxes reduce the marginal product of capital, leading to lower investment, capital stock, and output. The steady-state investment-output ratio, $(g+\delta)\,\overline{K}^{1-\alpha}$, decreases as the steady-state capital stock $\overline{K}$ decreases. Thus, the steady-state ratio of investment to output is smaller, and the ratio of consumption to output is larger, than their counterparts in the benchmark economy. The relative magnitude of those two ratios turns out to have important implications for asset pricing.

3.2.2 Asset Pricing Implications

The firm's value is the present discounted value of dividends after corporate income taxes. We add superscript C to emphasize that the corresponding variables are derived in an economy with corporate income taxes only.

$$V_t^C = \beta E_t \left\{ \frac{\Lambda_{t+1}^C}{\Lambda_t^C} \left[\left(D_{t+1}^C - \tau_c \Pi_{t+1}^C \right) + V_{t+1}^C \right] \right\}, \quad (18)$$

where D_{t+1}^C is defined accordingly as in equation (4), and $\tau_c \Pi_{t+1}^C$ is the corporate income taxes levied on profits, Π_{t+1}^C, as defined in equation (5).

The gross return to the firm's equity, a claim to the infinite sequence of dividends after corporate income taxes, is given by

$$R_{t,t+1}^{C} = \frac{V_{t+1}^{C} + \left(D_{t+1}^{C} - \tau_c \Pi_{t+1}^{C}\right)}{V_t^{C}}, \tag{19}$$

where V_t^C is defined in equation (18).

Proposition 3 *If two economies are identical except that the corporate income tax rate, τ_C, is zero in the first economy but positive in the second, then despite that the difference in lump-sum transfers offsets the difference in revenues from corporate income taxes, the equilibrium outcome, including the firm's value, are different in both economies.*

Proof. The differences in the equilibrium outcomes of the two economies follow from equations (17) and (18). In contrast to the economy with only dividend taxes, the firm's value is not reduced proportionally by corporate income taxes because of different equilibrium values of aggregate economic variables. ■

We use the same procedure to decompose the equity premium of a single-payout asset as in the economy with dividend taxes only. We obtain the following proposition.

Proposition 4 *If two economies are identical except that the corporate income tax rate, τ_C, is zero in the first economy but positive in the second, then despite that the difference in lump-sum transfers offsets the difference in revenues from corporate income taxes, the following results about the equity premium hold:*

The risk premium for the asset with a single-period payout, $EPM_t^{C,n}$, can be decomposed into the following three components:

$$\begin{aligned} EPM_t^{C,n} &= \exp\left[-cov_t\left(E_{t+1}\lambda_{t+n}^{C} - \lambda_{t+1}^{C}, \lambda_{t+1}^{C}\right)\right] \\ &\quad \times \exp\left\{-cov_t\left[\left(1+\theta^{C}\right) E_{t+1} d_{t+n}^{C}, \lambda_{t+1}^{C}\right]\right\} \\ &\quad \times \exp\left[cov_t\left(\theta^{C} E_{t+1}\pi_{t+n}^{C}, \lambda_{t+1}^{C}\right)\right], \qquad (20) \\ \text{where } \theta^{C} &= \frac{\tau_c \overline{\Pi}^{C}}{\overline{D}^{C} - \tau_c \overline{\Pi}^{C}}. \end{aligned}$$

where $\overline{\Pi}^C$ and $\overline{D}^C$ denote the steady-state values of corporate profits and before-tax dividends respectively.

Proof. See Appendix B. ■

As in the case of dividend taxes, there are also term and before-tax dividend uncertainty premiums. Despite the similarity of the functional form, the first term, $-cov_t\left(E_{t+1}\lambda^C_{t+n} - \lambda^C_{t+1}, \lambda^C_{t+1}\right)$, is quantitatively different from its counterparts in both the benchmark economy and the economy with dividend taxes only due to different equilibrium solutions.

The second and third terms together represent the dividend uncertainty premium. The second term, $-cov_t\left[\left(1+\theta^C\right)E_{t+1}d^C_{t+n}, \lambda^C_{t+1}\right]$, compensates the household for risk related to uncertain before-tax dividends. Here θ^C represents the ratio of tax liabilities to after-tax dividends. Compared with the case of dividend taxes, the risk premium is amplified by the multiplicative coefficient $1+\theta^C$.

The third term is related to the stochastic corporate income tax liabilities. When profits are high at the time of expansion, the tax liabilities are high as well. It is reasonable to expect $E_{t+1}\pi^C_{t+n}$ to be negatively correlated with λ^C_{t+1}. If that is the case, a negative risk premium arises from desirable cyclical coincidence of higher tax burden and lower marginal valuation of consumption goods. The procyclical tax burden eventually acts as payout insurance for shareholders, thus possibly reducing the risk premium. We therefore define the third term as the tax burden uncertainty premium. The size of the premium critically depends on the ratio of tax liabilities to after-tax dividends, θ^C. The higher the corporate income tax burden, the more important the tax-related premium. The second and third terms together determine the premium for the after-tax dividend uncertainty.

Compared to an economy with dividend taxes only, the corporate income tax liabilities, $\tau_c\overline{\Pi}^C$, are not proportional to before-tax dividends. As a result, the last two terms in equation (20) cannot be collapsed into one single term. Corporate income taxes introduce an additional term to the determination of the equity premium.

However, even though the tax burden uncertainty premium may be negative, the equity premium as a whole may be larger than that of the benchmark economy because of different dynamics of the stochastic discount factor and dividends, as reflected in the different values of the term premium and the modified before-tax dividend uncertainty premium.

4 Numerical Analysis

This section examines the quantitative implications of dividend and corporate income taxation on the real and financial variables. We compare the model implications of three economies: the benchmark economy without taxes, the economy with dividend taxes only, and the economy with corporate income taxes only.

We calibrate the parameters so that the model achieves the best fit with historical business cycle and return data in the benchmark economy without taxes. We then introduce, sequentially, dividend taxes and corporate income taxes into the benchmark economy and assess the impact of those taxes on the equity premium.

4.1 Calibration

The benchmark economy without taxes is the same as in Jermann (1998). We follow him in grouping the parameters into two sets. The first set contains $\{g, \delta, \alpha, \gamma, \sigma\}$, to which we assign the same values as in his model. The second set of parameters, $\{b, \eta, \beta, \rho\}$, concerns habit formation, capital adjustment costs, the pure time discount rate and the shock persistence. These parameters are particularly important for capturing salient features of the business cycle and obtaining a reasonable equity premium. We pick those four parameters so that the following four moments generated by our model simulations match those from historical business cycle and return data[8]. The moments are: (1) the standard deviation of consumption growth divided by the standard deviation of output growth, (2) the standard deviation of investment growth divided by the standard deviation of output growth, (3) the mean risk free rate, and (4) the equity premium.[9]

For the following parameter values, we can match the above four moments closely[10]:

$$b = 0.821, \beta^* = 0.992, \eta = 4.24, \rho = 0.995.$$

[8] We use Dynare second-order approximation to solve our model nonlinearly; Jermann (1998) uses a semi-nonlinear log-linear approximation approach.

[9] In order for our results to be comparable to other closely related work in the literature, all the parameters are calibrated to match the relevant data over the period from 1959 to 1985.

[10] Here β^* ,which is equal to $\beta(1+g)^{1-\gamma}$, represents the trend-adjusted time preference parameter.

All the parameter values for the benchmark calibration are summarized in Table 1.

4.1.1 Dividend and Corporate Income Tax Rates

We set the dividend tax rate to 41.1 percent, and the corporate income tax rate to 43.2 percent, close to the dividend and corporate income tax rates estimated by McGrattan and Prescott (2005)[11]. For the sake of expositional clarity, we do not take into account the depreciation allowance in the theoretical setup. In reality, investment that is used to replace the depreciated capital stock is exempt from corporate income taxation, and some fraction of investment is exempt from taxes as part of investment tax credit. We take those into account in computing the statistics of the economy with corporate income taxes.[12] The depreciation allowance narrows the tax base and, to some extent, moderates the impact of corporate income taxation on the economy. We set the fiscal depreciation rate to be the same as the economic rate. We also set the investment tax credit to 2 percent. Even after accounting for depreciation allowance, the statistics are still markedly different from those in an economy without corporate income taxes.

4.2 The Mechanism: How Taxes Affect Asset Pricing

This section presents the real and financial statistics generated from the model, and explains the mechanism through which taxes impact both dynamic responses of aggregate economic variables and asset pricing. We start with the description of the deterministic steady state of the three economies – the benchmark economy without taxes, the economy with dividend taxes only, and the economy with corporate income taxes only. The differences in the steady state of those three economies are important in explaining the differences in dynamic responses under alternative tax environments.

[11] McGrattan and Prescott estimates for the tax rates are based on the data in the 1960s. Alternative estimation, such as Gravelle (2004), suggest that those estimates are close to the average over the period from 1959 to 1985.

[12] The details are contained in Appendix A.

4.2.1 The Deterministic Steady State

Table 2 summarizes the steady-state values of real and financial variables for the three economies. Economy I (dividend taxes only) and the benchmark economy share the same steady state in terms of real economy variables and asset returns. That is true for any dividend tax rates as long as we assume that the tax revenues are rebated to the households in a lump sum. Due to the absence of uncertainty, the equity premiums are zero in the steady state. The market value of the firm in Economy I is $(1 - \tau_D)$ times lower than that of the benchmark economy due to dividend taxation.

The steady state in Economy II (corporate income taxes only), however, features a lower capital stock level and lower investment-output ratio. The market value of the firm in Economy II also reflects a larger adverse impact on investment when investment is made out of after-tax profits.

4.2.2 Analysis of Impulse Responses

This section analyzes the impulse responses of key economic variables in the three economies with different tax environment.

Figure 1 displays the impulse responses of consumption and investment to a 1 percent positive technology shock in the three economies. The left column compares the impulse responses of those two variables in an economy with dividend taxes (Economy I) with those in the benchmark economy, and the right column displays the comparison between the economy with corporate income taxes (Economy II) and the benchmark economy.

The impulse responses are the same in the benchmark economy and Economy I, as shown in the panels in the left column of Figure 1. That result is consistent with our earlier finding that proportional dividend taxation has no impact on log-deviations of key economic variables from their steady state values.

By contrast, the introduction of corporate income taxes into the benchmark economy alters the impulse responses of consumption and investment, as shown in the right column of Figure 1. Both consumption and investment respond more strongly in response to a given technology shock. That result appears to be counterintuitive from a partial equilibrium perspective, where the built-in procyclicality of corporate income taxes smooths the after-tax dividend payouts. For that reason, corporate income taxes are usually considered an automatic stabilizer of the economy.

However, the stabilizing role of corporate income taxes is due to the absence of the general equilibrium feedback of investment decisions on the discount rate. In a general equilibrium framework, investment decisions have an indirect impact on the stochastic discount factor through the general equilibrium interaction of consumption and investment.

Two mechanisms are at work. On the one hand, in response to a positive technology shock, procyclical corporate income tax liabilities discourage investment. On the other hand, a weaker investment response due to corporate taxes would imply a larger increase in current consumption, thus leading to a higher valuation of future consumption goods, which ultimately encourages investment.

We find that in an economy with habit formation, the encouragement mechanism dominates, resulting in a stronger response of investment to technology shocks. The rationale is as follows. Investment constitutes a lower fraction of output in the steady state of an economy with corporate income taxes. A lower investment-output ratio implies that investment has to respond more strongly to a given technology shock in order to smooth consumption. The investment responses are even more pronounced under the assumption of habit persistence. However, the presence of capital adjustment costs limits the ability of investment to smooth consumption, thus leading to higher volatility in both consumption and investment.[13]

Figure 2 displays the impulse responses of before– and after-tax dividends, and the marginal utility of consumption. In both economies with taxes, the impulse responses of before-tax dividends are countercyclical in the initial periods to accommodate procyclical investment and become procyclical later because of rising capital income in response to a positive technology shock. In an economy with corporate income taxes, before-tax dividends are more procyclical; The impact of investment on before-tax dividends is smaller because of the smaller investment-output ratio. Thus, despite stronger responses of investment to the technology shock, the initial countercyclical responses are not as pronounced as in the benchmark economy.

For the economy with corporate income taxes, however, it is the procyclicality of the after-tax dividends that matters for the payout uncertainty premium, represented by the multiplication of the second and third terms

[13]We conduct sensitivity analyses by altering the values of habit formation and capital adjustment cost parameters. As long as we maintain the assumption of habit formation, corporate income taxes are destabilizing because of the mechanism described in the text. The results of the sensitivity analysis are available from the authors upon request.

in equation (20). As shown in Figure 2, the after-tax dividends are not as procyclical when corporate income taxes are present. Because investment is made after corporate income taxes are paid, the movement of investment has a larger influence on after-tax dividends than on its before-tax counterpart. As a result, more procyclical investment leads to more countercyclical after-tax dividends in the initial periods. The after-tax dividends turn out to be more volatile as the before-tax dividends become more volatile because of the stronger responses of investment to technology shocks.

In the bottom right panel of Figure 2, the marginal valuation of the consumption good, λ, responds more negatively to a positive technology shock, consistent with stronger positive responses of consumption. The resulting increase in the volatility of the stochastic discount factor has strong implications for asset prices, as is discussed later.

In all, we find that key economic variables, including consumption, investment, before- and after-tax dividends, and the marginal valuation of consumption good λ respond more strongly to positive technology shocks in an economy with corporate income taxes.

4.2.3 Real and Financial Statistics

Table 3 reports the moments of the real and financial variables in the benchmark economy and in the two economies with alternative tax environments. The first two columns reflect the relative volatility of consumption and investment growth relative to that of output. The third column represents the risk free interest rate. The fourth and fifth columns represent the equity premium and the premium of the return on a long-term consol over the risk free interest rate. The sixth and seventh columns represent the standard deviations of the risk free interest rate and real equity return.

Our benchmark economy is similar to that of Jermann (1998). The volatility of consumption and investment relative to that of output, the average risk-free rate, the equity premium, and the standard deviation of the equity return in this benchmark economy are very close to those observed in the data.

However, our model also inherits two major shortcomings of the type of production economy in Jermann (1998), namely the overly volatile interest rates and the consequent high bond premium to compensate for real interest rate risk. The fact that models like Jermann (1998) and Boldrin, Christiano and Fisher (2001) do poorly on risk-free rate volatility is well known. Despite those shortcomings, Jermann's model is a good benchmark model to start with, given the difficulty of accounting for stylized facts on both business cycles and asset market. Since the main goal of our analysis is to examine the asset pricing implications of dividend and corporate income taxes in contrast to an economy without taxes, we choose instead to focus on comparing the benchmark economy with the economies under alternative tax environments.

In Economy I (dividend taxes only), the moments of the real and financial variables are the same as in the benchmark case, as reflected in their identical impulse responses.

In Economy II (corporate taxes only), investment growth is 3.11 times more volatile than output growth, compared to the corresponding value of 2.65 in the benchmark economy. Consumption is now more volatile as well. As explained in the previous section, the marginal rates of substitution become more volatile compared with those in the benchmark economy, which is reflected in a lower risk-free interest rate. The equity premium is now 7.86 percent, an increase from an equity premium of 6.18 percent in the benchmark economy. That increase has mostly come from the increase in the compensation for the volatility of the marginal rates of substitution, as reflected in a higher long-term bond premium.

In terms of the decomposition of the equity premium in equation (20), the positive term and before-tax payout uncertainty premiums dominate the negative tax burden uncertainty premium. In other words, even though there is an insurance (stabilization) component due to the presence of corporate income taxes, the more volatile dividends and stochastic discount factor lead to a higher equity premium. The standard deviation of both the risk-free interest rate and the equity return are higher in Economy II, reflecting more volatile consumption and investment in an economy with corporate income taxes.

5 Conclusion

This paper studies the asset pricing implications of dividend and corporate income taxes in a stochastic general equilibrium model with production *a la* Jermann (1998). In particular, we examine whether those two types of taxes introduce additional tax-related risk factors in the economy, and how the equity premium may be affected. We find that proportional dividend taxes reduce the firm value proportionally, but have no impact on the equity premium. This result comes from the fact that proportional dividend taxes affect the marginal cost and benefit of investment symmetrically and therefore not affect any marginal decisions.

Corporate income taxes, by contrast, have strong implications in terms of both investment decisions and asset pricing. Corporate income taxes reduce the marginal benefit of investment, thus discouraging investment. The firm's value falls more than proportionally because of lower level of capital stock. Corporate income taxes affect not only the level of the key economic variables but also their volatilities. Key economic variables, including consumption, dividends, and investment, are more volatile in a general equilibrium model with corporate income taxes. Thus, a larger equity premium is required to compensate for the risk brought by this type of taxes.

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Appendix

A. Corporate Income Taxes with Depreciation Allowance and Investment Tax Credit

Production in the economy takes place in a representative firm operating in perfectly competitive markets using a constant returns to scale technology. We assume that the representative firm does not issue new shares and finances its capital stock solely through retained earnings. Each period the representative firm maximizes the present value of a stream of after-tax dividends:

$$\max_{I_t} E_0 \sum_{t=0}^{\infty} \left\{ \beta^t \frac{\Lambda_t}{\Lambda_0} \left[(1-\tau_D) \widehat{D}_t \right] \right\} \tag{21}$$

where the post–corporate-income-tax dividends, $\widehat{D}_t$, are given by:

$$\widehat{D}_t = D_t - \tau_c \left(\Pi_t - \delta^f K_t - \zeta I_t \right). \tag{22}$$

Here we take into account the depreciation allowance with a fiscal depreciation rate of δ^f, and investment Such depreciation allowance narrows the tax base of corporate income taxes. The fiscal depreciation rate δ^f can be different from the economic depreciation rate δ.

The first-order condition for investment is now given by:

$$\begin{aligned} \frac{1-\zeta\tau_c}{\Phi'\left(\frac{I_t}{K_t}\right)} &= \beta E_0 \left\{ \frac{\Lambda_{t+1}}{\Lambda_t} \left[\alpha(1-\tau_c) \frac{Y_{t+1}}{K_{t+1}} + \tau_c \delta^f \right.\right. \\ &\left.\left. + \frac{(1-\zeta\tau_c) \left[(1-\delta) + \Phi\left(\frac{I_{t+1}}{K_{t+1}}\right) - \Phi'\left(\frac{I_{t+1}}{K_{t+1}}\right) \frac{I_{t+1}}{K_{t+1}} \right]}{\Phi'\left(\frac{I_{t+1}}{K_{t+1}}\right)} \right] \right\} \end{aligned} \tag{23}$$

In the quantitative analysis of Section 4, we set δ^f to the benchmark value of δ, and the investment immediate expensing parameter, ζ, is set to 0.02.

B. The Derivation of Equity Premium with Taxes

Here we prove Propositions 4, which decomposes the strip premium in an economy with corporate income taxes. Proposition 2 can be derived using the same procedure.

First, we consider a claim to the after-tax dividends in the n-th period only. The value of that asset, $V_t^{C,t+n}$, is approximated by

$$V_t^{C,t+n} = \overline{V}^{C,n} E_t \left[\exp \left(\lambda_{t+n}^C + \left(1+\theta^C\right) d_{t+n}^C - \theta^C \pi_{t+n}^C - \lambda_t^C \right) \right], \quad (24)$$

$$\theta^C = \frac{\tau_c \overline{\Pi}^C}{\overline{D}^C - \tau_c \overline{\Pi}^C} \quad (25)$$

where the lower case letters are the log-linear deviations of the corresponding variables from their steady-state values, and $\overline{V}^{C,n}$ is the steady-state value of the asset. The steady-state values are denoted with an upper bar above the corresponding variables.

We further define the one-period holding return of this asset as:

$$R_{t,t+1} \left[\widehat{D}_{t+n} \right] = \frac{V_{t+1}^{C,t+n}}{V_t^{C,t+n}}. \quad (26)$$

In order to solve for the conditional expected return $E_t \left(R_{t,t+1} \left[\widehat{D}_{t+n} \right] \right)$, we first take the expectation of $V_{t+1}^{C,t+n}$ at time t. Under the assumption of lognormality, the expression of the conditional expected return can be greatly simplified. The value asset of an n-th period asset $V_{t+1}^{C,t+n}$ can be rewritten as:

$$\begin{aligned} V_{t+1}^{C,t+n} = \overline{V}^{C,n} \exp \Big\{ & E_{t+1} \left[\lambda_{t+n}^C + \left(1+\theta^C\right) d_{t+n}^C - \theta^C \pi_{t+n}^C - \lambda_t^C \right] \\ & + \frac{1}{2} Var_{t+1} \left[\lambda_{t+n}^C + \left(1+\theta^C\right) d_{t+n}^C - \theta^C \pi_{t+n}^C \right] \Big\} \end{aligned} \quad (27)$$

We then take the conditional expectation of $V_{t+1}^{C,t+n}$, as expressed in the previous equation (27). After some manipulations, we get that:

$$\begin{aligned} E_t \left(R_{t,t+1} \left[\widehat{D}_{t+n} \right] \right) = \; & R_{t,t+1} \left[\mathbf{1}_{t+1} \right] \\ & \times \exp \left[-cov_t \left(E_{t+1} \lambda_{t+n}^C - \lambda_{t+1}^C, \lambda_{t+1}^C \right) \right] \\ & \times \exp \left\{ -cov_t \left[\left(1+\theta^C\right) E_{t+1} d_{t+n}^C, \lambda_{t+1}^C \right] \right\} \\ & \times \exp \left[cov_t \left(\theta^C E_{t+1} \pi_{t+n}^C, \lambda_{t+1}^C \right) \right], \end{aligned}$$

Here $R_{t,t+1}[\mathbf{1}_{t+1}]$ represents the risk-free rate computed under the assumption of lognormality. The derivations above follow the descriptions in Jermann (1994) closely.

Table 1 Benchmark Parameterization

	Parameters			
Production	g	δ	α	η
	0.005	0.025	0.36	4.24
Preferences	$\beta\,(1+g)^{1-\gamma}$	γ	b	
	0.992	5	0.821	
Technology Process	ρ	σ		
	0.995	0.01		

Table 2 Comparison of the Deterministic Steady State

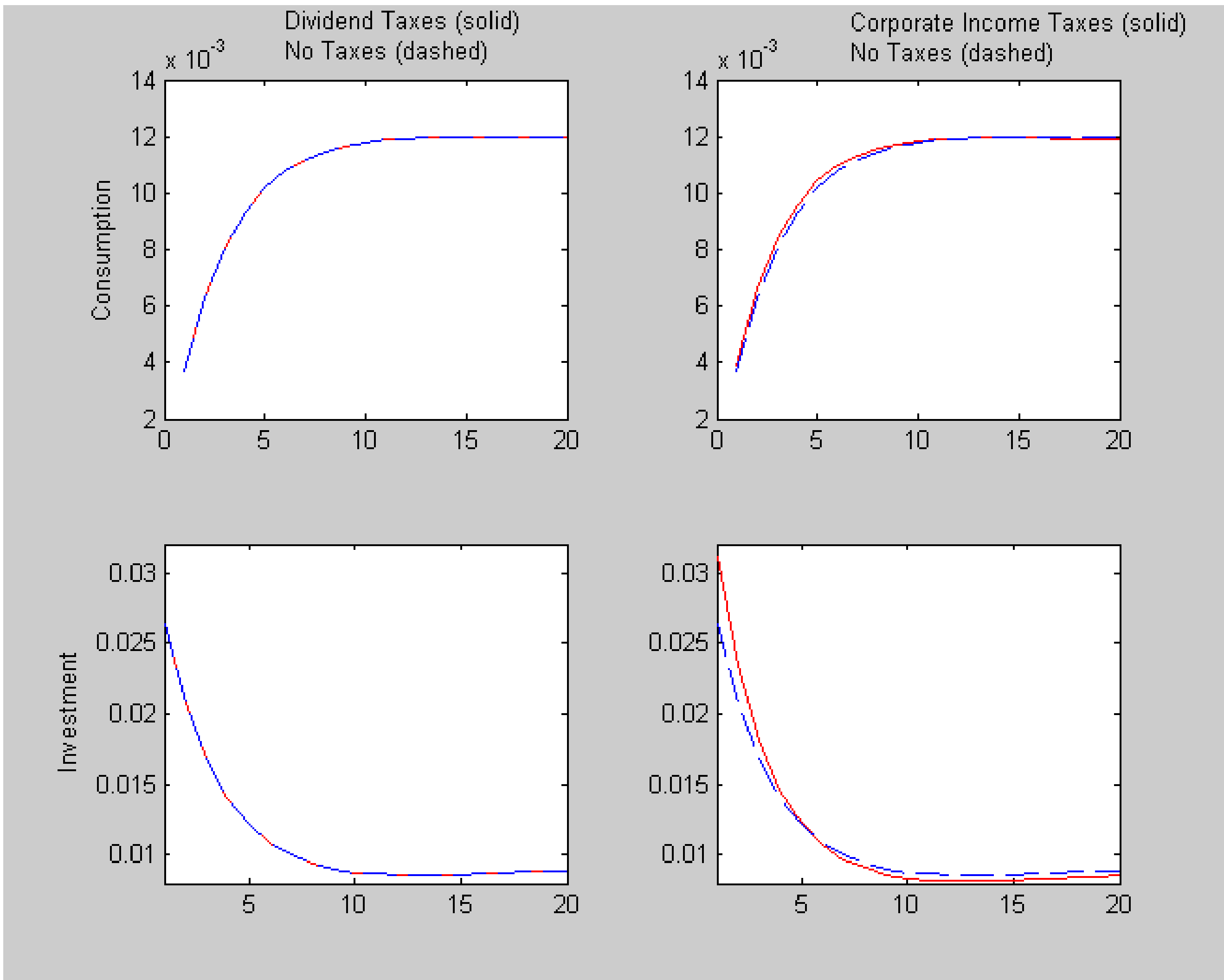
	τ_D	τ_C	$\frac{C}{Y}$	$\frac{I}{Y}$	R^f	R	V
The Benchmark Economy	0	0	71	29	5.12	5.12	34.0
Economy I: Dividend Taxes Only	41.1	0	71	29	5.12	5.12	20.0
Economy II: Corporate Income Taxes Only	0	43.2	77	23	5.12	5.12	24.0

Table 3 Comparison of the Real and Financial Statistics

	$\frac{\sigma_{\triangle C}}{\sigma_{\triangle Y}}$	$\frac{\sigma_{\triangle I}}{\sigma_{\triangle Y}}$	$E\left(R^f\right)$	EPM	BPM	σ_{R^f}	σ_R
The Benchmark Economy	0.51	2.65	0.80	6.18	5.38	12.95	16.98
Economy I: Dividend Taxes Only	0.51	2.65	0.80	6.18	5.38	12.95	16.98
Economy II: Corporate Taxes Only	0.53	3.11	-0.12	7.86	7.12	16.43	19.55
Data	0.51	2.65	0.80	6.18	1.70	5.67	16.54

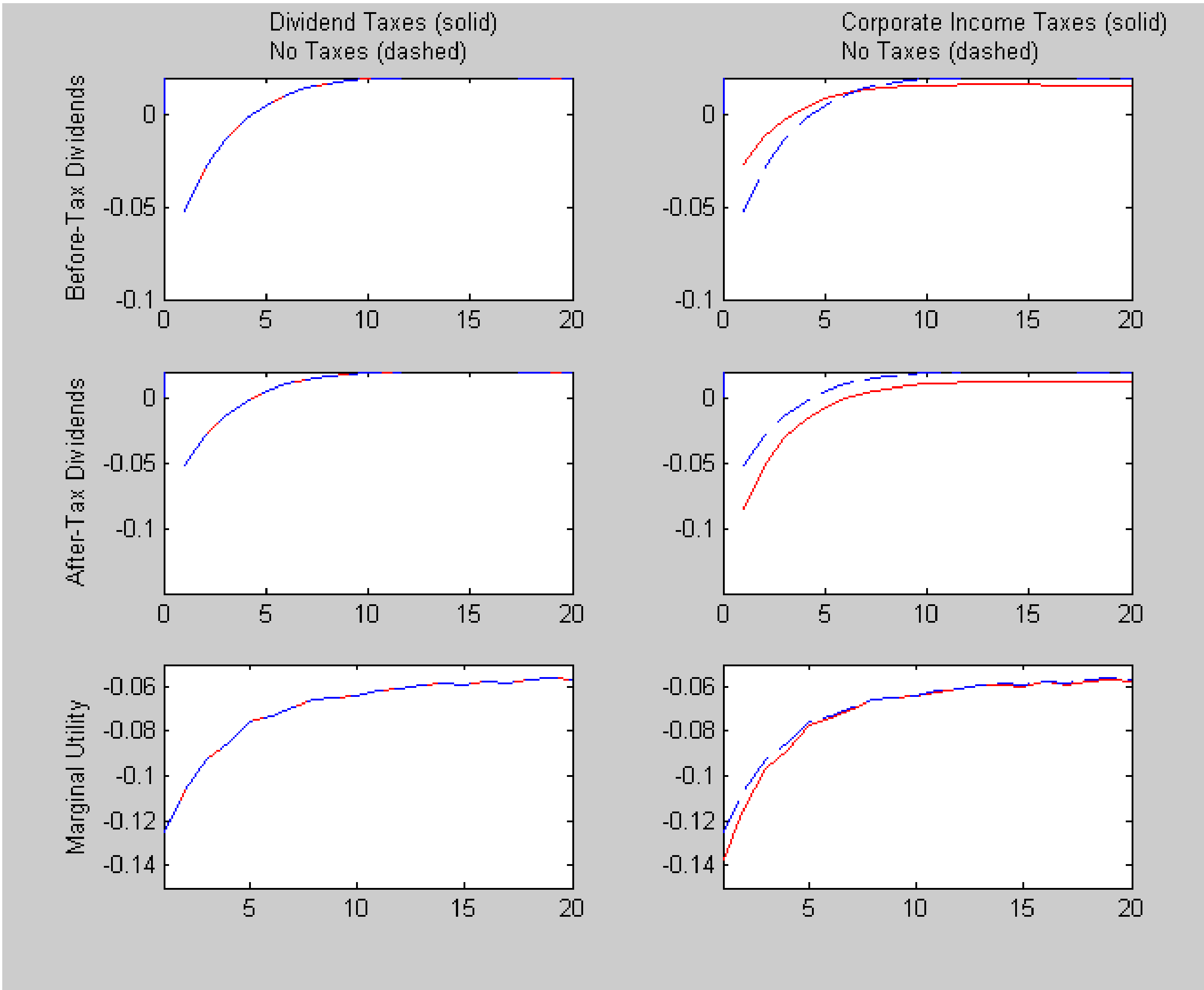
EPM represents the equity premium, and BPM represents the long-term bond risk premium. σ_{R^f} and σ_R represent the standard deviation of the risk free rate and the equity return respectively. The statistics are computed from 10,000 simulations. The data are from Jerrmann (1998).

Figure 1: Comparison of Impulse Responses - I



The impulse is a 1% positive productive technology shock, the responses are in % deviation from steady state values

Figure 2: Comparison of Impulse Responses - II



The impulse is a 1% positive productive technology shock, the responses are in % deviation from steady state values