Dynamic Effects of Permanent and Temporary Dividend Tax Policies on Corporate Investment and Financial Policies[*]

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Abstract

We develop a neoclassical partial equilibrium model to analyze the dynamic effects of permanent and temporary dividend tax policies on corporate investment and financing decisions. Facing a tax system with corporate and personal income taxes, dividend tax and capital gains tax, a firm decides how much to invest and how to finance investment by equity or debt subject to collateral constraints and capital adjustment costs. We characterize steady state and simulate transitional dynamics following tax policy changes. We find the following novel results: First, both temporary and permanent dividend tax changes do not have long-run effects on a firm's capital formation, but have short-run effects on its investment and financial policies. Second, an anticipated temporary dividend tax cut has a short-run effect of lowering investment, similar to an anticipated permanent dividend tax increase. Third, a firm responds asymmetrically to an anticipated permanent dividend tax increase versus an anticipated permanent dividend tax cut due to the collateral constraint. Finally, in anticipation of future tax changes, the firm engages in tax arbitrage by borrowing or saving in order to transfer corporate earnings across time so as to reduce shareholder's tax burden.

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1 Introduction

Dividends are taxed at both the corporate and personal levels in the United States. This double taxation of dividends may distort investment efficiency. Partly motivated by this consideration, the Bush administration enacted the Jobs and Growth Tax Relief Reconciliation Act in 2003. This act reduced the tax rates on dividends and capital gains and eliminated the wedge between these two tax rates through 2008. These tax cuts were extended through 2010 and may be repealed in the future. This naturally raises the following question: What are the dynamic effects of temporary and permanent dividend tax policies on corporate investment and financial policies?

Economists disagree about the economic effects of dividend taxation on investment. Two views are prevalent.[1] The key consideration is the marginal source of investment finance. Under the "new view," firms use internal funds and do not raise new equity. Thus, dividend taxation does not influence the user cost of capital and investment (Auerbach (1979a,b), Bradford (1981), and King (1977)). Under the "traditional view," the marginal source is new equity and the return to investment is used to pay dividends. A dividend tax cut reduces the user cost of capital and hence raises investment. Existing empirical evidence on these two views is inconclusive. For example, Poterba and Summers (1983, 1985) find evidence supporting the traditional view using data from the United Kingdom. Desai and Goolsbee (2004) find evidence supporting the new view using data from the United States. Auerbach and Hassett (2002) find that in the U.S. data there are firms behaving according to the new view and firms behaving according to the traditional view.

A limitation of the existing theoretical literature is that it deals mostly with permanent changes in dividend taxes. However, in reality many tax changes may not be permanent, or they may not be perceived as permanent. Our paper fills this gap by analyzing both temporary and permanent dividend tax changes. Building on the existing literature, we develop a dynamic partial equilibrium model of corporate investment and financing decisions in the tradition of

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[1] There is the third "tax irrelevance" view proposed by Miller and Scholes (1978, 1982). According to this view, marginal investors do not face differential taxes on dividends and capital gains. Thus, dividend taxation has no effect on investment. This view has been generally rejected by empirical evidence. See Auerbach (2002), Gordon and Dietz (2006), or Poterba and Summers (1985) for an exposition of the three views.

Hall and Jorgenson (1967) and Jorgenson (1963).[2] We consider a tax system with corporate and personal income taxes, dividend tax and capital gains tax. A firm decides how much to invest and how to finance investment subject to collateral constraints and capital adjustment costs. When making financing decisions, the firm decides whether to use internal funds, debt, or external equity. The firm can borrow or save and may be in one of three finance regimes – dividend distribution, equity issuance, and liquidity constrained. The firm is forward-looking and has perfect foresight about future course of tax policies, when making investment and financing decisions.

We focus on the dynamic effects of dividend tax policies only, holding other taxes fixed. We characterize the steady state and simulate transitional dynamics following temporary and permanent changes in dividend tax policies. Our analysis demonstrates that the dynamic effects of dividend tax policies depend on whether the firm is mature or young. A mature firm does not respond to an unanticipated permanent dividend tax change, but responds to a temporary dividend tax change only in the short run by reducing investment. By contrast, a young growth firm responds to both types of tax change during its transition to a steady state. But these tax changes have no long-run effects on both mature and growth firms's capital formation. We also find that in response to a future anticipated permanent dividend tax cut, a mature firm engages in intertemporal tax arbitrage in order to reduce shareholders' tax burden. In particular, the firm reduces dividend payments, saves corporate income, and increases investment before the time of the dividend tax cut. At the time of the tax cut, the firm reduces investment and raises borrowing. In addition, equity value and dividend payments surge. We also find that this firm does not respond symmetrically to dividend tax changes because of capital market imperfections.

Our analysis is in the spirit of Abel (1982), Auerbach (1989), Auerbach and Hines (1987), and Auerbach and Kotlikoff (1987), who analyze the dynamic effects of permanent and temporary corporate tax changes. Existing literature lacks a similar analysis of dividend tax policies. Such an analysis is necessary and important because we show that dividend taxation has some very different impacts on firms' investment and financing decisions than other taxes. Recently,

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[2] Our model is also related to the literature on investment-cash flow sensitivity, e.g., Fazzari et al. (1988), Gilchrist and Himmelberg (1995, 1998), and Gomes (2001). This literature does not consider issues of tax policy analyzed in our paper.

Gourio and Miao (2008), Korinek and Stiglitz (2006), and McGrattan and Prescott (2005) have considered related theoretical issues.[3] Gourio and Miao study the long-run effects of a permanent dividend tax cut on aggregate capital accumulation in a general equilibrium model with firm heterogeneity in idiosyncratic productivity shocks. They do not consider temporary tax changes and transitional dynamics. Korinek and Stiglitz derive some similar results found in this paper. They do not consider capital adjustment costs, debt financing, and taxes on corporate income, capital gains, and interest income, that are important for firm's investment and financial policies. In a general equilibrium growth model, McGrattan and Prescott (2005) show that permanent changes in the effective marginal tax rate on corporate distributions affect equity value, but not the capital-output ratio. This result is consistent with our result on the long-run effects of permanent dividend tax changes. As in Bradford (1981), they do not distinguish between dividends and repurchases by assuming that a flat tax rate is applied to the total corporate distributions.

The remainder of the paper proceeds as follows: Section 2 sets up the model. Section 3 characterizes the firm's investment and financial policies and analyzes steady state. Section 4 simulates transitional dynamics following dividend tax changes. Section 5 concludes. Proofs and numerical methods are relegated to the appendices.

2 The Model

We consider a single firm's decision problem in a partial equilibrium model. In order to analyze transitional dynamics following a tax change in the simplest possible way, we consider a deterministic environment as in the macroeconomics and public finance literature (e.g., Abel (1982), Auerbach (1979b), Auerbach and Kotlikoff (1987), and Ljungqvist and Sargent (2004, Chapter 11)).[4] In this environment, time is discrete and the horizon is infinite. We denote time by $t = 1, 2, ...$ We start with describing the firm's technology and its financing choice, and then describe tax system. We finally formulate the firm's decision problem.

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[3] Like our paper, Sinn (1991) also lays out a model of the effects of dividend taxation in which firms go through different phases from immature to mature. But he does not study dynamic effects of tax changes.

[4] In the present paper, we do not consider general equilibrium and focus on firm behavior only. We do not study household behavior and government budget deficits. See Gourio and Miao (2006) for a general equilibrium analysis of dividend taxation.

2.1 Technology and Financing

The firm combines labor and capital to produce output. Instead of explicitly modeling production function and market environment, we begin by specifying operating profits as a function $\pi(k)$ of capital input k. This function may be derived after solving the simple static labor choice given a constant wage rate. We assume $\pi(k)$ is differentiable, increasing, concave, and satisfies the usual Inada condition:

$$\pi(0) = 0, \ \lim_{k \to 0} \pi'(k) = \infty, \ \lim_{k \to \infty} \pi'(k) = 0.$$

Concavity of π may reflect a decreasing returns to scale production function or monopoly power (e.g., Abel and Eberly (1999) and Cooper and Ejarque (2003)).

The firm may make investment x_t to increase its capital stock so that the capital stock in period t satisfies

$$k_t = (1 - \delta) k_{t-1} + x_t, \ k_0 \text{ given}, \tag{1}$$

where $\delta \in (0, 1)$ denotes the depreciation rate. Investment incurs adjustment costs. Following many papers in the empirical investment literature, we assume the following quadratic adjustment cost function:

$$C(x_t, k_{t-1}) = \frac{\psi}{2} \left(\frac{x_t}{k_{t-1}} - \delta \right)^2 k_{t-1}, \tag{2}$$

where $\psi > 0$.

The firm has four potential sources of funds to finance investment: external equity, one-period bond, internal savings, and current cash flows. Many researchers argue that external financing is costly due to transactions costs and asymmetric information. In this paper, we do not consider such costs associated with external equity financing.[5] We restrict attention to costs associated with debt financing only. Without these costs, the firm would issue debt as much as possible because debt has a tax advantage in that interest payments are tax deductible. In our deterministic model, we may simply assume that the firm can borrow and lend at a constant pretax interest rate r. Because of the enforcement problem, the lender imposes a collateral

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[5] We can incorporate such costs using the approach of Gomes (2001) and Hennessy and Whited (2005). This modeling does not add any new insights into our tax policy analysis.

constraint requiring the liquidation value of capital be sufficient to repay the loan, similar to Kiyotaki and Moore (1997). That is, the debt level b_t must satisfy

$$(1+r)\, b_t \leq \eta k_t, \;\; b_0 \text{ given}, \tag{3}$$

where $\eta \in (0,1)$ may represent the sale price of capital. Note that we allow the firm to save. We interpret negative value of b_t as corporate savings.

There are alternative ways of modeling debt in this setup. For instance, we could have an exogenous upper bound $\bar{b}$ for debt, or we could assume that the interest cost is an exogenous increasing function of leverage. The choice of how to model financial constraint is not of primary importance for our results. Also, unlike Hennessy and Whited (2005), Miao (2005), and many other papers following the tradeoff theory of debt in corporate finance, we do not consider default in our deterministic model. Introducing default decision will significantly complicate our analysis.

2.2 Tax System

We consider a tax system with corporate and personal taxes. For simplicity, we assume that both corporations and individuals face flat taxes. Because we focus on the changes of the dividend taxes only, we assume that other taxes are constant over time. Specifically, in period t, shareholders of the firm face tax rates τ_t^d on dividends, τ^i on labor and interest income, and τ^g on accrued capital gains.[6] We assume $\tau_t^d \geq \tau^g$ for all t, which is consistent with the U.S. tax system. The firm faces corporate income tax rate τ^c in all periods.

Under the U.S. tax system, interest payments on debt are tax deductible and depreciation has tax allowances. Assume the depreciation expense is equal to the economic depreciation δk. We treat the adjustment cost as the cost associated with retraining of workers, which is tax deductible. Thus, corporate taxable income y equals operating profits, less adjustment cost, less economic depreciation, and less interest payments:

$$y\,(k, x, b) = \pi\,(k) - C\,(x, k) - \delta k - rb. \tag{4}$$

Note that if b takes a negative value, then it is interpreted as savings and $-rb$ is interest income.

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[6] In reality, capital gains are taxed on realization rather than on accrual. Incorporating a realization-based capital gains tax would complicate our analysis and is not important in this context.

2.3 The Firm's Decision Problem

In order to formulate the firm's decision problem, we first derive the firm's equity valuation equation. Let the ex-dividend equity value be P_t at date t. The following no arbitrage equation must hold:

$$r_{t+1}^e = \frac{1}{P_t}\left[\left(1-\tau_{t+1}^d\right)d_{t+1} + \left(1-\tau^g\right)\left(P_{t+1}^0 - P_t\right)\right], \tag{5}$$

where r_{t+1}^e denotes the required return to equity between period t and period $t+1$, d_{t+1} is the firm's period $t+1$ dividend payment, and P_{t+1}^0 is the period $t+1$ value of shares outstanding in period t. The firm may issue new shares or repurchase old shares. Thus, equity value at date $t+1$ satisfies $P_{t+1} = P_{t+1}^0 + s_{t+1}$, where s_{t+1} denotes the value of shares newly issued (repurchases) if $s_{t+1} \geq (<)\, 0$.

Because we assume there is no uncertainty, there is no risk premium for equity. Thus, no arbitrage implies that the required return to equity is equal to the after tax interest rate: $r_{t+1}^e = \left(1-\tau^i\right) r$. It follows that we can rewrite equation (5) as

$$P_t\left[\left(1-\tau^i\right) r + 1 - \tau^g\right] = \left(1-\tau_{t+1}^d\right) d_{t+1} + \left(1-\tau^g\right)\left(P_{t+1} - s_{t+1}\right). \tag{6}$$

We define the cum-dividend equity value V_{t+1} as

$$V_{t+1} = P_{t+1} - s_{t+1} + \frac{1-\tau_{t+1}^d}{1-\tau^g} d_{t+1}. \tag{7}$$

Using (6), we can then show that

$$V_t = \frac{1-\tau_t^d}{1-\tau^g} d_t - s_t + \frac{V_{t+1}}{1 + r\left(1-\tau^i\right)/\left(1-\tau^g\right)}. \tag{8}$$

We may solve this equation forward and impose a no bubble condition to obtain equity value in any period $t_0 \geq 1$:

$$\sum_{t=t_0}^{\infty}\left(\frac{1}{1 + r\left(1-\tau^i\right)/\left(1-\tau^g\right)}\right)^{t-t_0}\left(\frac{1-\tau_t^d}{1-\tau^g} d_t - s_t\right). \tag{9}$$

This equation implies that the discount rate for equity is given by $r\left(1-\tau^i\right)/\left(1-\tau^g\right)$.

Assume that management acts in the best interest of shareholders. Thus, the firm's problem is to choose investment and financial policies (x, k, b, s, d) so as to maximize its equity value (9) subject to the capital accumulation equation (1), the collateral constraint (3), and the following constraints:

$$d_t + x_t + (1 + r)\, b_{t-1} = \pi\left(k_{t-1}\right) - C\left(x_t, k_{t-1}\right) - \tau^c y\left(k_{t-1}, x_t, b_{t-1}\right) + b_t + s_t, \tag{10}$$

$$d_t \geq 0, \tag{11}$$

$$s_t \geq -\bar{s}, \tag{12}$$

Equation (10) describes the flow of funds condition for the firm. The source of funds consists of after-tax profits, new debt, and new equity issuance. The use of funds consists of investment expenditure, and dividend payments and debt repayments. Dividend payments cannot be negative. We thus impose constraint (11). There may be further constraints on dividend payments. For example, one may assume that the firm should pay a fraction of earnings as dividends (e.g., Auerbach (2002) and Poterba and Summers (1983)). The motivation for such a constraint requires a richer model than the present one, notably asymmetric information or agency conflict between managers and shareholders. Such modeling is beyond the scope of the present paper.

There may also be effective restriction on share repurchases. In the United States, share repurchases are allowed. However, regular repurchases may lead the IRS to treat repurchases as dividends. Also, repurchases may be costly. These costs may be associated with asymmetric information (see, e.g., Brennan and Thakor (1990)). To capture these costs, we follow Poterba and Summers (1985) to impose a constraint that share repurchases are bounded by some maximal amount $\bar{s} \geq 0$.

3 Analytical Results

In order to analyze the dynamic effects of dividend tax changes, we first characterize the firm's investment and financial policies. We then derive some analytical results for steady state.

3.1 Financial Policy and Finance Regimes

Let λ_t^d, λ_t^s and λ_t^b be the nonnegative Lagrange multipliers associated with constraints (11), (12), and (3), respectively. We can then derive the following first-order conditions:

$$s_t : \frac{1-\tau_t^d}{1-\tau^g} + \lambda_t^d + \lambda_t^s = 1, \tag{13}$$

$$b_t : \frac{1-\tau_t^d}{1-\tau^g} + \lambda_t^d - (1+r)\,\lambda_t^b = \frac{1+(1-\tau^c)\,r}{1+r\,(1-\tau^i)\,/\,(1-\tau^g)} \left(\frac{1-\tau_{t+1}^d}{1-\tau^g} + \lambda_{t+1}^d \right). \tag{14}$$

We also have the usual transversality condition and the complementary slackness condition, which are omitted here for simplicity.

We first consider the firm's dividend policy, which is characterized by equation (13). This equation admits the following interpretation. Raising one dollar of new equity to pay dividends relaxes the dividend constraint and the share repurchase constraint. In addition, the shareholder receives \$ $\left(1-\tau_t^d\right)/\left(1-\tau^g\right)$ of after-tax dividends. Thus, the expression on the left side of (13) represents the marginal benefit to the shareholder. On the other hand, one dollar increase in new equity lowers equity value by one dollar and hence the expression on the right side of (13) gives the marginal cost to the shareholder. Equation (13) requires that the preceding marginal benefit and marginal cost must be equal at optimum.

If $\tau_t^d = \tau^g$ for all t, then there is no tax differential between dividends and capital gains. Equation (13) implies that $\lambda_t^d = \lambda_t^s = 0$. In this case, the firm's dividend policy is irrelevant. That is, it does not matter for firm value and investment policy how much earnings to retain for use as internal finance, rather than distributing dividends and raising new equity in the external equity market. More formally, in equation (9), the payout $d_t - s_t$ can be determined. However, dividends d_t and new equity s_t are indeterminate. This is the celebrated Miller and Modigliani (1961) dividend policy irrelevance theorem.

However, if $\tau_t^d \neq \tau^g$ for some t, then the firm's financial policy matters. Because according to the U.S. tax system before the 2003 dividend tax cut the dividend tax rate is higher than the capital gains tax rate, we assume that $\tau_t^d > \tau^g$ for all t.[7] In this case, it follows from (13) that we cannot have $\lambda_t^d = \lambda_t^s = 0$. That is, it is not optimal for the firm to simultaneously issue

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[7] If $\tau_t^d < \tau^g$, then the firm will issue new equity to pay dividends to the extent possible. This case never happens under the U.S. tax system.

new equity and distribute dividends. The intuition is simple. New equity or share repurchases change equity value and hence capital gains. Thus, they are taxed at the capital gains rate τ^g. By contrast, dividends are taxed at a higher rate τ_t^d. To maximize equity value, the firm should reduce dividends and repurchase shares to the extent possible. This implies that one of the constraints (11) and (12) must be binding. This observation gives us three cases to consider. Each case corresponds to a different *finance regime.*

In the first case, $d_t > 0$ and $s_t = -\bar{s}$. We call this case the *dividend distribution regime.* In this regime, the firm has enough retained earnings to finance investment and to distribute dividends. In addition, the firm has exhausted opportunities to repurchase shares so that the share repurchase constraint binds, $s_t = -\bar{s}$. This regime corresponds to the "new view" of dividend taxation. In the second case, $d_t = 0$ and $s_t > -\bar{s}$. We call this case the *equity issuance regime.* In this regime, the firm does not have enough internal funds to distribute dividends. Instead, the firm reduces dividends to the extent possible so that the nonnegative dividend constraint binds, $d_t = 0$. In addition, the firm has unused opportunities to repurchase shares in that $s_t > -\bar{s}$. The marginal source of investment finance is the external equity market. This regime reflects the traditional view of divided taxation. In the third case, $d_t = 0$ and $s_t = -\bar{s}$. We call this case the *liquidity constrained regime.* In this regime, the firm exhausts all internal funds to finance investment and hence does not distribute dividends. In addition, the firm does not issue new equity because the marginal return to investment does not justify the reduction in equity value due to share dilution. In this regime, a windfall addition to current earnings, which conveys no information about the firm's future profitably, will raise investment. The presence of firms in this regime may account for the excess sensitivity of investment to measures of internal funds. We should emphasize that finance regimes may change over time during the transitional phase as the firm accumulates capital over time.

We next turn to the debt policy, which is characterized by equation (14). Its interpretation is the following. The left side of (14) represents the marginal benefit. An increase in debt by one dollar raises after-tax dividends by $\$ \left(1 - \tau_t^d\right) / (1 - \tau^g)$. In addition, it relaxes the non-negative dividend constraint (11), resulting in a benefit of $\$\lambda_t^d$. It also tightens the collateral constraint (3), resulting in a cut of the benefit of $\$ (1 + r) \lambda_t^b$. The right side of equation (14) represents the marginal cost of debt. A dollar increase in debt raises debt repayment in the next period by $\$1 + (1 - \tau^c)\, r$. Thus, the after-tax cost to the shareholder due to dividend reduction in the next period is given by $\$\left(1 + (1 - \tau^c)\, r\right)\left(\left(1 - \tau^d_{t+1}\right)/\left(1 - \tau^g\right) + \lambda^d_{t+1}\right)$. Because the discount rate is given by $r\left(1 - \tau^i\right)/\left(1 - \tau^g\right)$, we obtain the discounted cost in period t given by the right side of (14). An optimal debt policy requires that the preceding marginal benefit equal the marginal cost.

We may interpret equation (14) as an intertemporal Euler equation for dividends, similar to the consumption Euler equation. Distributing \$1 of dividends in period t generates $\$\left(1 - \tau^d_t\right)/\left(1 - \tau^g\right)$ of after-tax benefit to the shareholders. Alternatively, the firm may save this \$1 and distribute dividends in the next period using savings $\$\left(1 + (1 - \tau^c)\, r\right)$. This strategy generates a discounted benefit to the shareholders represented by the right side of equation (14). In addition, this strategy relaxes the collateral constraint, generating a benefit of $\$\left(1 + r\right)\lambda^b_t$. At optimum, the firm is indifferent between the preceding two strategies as required by equation (14).

It is interesting to consider the case with constant tax rates $\tau^d_t = \tau^d$ for all t. We have the following result that will be used later.

Proposition 1 *Suppose* $\tau^d_t = \tau^d$ *for all* t *and the firm is not in the liquidity constraint regime in period* $t + 1$. *If*

$$1 - \tau^i > (1 - \tau^c)(1 - \tau^g), \tag{15}$$

then the firm borrows to the extent possible so that the collateral constraint binds in period t. *If* $1 - \tau^i = (1 - \tau^c)(1 - \tau^g)$, *then the firm's debt policy is indeterminate. If* $1 - \tau^i < (1 - \tau^c)(1 - \tau^g)$, *then the firm prefers to reduce debt to the extent possible in period* t, *instead of borrowing.*

This result is related to Miller's (1977) analysis. The intuition is the following. The left side of (15) represents the after-tax interest income from a dollar of bond, and the right side of (15) represents the after-tax benefit if the same dollar is taxed as equity. Condition (15) says that shareholders benefit more from issuing bond. Thus, if the firm is not liquidity constrained in the next period so that it is able to repay debt, it prefers to issue debt to the extent possible so that the collateral constraint binds.

Note that if $1-\tau^i = (1-\tau^c)(1-\tau^g)$, then the tax advantage of debt is fully offset by personal taxes so that the firm is indifferent between debt and equity. If $1-\tau^i < (1-\tau^c)(1-\tau^g)$, then the firm prefers to save corporate income to the extent possible, instead of borrowing. This case does not happen under the current U.S. tax law.

3.2 Investment Policy

We first derive a q-theoretic investment equation and then derive the user cost of capital. This analysis generalizes Abel (1990), Auerbach (1979b), Edward and Keen (1984), and Poterba and Summers (1985) to include adjustment cost and personal taxes.

3.2.1 q theory

Let q_t denote the Lagrange multiplier associated with equation (1). It represents the shadow value of capital and is often referred to as marginal q. We can easily derive the following first-order conditions:

$$x_t : q_t = \left(\frac{1-\tau_t^d}{1-\tau^g} + \lambda_t^d\right)\left[1 + (1-\tau^c)\, C_1(x_t, k_{t-1})\right] \tag{16}$$

$$\begin{aligned} k_t \quad : \quad q_t = \eta\lambda_t^b + \frac{1}{1 + r(1-\tau^i)/(1-\tau^g)} \{ & q_{t+1}(1-\delta) + \\ & \left(\frac{1-\tau_{t+1}^d}{1-\tau^g} + \lambda_{t+1}^d\right)\left[(1-\tau^c)\left(\pi'(k_t) - C_2(x_{t+1}, k_t)\right) + \tau^c\delta\right] \Big\} \end{aligned} \tag{17}$$

Equation (16) admits the following interpretation. Its left side represents the marginal benefit from a dollar increase in investment, while its right side represents the associated marginal cost. This cost consists of expenditure and adjustment costs and reflects the after tax value to the shareholder. Given the quadratic adjustment cost function in (2), we may rewrite equation (16) as

$$\frac{x_t}{k_{t-1}} = \frac{1}{\psi(1-\tau^c)}\left(\frac{q_t}{\frac{1-\tau_t^d}{1-\tau^g} + \lambda_t^d} - 1\right) + \delta. \tag{18}$$

This equation provides the structural equation used in the empirical investment literature (e.g., Desai and Goolsbee (2001)). It may be used to test the traditional and new views of dividend taxation. Specifically, under the traditional view, $\lambda_t^s = 0$ and thus $\left(1-\tau_t^d\right)/\left(1-\tau_t^g\right) + \lambda_t^d = 1$.

We may then rewrite equation (18) as

$$\frac{x_t}{k_{t-1}} = \frac{1}{\psi\left(1-\tau^c\right)}\left(q_t - 1\right) + \delta. \tag{19}$$

Under the new view, $\lambda_t^d = 0$, and thus

$$\frac{x_t}{k_{t-1}} = \frac{1}{\psi\left(1-\tau^c\right)}\left(\frac{1-\tau^g}{1-\tau_t^d}q_t - 1\right) + \delta. \tag{20}$$

To test the two views of dividend taxation, one may estimate the preceding two equations and show which one fits the data better (see Poterba and Summers (1985) for such a test).

Equation (17) demonstrates that marginal q satisfies an intertemporal asset pricing equation. The left side of (17) represents the marginal cost of purchasing one dollar of capital. The right side of (17) represents the marginal benefit of the capital purchase. The term $\eta\lambda_t^b$ represents the benefit from relaxing the collateral constraint. Other benefits consist of the increase in cash flows in the next period and the reselling value of capital. The latter benefits are discounted to the present according to the discount rate $r\left(1-\tau^i\right)/\left(1-\tau^g\right)$.

Equations (16) and (17) jointly determine the firm's optimal investment policy. Figure 1 illustrates this policy for the case without adjustment cost. When the investment demand is low, as with the MB1 schedule, investment spending can be financed from internal funds, at the expense of extra dividends. The marginal cost is equal to $\left(1-\tau_t^d\right)/\left(1-\tau^g\right)$. By contrast, for high investment demand, as with the MB3 schedule, the firm raises new equity and the marginal cost is equal to 1. For an intermediate level of investment demand, as with the MB2 schedule, the firm is constrained to invest at the amount of retained earnings plus new debt issuance, $\left(1-\tau^c\right)\pi\left(k_{t-1}\right) + \tau^c\delta k_{t-1} + b_t - \left(1 + r\left(1-\tau^i\right)\right)b_{t-1} - \bar{s}$. Figure 1 also illustrates the firm's financing hierarchy (Fazzari et al. (1988)). That is, to finance investment, the firm prefers to use internal funds first, and then to use a mix of internal funds and debt next, and finally to use external equity markets.

[Insert Figure 1]

Note that equation (17) shows that the dividend tax rate in the future influences the current marginal q, and thus may impact the current investment as revealed by equation (16). In particular, dividend taxation has an impact on investment only if the dividend tax rate changes in at least two adjacent periods or the finance regime changes in at least two adjacent periods. If the dividend tax rate is constant over time and the finance regime does not change over time, i.e., both τ_t^d and λ_t^d are constant over time, then one can use equations (14), (16) and (17) to show that dividend taxation has no effect on investment. In this case, dividend taxation acts as a profit tax which does not impact the firm's marginal incentive to invest because it changes the marginal benefit and marginal cost by an equal amount. That is, dividend taxes are essentially lump-sum taxes levied on the initial holders of corporate capital, with no distortionary effect on real investment. They only change equity value. This observation corresponds to the new view of dividend taxation. We will revisit this result in Proposition 3 later.

3.2.2 User Cost of Capital

To analyze the effects of dividend taxation on investment, it useful to apply the user cost of capital framework following Jorgenson (1963). We generalize Abel's (1990) and Jorgenson's (1963) definition of the user cost of capital to include adjustment costs and personal taxes. We define the user cost of capital as the cost u_t such that it is equal to the pre-tax marginal cash flow of an additional unit of capital, i.e.,

$$u_t = \pi'\left(k_t\right) - C_2\left(x_{t+1}, k_t\right). \tag{21}$$

Using (17), we can derive that

$$u_t = -\frac{\delta\tau^c}{1-\tau^c} + \frac{1}{1-\tau^c}\left(\frac{1-\tau_{t+1}^d}{1-\tau^g} + \lambda_{t+1}^d\right)^{-1} \times \tag{22}$$

$$\left[q_t\left(r\left(1-\tau^i\right)/\left(1-\tau^g\right)+\delta\right) - \Delta q_t\left(1-\delta\right) - \eta\lambda_t^b\left(1+r\left(1-\tau^i\right)/\left(1-\tau^g\right)\right)\right],$$

where $\Delta q_t = q_{t+1} - q_t$. Thus, the user cost of capital is equal to the sum of the tax-adjusted values of the interest rate, economic depreciation, and capital loss, less the shadow cost associated with relaxing the collateral constraint and the depreciation allowance.

3.3 Steady State

In a steady state, all variables are constant over time. Thus, we remove time subscripts in all variables within this subsection. In a steady state, the firm accumulates a large amount of capital so that it is never liquidity constrained. Proposition 1 then implies that if condition

(15) holds, then the collateral constraint binds in the steady state. We shall maintain this assumption throughout because it is the relevant case under the U.S. tax system. We can then use the collateral constraint to derive the steady-state debt level

$$b^* = \eta k^* / (1+r), \tag{23}$$

where k^* denotes the steady-state capital stock. We can also derive this result from equation (14):

$$(1+r)\lambda^b = \left(\frac{1-\tau^d}{1-\tau^g} + \lambda^d\right)\left(1 - \frac{1+(1-\tau^c)r}{1+r(1-\tau^i)/(1-\tau^g)}\right). \tag{24}$$

Thus, given condition (15), we have $\lambda^b > 0$ so that the collateral constraint binds in the steady state.

To derive the steady-state capital stock k^*, we observe that the steady-state investment level is given by $x^* = \delta k^*$ so that the firm does not face adjustment costs. Thus, equations (14), (16) and (17) imply that

$$q^* = \frac{1-\tau^d}{1-\tau^g} + \lambda^d, \tag{25}$$

$$\left[1 + \frac{r\left(1-\tau^i\right)}{1-\tau^g}\right]\left(q^* - \eta\lambda^b\right) = q^*(1-\delta) + \left(\frac{1-\tau^d}{1-\tau^g} + \lambda^d\right)\left[(1-\tau^c)\pi'(k^*) + \tau^c\delta\right], \tag{26}$$

where λ^b is given in equation (24). Simplifying the preceding equations, we obtain that the steady-state capital stock k^* satisfies

$$\pi'(k^*) = \delta + \frac{r\left(1-\tau^i\right)}{(1-\tau^c)(1-\tau^g)} - \frac{\eta r}{1+r}\left[\frac{1-\tau^i}{(1-\tau^c)(1-\tau^g)} - 1\right]. \tag{27}$$

The first two terms on the right side of equation (27) give the steady-state user cost of capital in the case without debt financing. The last term captures the effect of debt financing on the user cost. From equation (27), it is straightforward to show that the steady-state capital stock decreases with the depreciation rate, the interest rate, the corporate income tax rate, and the capital gains tax rate. It increases with the resale price of capital or the collateralization rate η. The intuition for the latter result is that an increase in η relaxes the collateral constraint and raises debt capacity. This allows the firm to take more tax advantage of debt and hence reduces the user cost of capital. Importantly, equation (27) shows that dividend taxation has no effect on the steady-state user cost of capital and thus does not impact the steady-state capital stock. This result is consistent with the new view of dividend taxation.

We can also derive the steady-state effective tax rate often used in the public finance literature. The effective tax rate is the hypothetical tax rate that, if applied to economic income, would offer the same investment incentives in the presence of various taxes (e.g., Auerbach (1983)). In our model with personal and corporate taxes and with debt financing, we can use equation (27) to derive that the effective tax rate is given by

$$1-\frac{1}{\frac{\eta}{1+r}+\left(1-\frac{\eta}{1+r}\right)\frac{1-\tau^i}{(1-\tau^c)(1-\tau^g)}}.$$

This expression shows that dividend taxation has no impact on the steady-state effective tax rate.

It remains to determine the steady-state values of dividend distribution and share issuance. We suppose $\tau^d > \tau^g$, because payout policy is irrelevant when $\tau^d = \tau^g$. It turns out there are two cases depending on the value of the share repurchase limit $\bar{s}$. To see this, we use (10) to derive the steady-state flow of funds equation

$$d^* = (1-\tau^c)\left(\pi\left(k^*\right)-\delta k^*-rb^*\right)+s^*.$$

If the steady-state after-tax earnings $(1-\tau^c)\left(\pi\left(k^*\right)-\delta k^*-rb^*\right)$ are sufficient to spend on share repurchase,[8] then the firm will exhaust share repurchase opportunities so that the share repurchase constraint binds. In addition, the firm will distribute remaining earnings as dividends. However, if the steady-state after-tax earnings are not large enough, then the firm will exhaust all these earnings to repurchase shares and will have nothing to distribute dividends. We summarize the preceding analysis in the following:

Proposition 2 *Suppose $\tau^d \geq \tau^g$ and condition (15) holds. Then the steady capital stock k^* and debt level b^* are given by equations (27) and (23), respectively. In addition, suppose $\tau^d > \tau^g$. If*

$$\bar{s} \geq (1-\tau^c)\left(\pi\left(k^*\right)-\delta k^*-rb^*\right), \tag{28}$$

then in the steady state,

$$d^*=0,\ \ s^*=-(1-\tau^c)\left(\pi\left(k^*\right)-\delta k^*-rb^*\right).$$

---

[8] We can show that the steady state earnings are positive. To show this, we observe that equation (27) implies that $\pi'\left(k^*\right) > \delta - rb^*/k^*$. Since π is concave and $\pi(0)=0$, we can show that $\pi\left(k^*\right) > k^*\pi'\left(k^*\right)$. Thus, we obtain $\pi\left(k^*\right)-\delta k^*-rb^* > 0$.

If

$$\bar{s} < (1-\tau^c)(\pi(k^*) - \delta k^* - rb^*), \tag{29}$$

then in the steady state,

$$d^* = (1-\tau^c)(\pi(k^*) - \delta k^* - rb^*) - \bar{s} > 0,\ s^* = -\bar{s}.$$

4 Simulations of Transitional Dynamics

Our model does not permit a closed-form solution for the analysis of transitional dynamics. We thus solve the model numerically and conduct a simulation analysis. We relegate our numerical method and simulation procedure to Appendix B. We use our model as a laboratory to evaluate the dynamic effects of dividend tax policies.

4.1 Baseline Parametrization and Results

In order to solve the model numerically, we first parameterize a baseline model. We should point out that we set baseline parameter values to illustrate the workings of the model and do not intend to match data moments as in the real business cycle literature. However, we still require these parameter values be within the range of values estimated or calibrated by other studies in the literature. Given the uncertainty surrounding parameters, we emphasize that our results are largely qualitative rather than quantitative.

As is standard in the literature, we choose the operating profit function $\pi(k) = k^\alpha$, where $\alpha \in (0,1)$. Within the range of estimates reported in Cooper and Haltiwanger (2005), Cooper and Ejarque (2003), and Hennessy and Whited (2005), we set $\alpha = 0.55$. Following Cooper and Ejarque (2003), Gilchrist and Himmelberg (1995), we set the depreciation rate $\delta = 0.15$. As in the finance literature, we set the interest rate $r = 0.06$. Within the range of estimates in Ramey and Shapiro (2001), we set the resale price of capital $\eta = 0.30$.

The adjustment cost parameter ψ plays a key role in the analysis. If this parameter takes a very large value, then tax policy has a small effect on investment as revealed by equation (18). In the early investment literature, researchers find that the estimate is extremely high, around 20 (e.g., Summers (1981)). Recently, using micro-level data and more sophisticated econometric methodologies, researchers have found a much smaller estimate, which is around

1 (e.g., Cooper and Haltiwanger (2005), Cummins, Hassett and Hubbard (1994), and Gilchrist and Himmelberg (1998)). Using a calibration methodology, Gourio and Miao (2006) also find that the adjustment cost parameter is close to 1. Consequently, in the present paper, we set $\psi = 1$ as a benchmark.

We next turn to tax rates. It is delicate to calibrate tax rates since in reality they are nonlinear and change each year, while we have assumed flat rates in our model. In order to mimic the Bush administration's dividend tax cuts in 2003, we suppose that the tax rates in the baseline model are constant over time and are given by the federal statutory rates in 2003 before the Bush administration's dividend tax cut. We thus set the corporate income tax rate $\tau^c = 0.35$ for our firm under study. The tax rates on dividends, labor income, and capital gains depend on the individual's income tax bracket. We suppose that shareholders of the firm have income falls into the tax bracket with $\tau^i = 0.28$. This household faces the statutory capital gains tax rate 0.20. Because capital gains have a tax deferral advantage and the opportunity to step up basis at death, the effective rate is much lower than this level. We follow Poterba (2004) in assuming that the accrual-based effective capital gains tax rate is 25% of the statutory rate. We thus set $\tau^g = 0.05$. Because dividends are taxed at the personal income tax rate before the 2003 tax reform, we set $\tau^d = 0.28$.

We finally set the value of share repurchase limit $\bar{s}$. The existing literature does not provide an estimate for this parameter. This parameter does not influence the steady-state capital stock and debt level, but is crucial for determining the steady-state values of dividends and share repurchase as demonstrated in Proposition 2. We set $\bar{s} = 0.5$, such that condition (29) is satisfied in the steady state. In this case, the firm distributes dividends and the share repurchase constraint binds in the steady state. Note that the value $\bar{s} = 0.5$ is about 43% of the steady-state after-tax earnings. This implies that the firm distributes about 57% of after-tax earnings as dividends. These relative magnitudes are roughly consistent with the data.

In summary, we list the baseline parameter values in Table 1.

Table 1. Baseline Parameter Values

	Parameter	Value
Corporate income tax	τ^c	0.35
Personal income tax	τ^i	0.28
Dividend tax	τ^d	0.28
Capital gain tax	τ^g	0.05
Exponent on capital	α	0.55
Resale price of capital	η	0.30
Interest rate	r	0.06
Depreciation rate	δ	0.15
Adjustment cost	ψ	1.00
Share repurchase limit	$\overline{s}$	0.50

Given the parameter values listed in Table 1, we first solve the steady state and then simulate the transitional dynamics when the firm is initially off the steady state. To assess the accuracy of our numerical method detailed in the appendix, we observe that the steady-state capital stock admits a closed form solution as shown in Section 3.3. Given the baseline parameter values, this solution takes the value 7.89. To compare with this exact solution, we find that the steady-state capital stock derived from our numerical method is given by 7.87, implying an error of 0.3% of the exact solution.

Figure 2 depicts the policy functions of equity issuance and dividend distribution and reveals the following two features: First, for a given debt level, a firm with a large amount of capital distributes dividends and repurchases equity to the extent possible. By contrast, a firm with a small amount of capital raises new equity but does not distribute dividends. Second, for a given sufficiently large amount of capital, a firm with a larger amount of debt burden distributes less dividends and repurchase shares to the extent possible. By contrast, for a given sufficiently small amount of capital stock, a firm with a larger amount of debt burden raises more new equity and does not distribute dividends.

[Insert Figure 2 Here]

Figure 3 shows the transitional dynamics when the firm initially has capital $k_0 = 0.1$ and does not have any debt $b_0 = 0$. From the figure, we see that the firm issues new equity, takes on debt and does not pay dividends when it is small (as measured by capital stock). When the firm has low capital stock, the marginal product of capital is high, inducing the firm to make large investment. As the firm continues to accumulate capital over time, the collateral constraint is relaxed, leading the firm to take on more debt. After the firm accumulates a sufficient amount of assets, it starts to pay dividends and does not raise new equity. It also repurchases shares until the share repurchase constraint binds. Along the transitional path to the steady state, firm value and equity value rise over time, but the investment rate, the market-to-book ratio and Tobin's q all fall over time.[9] It takes about 30 periods for the firm to reach its steady state. Note that both the market-to-book ratio and Tobin's q are higher than 1 (around 3) in the steady-state.[10] This result reflects our assumption that the operating profit function π is concave in k due to market power or decreasing-returns-to-scale technology. This assumption also implies that Tobin's q is not equal to marginal q (Hayashi (1982)).

[Insert Figure 3 Here]

4.2 Policy Experiments

Before getting into the detailed analysis, we emphasize three key points at outset. First, the distinctions between permanent and temporary policy changes, and between anticipated and unanticipated policy changes are important. We thus consider four policy experiments by considering the four possible different combinations. Such policy experiments are standard in the macroeconomics and public finance literature. As is standard in this literature, we assume that firms have perfect foresight about the future course of tax policies.

Second, the distinction between mature and growth firms is important. A mature firm owns a large amount of capital and has reached its steady state. A growth firm starts with a small amount of capital and has not yet reached its steady state. The standard policy analysis in the macroeconomics and public finance literature typically starts with an initial steady state and then analyzes transitional dynamics to a new steady state following a policy change. We will conduct this analysis, and thus, effectively focus on mature firms. We acknowledge that this analysis rules out growth firms. We thus consider a growth firm in Section 4.2.5, and show that a dividend tax cut may have dramatically different effects on it.

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[9] Firm value, the market-to-book ratio, and Tobin's q in period t are defined as $V_t + (1+r)\,b_{t-1}$, V_t/k_{t-1}, and $\left(V_t + (1+r)\,b_{t-1}\right)/k_{t-1}$, respectively.

[10] We do not display the first few values of Tobin's q in Figure 3 because the initial capital stock is very small, resulting in very high values of Tobin's q initially.

Third, capital market imperfections may cause asymmetric responses to an anticipated permanent dividend tax cut versus an anticipated permanent dividend tax increase.[11] The key intuition is that the collateral constraint limits the firm's ability to transfer corporate income across periods in order to engage in tax arbitrage. We illustrate this point in Section 4.2.6.

4.2.1 An Unanticipated Permanent Dividend Tax Cut

We start with the policy experiment in which there is an unanticipated permanent dividend tax cut at $t = 1$. We consider the impact of this policy change on a mature firm that has already reached the steady state at the initial date $t = 1$. This firm's initial predetermined capital stock k_0 and debt level b_0 take the steady-state values k^* and b^*, respectively. We have the following result:

Proposition 3 *An unanticipated permanent dividend tax cut has no effect on a mature firm's corporate investment and financial policies. In addition, if condition (28) holds, then dividend taxation does not affect a mature firm's equity value. If condition (29) holds, then an unanticipated permanent dividend tax cut raises a mature firm's equity value.*

The intuition behind this proposition is related to the discussion in Section 3.2.1 and Proposition 1. After an anticipated permanent dividend tax cut, the dividend tax rate does not change over time. In addition, it does not change a mature firm's finance regime over time. Thus, this dividend tax cut raises the marginal benefit of investment and the associated marginal cost by an equal amount, leaving the marginal incentive to invest unchanged.

By Proposition 2, when after-tax earnings are higher than the limit of the share repurchase expense, then the firm still has cash to distribute dividends after exhausting the share repurchase limit. Thus, a permanent dividend tax cut raises after-tax dividends and hence equity value. By contrast, if the firm has the opportunity to spend all earnings to repurchase shares, then the firm will not distribute any dividends to shareholders, and thus will effectively avoid dividend taxes. As a result, dividend taxation does not affect equity value.

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[11] Bernanke and Gertler (1989) show that capital market imperfections cause asymmetric responses to productivity shocks.

4.2.2 An Anticipated Permanent Dividend Tax Cut

We next consider the policy experiment in which there is an anticipated permanent dividend tax cut at some future date T, say, $T = 5$. In particular, starting from $T = 5$, the dividend tax rate is cut to the same level 0.20 of the statutory capital gains tax rate forever. Figure 4 illustrates the effects of this policy. The top-right panel of Figure 3 shows that the firm does not issue new equity, but repurchases share to the extent possible following the policy change. This is because the mature firm has sufficient earnings to finance share repurchase and investment. In anticipation of the tax cut in period 5, the firm restricts dividend payments starting in period 1 until period 4. In period 5 when the dividend tax cut is enacted, the firm pays a huge amount of dividends. In order to transfer earnings across periods to engage in tax arbitrage, the firm reduces borrowing and starts accumulating savings until period 4. In period 5, the firm borrows a large amount of debt reaching the credit limit. After period 5, the firm reduces dividend payments over time until it reaches the new steady state.

[Insert Figure 4 Here]

The middle-left panel of Figure 4 depicts the transition path of capital. A decrease in the dividend tax rate in period 5 raises marginal benefit from investment in period 4. In anticipation of this tax cut, the firm purchases more capital than the steady-state value in period 4 as shown in equation (17). Because of the convex adjustment cost, the capital stock increases gradually until period 2 and then decreases starting from period 3, gradually reaching the original steady-state value. The middle-right panel of Figure 4 shows that investment jumps up in period 1 in anticipation of a future dividend tax cut. It then decreases until period 5. After period 5 the firm raises investment and the investment rate gradually reaches the steady state value of 0.15. This pattern reflects the hump-shaped transition path of capital.

The bottom-left panel of Figure 4 shows that in response to the dividend tax cut in period 5, equity value jumps up immediately because the firm capitalizes the savings of dividend tax payments. It gradually rises until period 5, and then plummets in period 6, reflecting the firm's dividend payout policy illustrated in the top-right panel of Figure 4. After period 6, it gradually falls over time, until reaching a new higher steady-state value. By contrast, firm value decreases until period 5 and then rises to a new higher steady-state value. This reflects the fact that debt decreases until period 4 and jumps up in period 5. The bottom-right panel of Figure 4 shows that the market-to-book ratio rises gradually until period 5. It jumps down in period 6 and then gradually rises until reaching a new higher steady-state value. By contrast, Tobin's q falls until period 5 and then starts to rise until reaching a new steady state.

4.2.3 An Unanticipated Temporary Dividend Tax Cut

In the previous two policy experiments, we have shown that (i) an unanticipated permanent dividend tax cut has no short- or long-run effects on a mature firm's capital formation, and (ii) an anticipated permanent dividend tax cut in the future has no long-run effect on a mature firm's capital formation, but has a short-run effect that stimulates investment and capital accumulation. In this subsection, we will show that an unanticipated temporary dividend tax cut discourages capital accumulation in the short run.

We consider a policy experiment in which there is an unanticipated temporary dividend tax cut at $t = 1$ from the level of 0.28 to the level of 0.20 until period $T = 5$. After period $T = 5$, the dividend tax rate reverts to the previous level of 0.28. Figure 5 depicts the effects of this policy. The top-right panel of Figure 5 shows that the firm is always in the dividend distribution regime. In anticipation of reverting back to the original tax rate starting in period 5, the firm cuts dividend payments in this period, shifting cash to the first 4 periods in order to raise dividend payments in those periods. The presence of the collateral constraint limits the firm's ability to transfer cash in the future to the present. The firm chooses debt level such that the collateral constraint binds in all periods.

In anticipation of a dividend tax increase in period 5 from the level in period 4, the firm cuts investment in period 4 as demonstrated in the two middle panels of Figure 5. Because of the presence of adjustment costs, capital gradually falls at a higher speed until period 4 and gradually rises at a lower speed until reaching the original steady-state value. This pattern also implies that the investment rate falls until period 4, but jumps up in period 5 and then falls gradually until reaching the steady state.

The bottom-left panel of Figure 5 shows that both equity value and firm value jump up in period 1, capitalizing the savings of dividend taxes. Importantly, they fall until period 5 to values lower than their steady-state values, even though the dividend tax rate is never higher than its original level. After period 5, both equity value and firm value gradually rise to their original steady-state values. These transition paths reflect the dynamics of the firm's assets or capital illustrated in the middle-left panel. The bottom-right panel of Figure 5 shows that the market-to-book ratio and Tobin's q initially jump up and then exhibit the opposite pattern because of the effects of changes in capital in the denominator dominates.

[Insert Figure 5 Here]

4.2.4 An Anticipated Temporary Dividend Tax Cut

In this experiment, we suppose that at some future date $T_1 = 5$, the dividend tax rate is cut to the level of 0.20 until period $T_2 = 9$. Starting from period 10, the dividend tax rate reverts to the previous level of 0.28. Figure 6 depicts the effects of this policy. Its top-left panel reveals that this policy is similar to an anticipated tax cut lasting for 4 periods as illustrated in the top-left panel of Figure 4 followed by a tax increase as illustrated in the top-left panel of Figure 5. Once we understand this analogy, we can immediately see that the transition dynamics in this experiment follow a pattern similar to that of Figure 4 combined with Figure 5. So we omit a detailed discussion here.

[Insert Figure 6 Here]

4.2.5 Mature versus Growth Firms

So far, we have focused on the effects of a dividend tax cut on a mature firm. As pointed out previously, its effects on a growth firm may be dramatically different. To illustrate this point, we consider the policy experiment in which there is an unanticipated permanent dividend tax cut in period 1. We have shown in Section 4.2.1 that this policy has no effect on a mature firm. By contrast, this policy has impact on a growth firm. To illustrate this impact, we consider a growth firm that initially owns capital stock $k_0 = 0.1$ and does not inherit any debt, $b_0 = 0$. Figure 7 depicts the impact of the policy. Comparing this figure with Figure 3, we observe that the transitional dynamics after an unanticipated permanent dividend tax cut follow a pattern similar to that in the case without the tax cut. Importantly, the dividend tax cut impacts the transition path to the steady state. In particular, the transition to the steady state is faster after the tax cut as illustrated in the middle-left panel of Figure 7. Given the lower dividend tax rate, the growth firm finds it profitable to issue more equity, which allows it to invest more. This relaxes the collateral constraint and permits the firm to take on more debt.

[Insert Figure 7 Here]

4.2.6 Asymmetric Response to Tax Changes

So far, we have focused on the dynamic effects of dividend tax cuts. We now conduct an experiment to illustrate that the firm may respond asymmetrically to a dividend tax increase. In this experiment, we assume that the dividend tax rate remains to be 0.28 until period 4 and then rises in period 5 to 0.36 thereafter permanently. Figure 8 depicts the effects of this policy. Comparing this figure with Figure 4, we observe that the transition dynamics following an anticipated permanent dividend tax increase and an unexpected temporary dividend tax cut exhibit the same pattern. This result reflects the fact that (i) these two policies do not affect the steady state, and (ii) the paths of dividend tax rates for these two policies follow the same pattern.

Comparing Figure 8 with Figure 4, we find that the firm's responses to an anticipated permanent dividend tax cut and an anticipated permanent dividend tax increase are asymmetric, even though the dividend tax rate increases and decreases by an equal amount. In particular, from period 1 to period 5, capital decreases by a large amount if there is a tax cut, while it does not increase by much if there is a tax increase. In addition, the debt level is strongly affected when there is a tax cut, but only mildly when there is a tax increase. The main reason for this result is due to capital market imperfections. In anticipation of a permanent dividend tax increase in the future, the firm borrows against future earnings so as to distribute dividends before the enactment of the tax increase. Because of capital market imperfections, the firm's borrowing is limited by the collateral constraint. By contrast, in anticipation of a permanent dividend tax cut in the future, the firm can reduce borrowing and save corporate income without any constraint so as to distribute a large amount of dividends when the dividend tax cut takes place.

[Insert Figure 8]

Note that we model capital market imperfections using collateral constraints as in Kiyotaki and Moore (1997). We believe our asymmetry result survives under alternative modeling of capital market imperfections. Capital market imperfections can often be motivated by asymmetric information and moral hazard. In this case, there is a wedge between the costs of internal and external funds (e.g., Bernanke and Gertler (1989)). This implies that the firm's borrowing is limited relative to the first best in response to a future dividend tax increase.

5 Conclusion

In this paper, we have provided a neoclassical framework for analyzing the dynamic effects of dividend tax policies on corporate investment and financial policies in partial equilibrium. We have analyzed steady-state properties and simulated transitional paths. We find that the dynamic effects of dividend tax policies may differ dramatically from those of other tax policies often analyzed in the literature. We summarize our main findings below:

1. Both temporary and permanent dividend tax policies have no long-run effects on mature or growth firms' capital formation. But they have transitory effects on investment and financial policies, except for an unanticipated permanent dividend tax change applied to a mature firm.

2. An unanticipated permanent dividend tax change has no short- or long-run effects on a mature firm's capital formation. But an unanticipated permanent dividend tax cut (increase) speeds up (slows down) a growth firm's transition to a steady state.

3. An anticipated permanent dividend tax cut in the future has a short-run effect of raising current investment. By contrast, an unanticipated temporary dividend tax cut has a short-run effect of lowering current investment. In response to this policy, equity value and firm value jump up immediately, but fall below their steady-state values until the period when the dividend tax rate reverts to its original level.

4. In anticipation of a future dividend tax cut, the firm restricts dividend payments, reduces borrowing, and accumulates savings until the period when the tax cut is enacted. In this period, dividend payments and equity value surge.

5. Because of capital market imperfections, a firm's responses to an anticipated permanent dividend tax cut and an anticipated permanent dividend tax increase are asymmetric.

Our findings are mostly qualitative - we study the economic mechanisms at work - and we leave a serious quantitative match of U.S. data for future research. Our theoretical and simulation results may help to understand and guide empirical studies. Chetty and Saez (2005) find evidence that dividend payments surged following the 2003 dividend tax cut. Auerbach and Hassett (2005) find evidence that firm value increased after the 2003 dividend tax cut was announced. Our model suggests that these two pieces of empirical evidence are consistent with firm behavior when the dividend tax cut was unanticipated, but once enacted, was viewed as temporary. Our framework is useful for analyzing other tax policies such as corporate and capital gains taxes, and can be extended in a number of dimensions. In particular, it can be embedded in a general equilibrium model. Gourio and Miao (2008) conduct such an analysis. They also point out one limitation of the present analysis: In an aggregate economy with firm heterogeneity in productivity, there are both growth and mature firms in the cross section, and thus, an unanticipated permanent dividend tax cut has a long-run effect of stimulating aggregate capital formation.[12] Gourio and Miao (2007) extend the preceding paper and the present paper to consider entry and exit in a general equilibrium model. Finally, our framework links the literature of macroeconomics, public finance, and corporate finance and can be used to address various questions in these fields. We hope our work will stimulate further interaction among researchers in these fields.

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[12] Korinek and Stiglitz (2006) make a similar point.

Appendix

A Proofs

Proof of Proposition 1: Suppose the collateral constraint does not bind in period $t \geq 1$ at optimum. Holding the investment policy fixed, consider the firm's new debt policy of raising the debt level by a small amount $\Delta > 0$ such that the collateral constraint still holds. There are two cases. In the first case, the firm is in the dividend distribution regime in period $t+1$ so that $d_{t+1} > 0$. The firm uses the extra debt to pay dividends at date t. The after-tax benefit to the shareholders is $\left(1-\tau^d\right) / \left(1-\tau^g\right) \Delta$. The associated cost is that the firm has to repay debt in period $t+1$. To do so, the firm cuts dividends in period $t+1$ by the amount $\left(1+\left(1-\tau^c\right) r\right) \Delta$ and the after-tax cost to the shareholders is $\left(1-\tau^d\right) / \left(1-\tau^g\right)\left(1+\left(1-\tau^c\right) r\right) \Delta$. If Δ is sufficiently small, then the non-negative dividend constraint in period $t+1$ still holds. The cost discounted to period t is given by

$$\frac{1}{1+r\left(1-\tau^i\right) / \left(1-\tau^g\right)} \frac{1-\tau^d}{1-\tau^g}\left(1+\left(1-\tau^c\right) r\right) \Delta.$$

If condition (15) holds, then this cost is less than the benefit $\left(1-\tau^d\right) / \left(1-\tau^g\right) \Delta$. Thus, shareholders benefit from this new debt policy, leading to a contradiction.

If $1-\tau^i=\left(1-\tau^c\right)\left(1-\tau^g\right)$, then we can also use the previous variational argument to show that the firm is indifferent about the previous new debt policy. If $1-\tau^i<\left(1-\tau^c\right)\left(1-\tau^g\right)$, then by the previous variational argument, the firm benefits from reducing debt.

Turn to the second case, where the firm is in the equity issuance regime in period $t+1$ so that $s_{t+1} > -\bar{s}$. We can use the same variational argument for share repurchase instead of dividend payments to derive the desired result. Q.E.D.

Proof of Proposition 2: See the main text. Q.E.D.

Proof of Proposition 3: Consider the sequence of constant dividend tax rate $\tau_t^d = \tau^d$. Let the associated steady-state solution for investment and financial policies be $(k^*, x^*, b^*, d^*, s^*)$. Let the associated steady-state solution for the Lagrange multipliers be λ^d, λ^b, and λ^s. A mature firm initially has capital and debt $k_0 = k^*$ and $b_0 = b^*$. Then it operates in a steady state in that $(k_t, x_t, b_t, d_t, s_t) = (k^*, x^*, b^*, d^*, s^*)$ and $\left(\lambda_t^d, \lambda_t^b, \lambda_t^s\right) = \left(\lambda^d, \lambda^b, \lambda^s\right)$ for all t. This solution is optimal because one can easily check it satisfies the first-order conditions (13)-(17). In addition, it satisfies the complementary slackness condition and the transversality condition. Because $(k^*, x^*, b^*, d^*, s^*)$ is independent of the dividend tax rate τ^d, it is still optimal when τ_t^d takes a different constant value $\bar{\tau}^d$ for all t.

If condition (28) holds, then $d^* = 0$ by Proposition 2, and thus equity value is independent of dividend taxation by (9). If condition (29) holds, then $d^* > 0$ and $s^* = -\bar{s}$. Thus, (9) implies that equity value rises when there is an unanticipated permanent dividend tax cut. Q.E.D.

B Numerical Method

In order to solve the model numerically, we first rewrite the firm's decision problem as a dynamic programming problem:

$$V_t\left(k_{t-1}, b_{t-1}\right) = \max_{x_t, b_t, s_t} \frac{1-\tau_t^d}{1-\tau^g} d_t - s_t + \frac{1}{1 + r\left(1-\tau^i\right) / \left(1-\tau^g\right)} V_{t+1}\left(k_t, b_t\right), \tag{B.1}$$

subject to (1), (3), (10), (11), and (12). Here $V_t(\cdot, \cdot)$ denotes the value function in period t. When the dividend tax rate τ_t^d is constant over time, the problem becomes stationary. In this case, we denote the stationary value function by $V(\cdot, \cdot)$.

We now outline our numerical procedure.[13]

Step 1. Solve the firm's stationary dynamic programming problem, when tax rates are constant over time. To solve this problem, we discretize the state space and use value function iteration. In each iteration, we interpolate the resulting value function by the spline method.

Step 2. From step 1, we obtain the converged value function $V(k, b)$ and decision rules for capital, debt, and new equity, $g^k(k, b)$, $g^b(k, b)$ and $g^s(k, b)$, respectively. Starting from an initial value (k_0, b_0), we iterate $k_{t+1} = g^k(k_t, b_t)$ and $b_{t+1} = g^b(k_t, b_t)$ until convergence to obtain the steady state values k^* and b^*. We compare this solution with the analytical solution obtained in Proposition 2. If they are sufficiently close, we go to Step 3. Otherwise, we increase grid points and go to Step 1.

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[13] The code is available upon request.

Step 3. To simulate the transition dynamics following a tax policy change, we suppose it takes T periods for the firm to reach a new steady state. We then solve the finite horizon dynamic programming problem (B.1) by backward induction starting with $V_T = V$. Again, we interpolate the value function by the spline method.

Step 4. From Step 3, we obtain decision rules $g_t^k\left(k_{t-1}, b_{t-1}\right)$, $g_t^b\left(k_{t-1}, b_{t-1}\right)$, and $g_t^s\left(k_{t-1}, b_{t-1}\right)$ for capital, debt, and new equity, respectively. Using these decision rules, we can derive the sequence $\left\{k_t, b_t, s_t\right\}_{t=1}^T$, starting with any initial value $\left(k_0, b_0\right)$. If $\left(k_{T-1}, b_{T-1}\right)$ is close to the steady-state value $\left(k^*, b^*\right)$, we go to Step 5. Otherwise, we increase T and go back to Step 3. For the parameter values under our consideration, we find $T = 30$ is sufficient.

Step 5. Given values of $\left\{k_t, b_t, s_t\right\}_{t=1}^T$, we use (1) and (10) to derive $\left\{x_t\right\}_{t=1}^T$ and $\left\{d_t\right\}_{t=1}^T$, respectively.

When solving the firm's dynamic programming problem, we discretize the state space for capital and debt with more grid points put on lower capital values. We allow the choice variables of capital and debt to lie in a grid with much more points than those in the grid for the state space.

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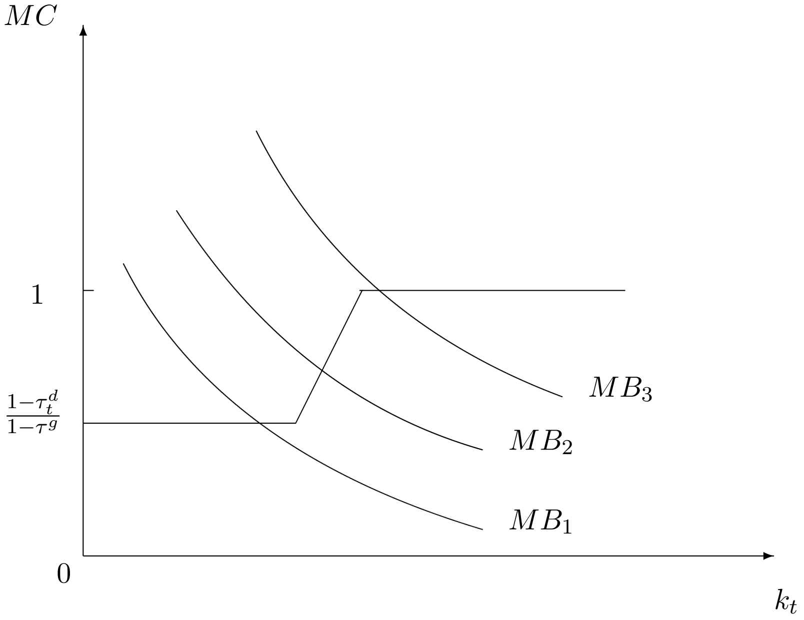
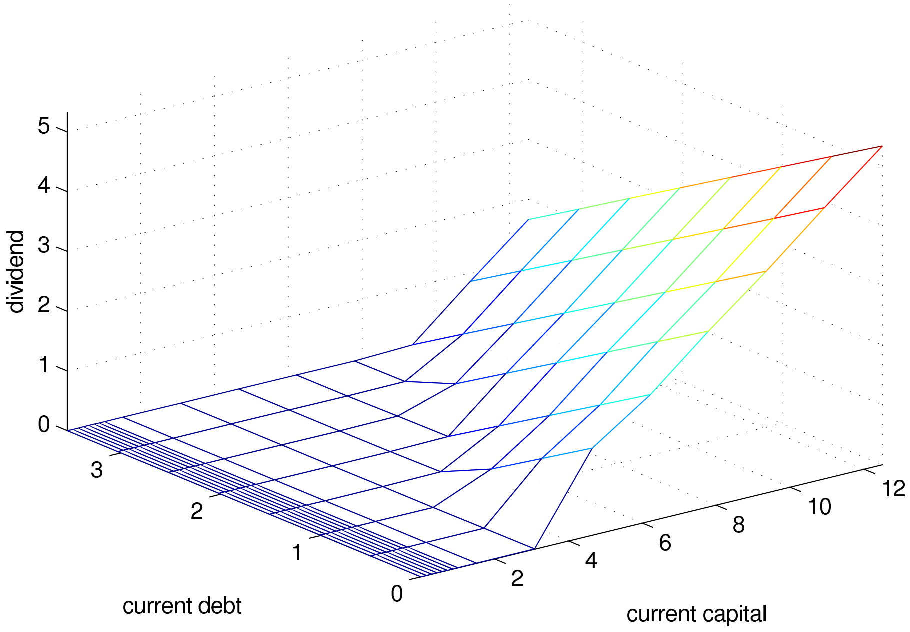


Figure 1: **Determination of optimal investment policy for the case without adjustment costs.** The curves MB1, MB2, and MB3 plot three different schedules of the marginal benefit of investment. The three line segments plot the marginal cost of investment.



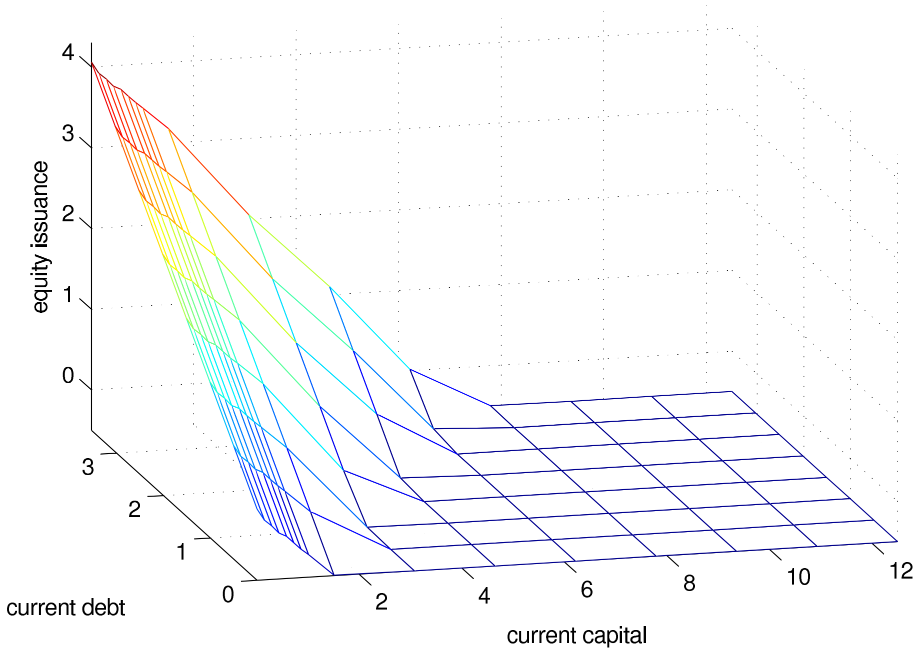


Figure 2: **Policy functions for equity issuance and dividend distribution.** The parameter values are given in Table 1.

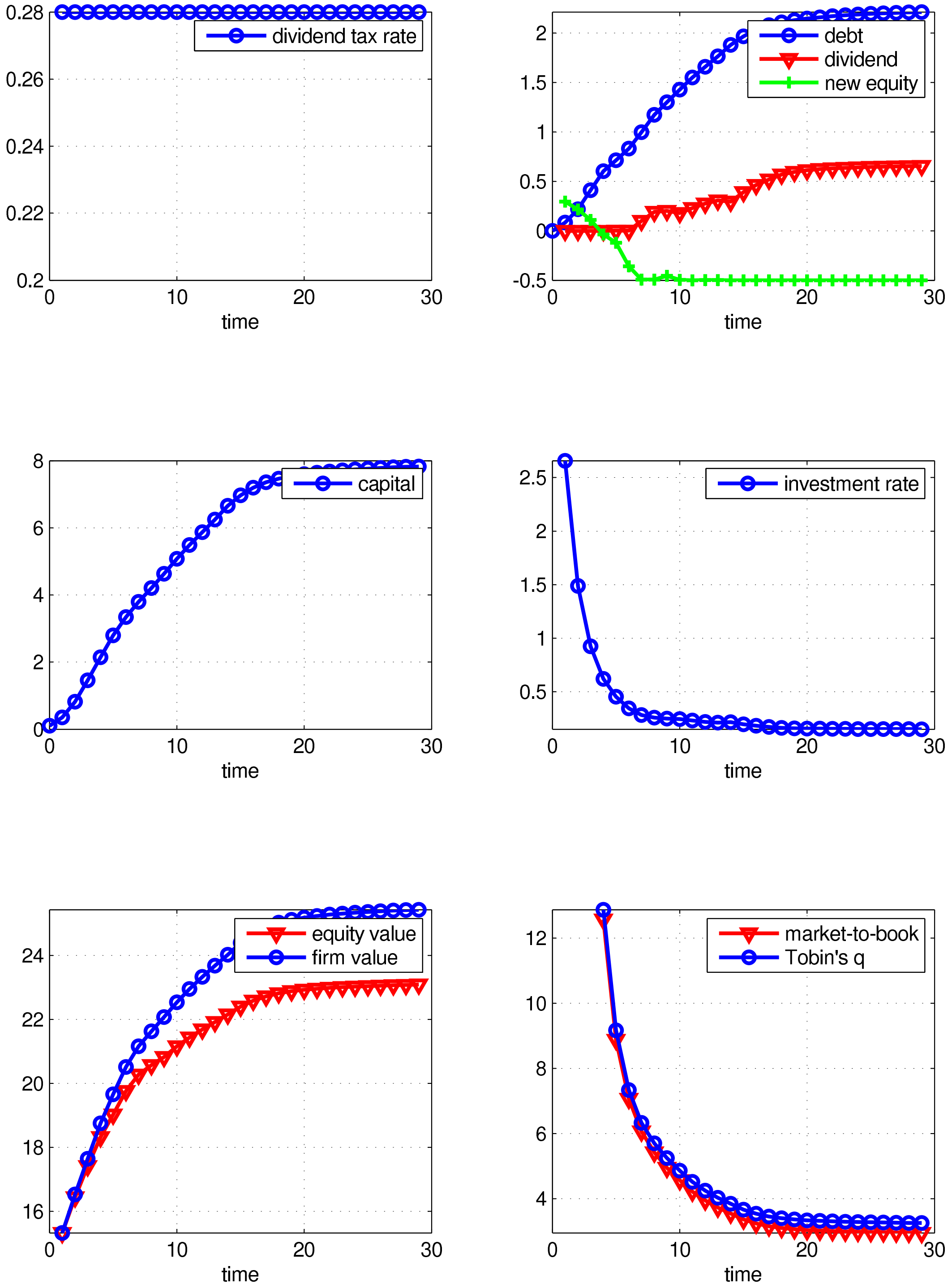


Figure 3: **Transitional dynamics for the baseline model.** The firm starts with initial state $(k_0, b_0) = (0.1, 0)$. The parameter values are given in Table 1.

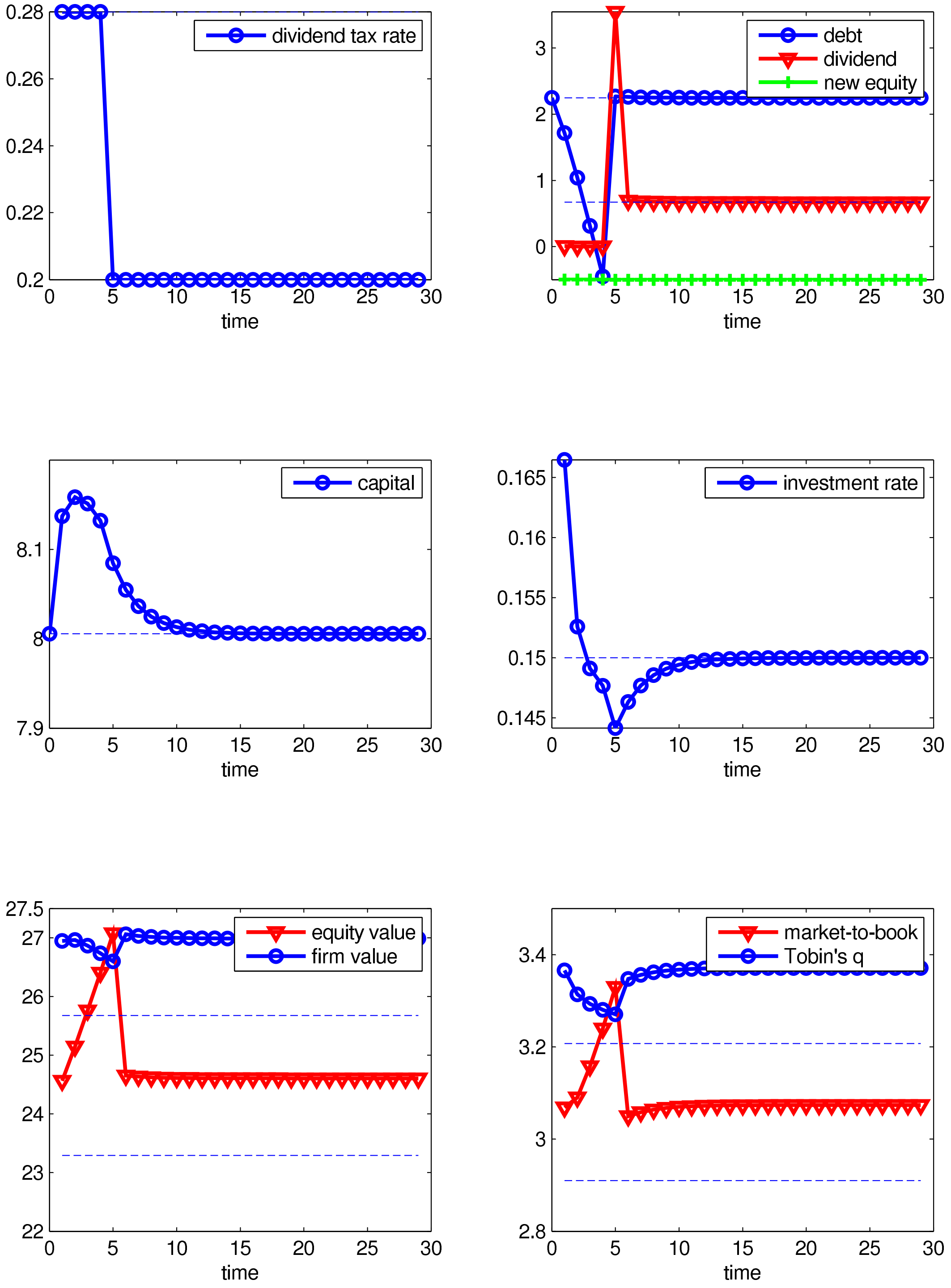


Figure 4: **Transitional dynamics following an anticipated permanent dividend tax cut from 0.28 to 0.20 starting from period 5.** The firm is mature and initially in the steady state. Dashed lines plot initial steady state values for the baseline model.

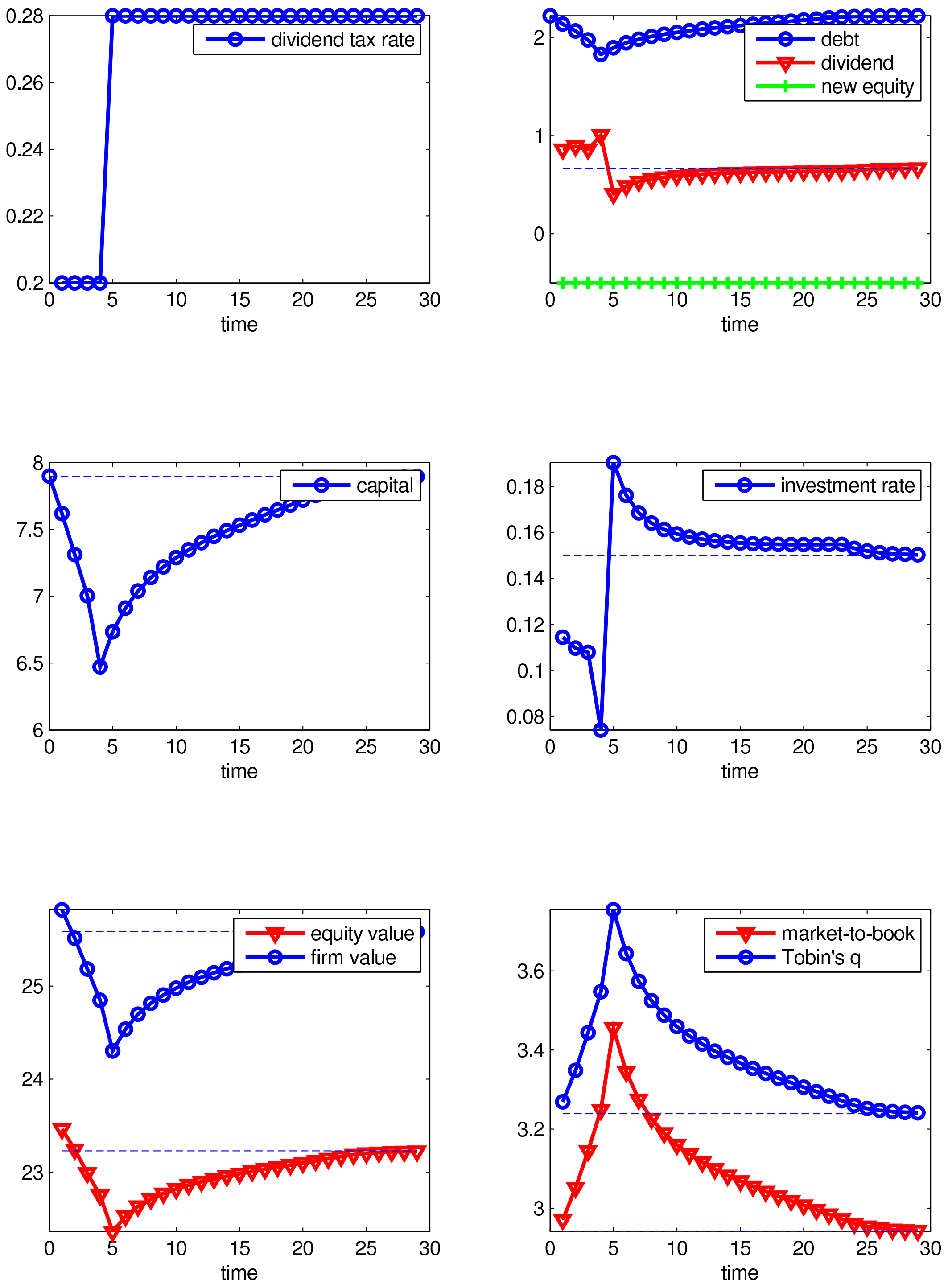


Figure 5: **Transitional dynamics following an unanticipated temporary dividend tax cut from 0.28 to 0.20 until period 4.** The firm is mature and initially in the steady state. The dashed lines plot the initial steady state values for the baseline model.

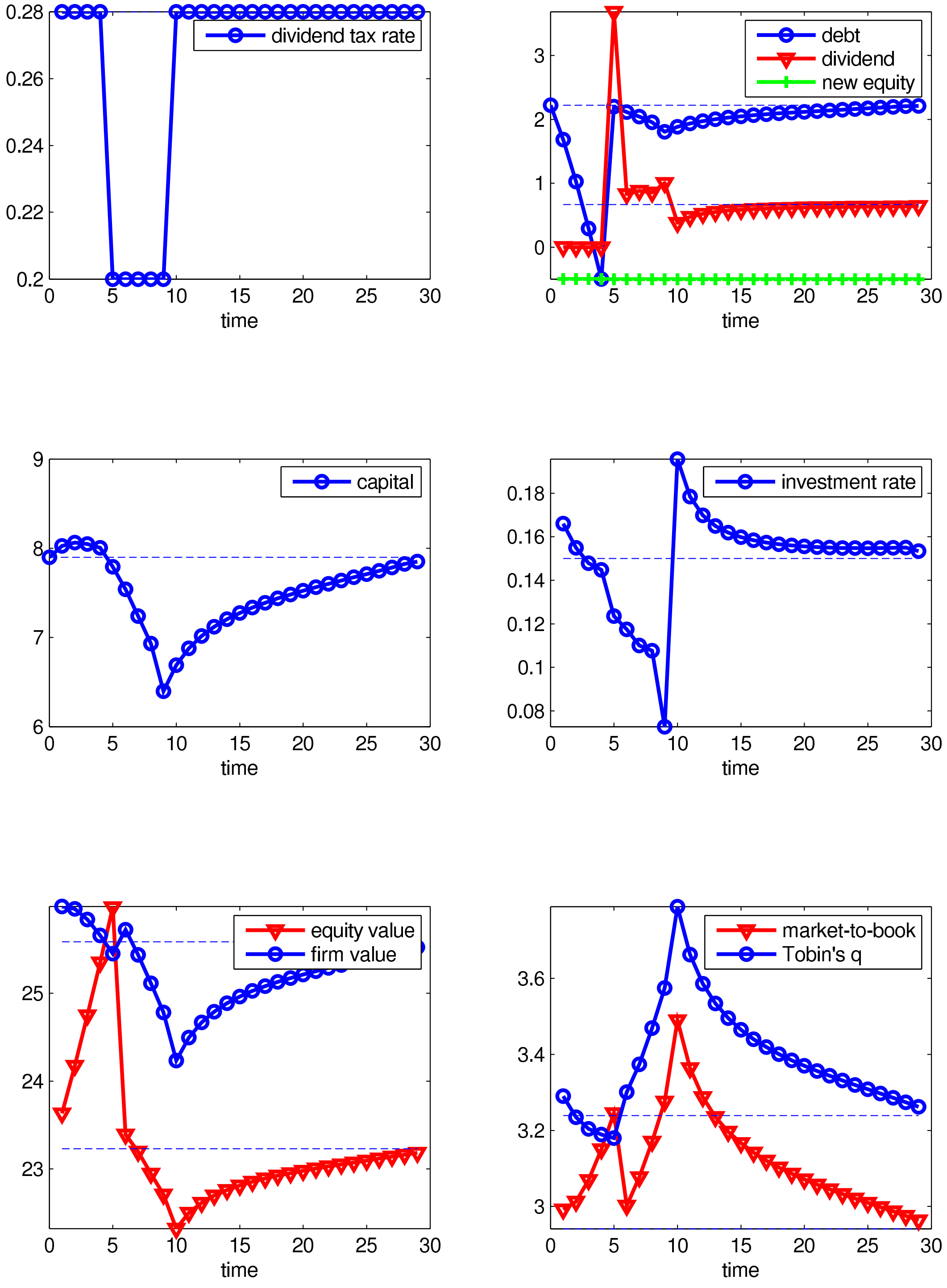


Figure 6: **Transitional dynamics following an anticipated temporary dividend tax cut from period 5 until period 9.** The firm is mature and initially in the steady state. The dashed lines plot the initial steady state values for the baseline model.

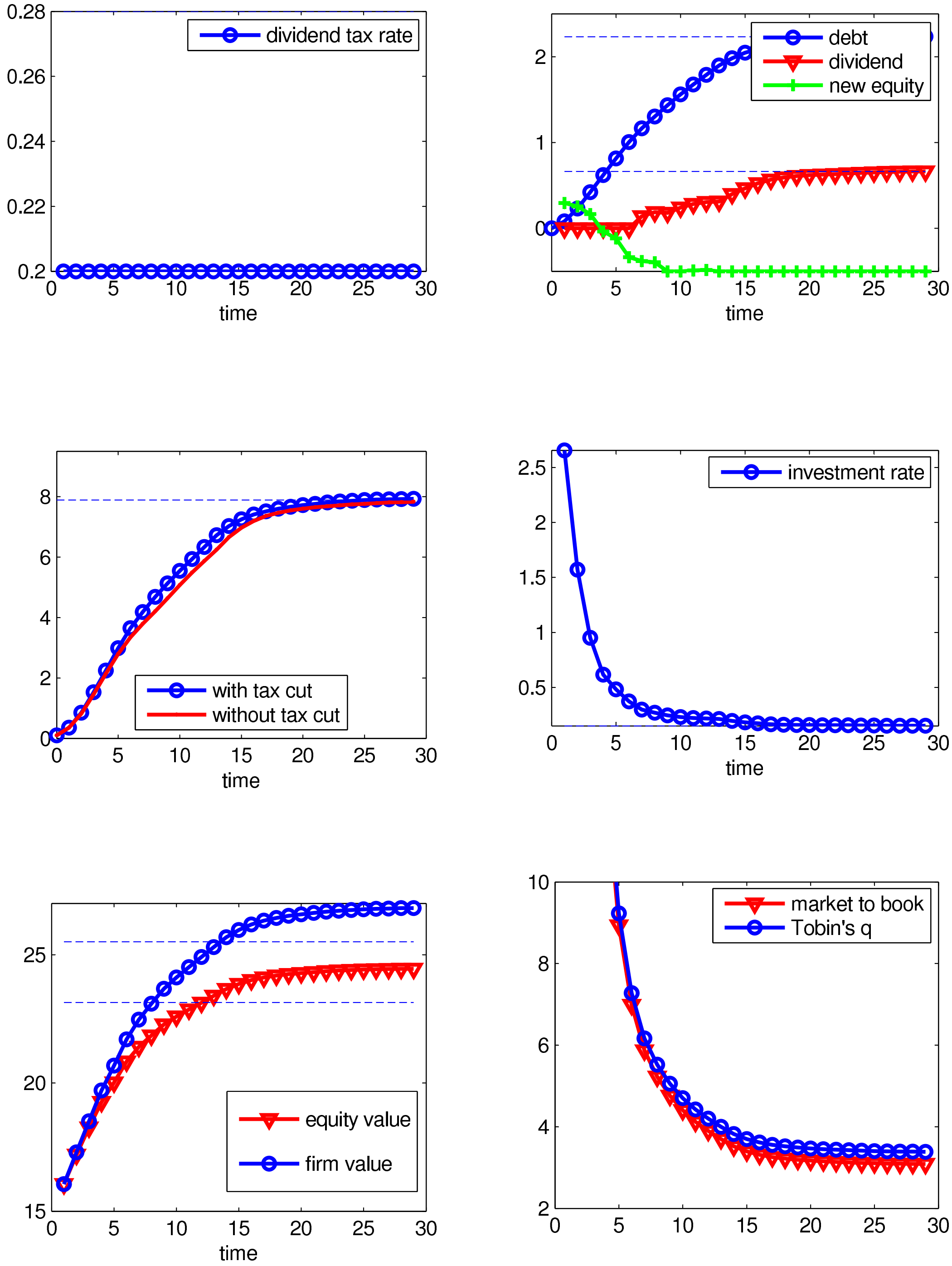


Figure 7: **Transitional dynamics following an unanticipated permanent dividend tax cut from 0.28 to 0.20.** The growth firm starts with an initial state $(k_0, b_0) = (0.1, 0)$. The dashed lines plot the initial steady state values given parameter values listed in Table 1. In the middle-left panel, the solid line plots the capital path when there is no tax cut. For better visual effect, the first four data points are deleted in the bottom-right panel.

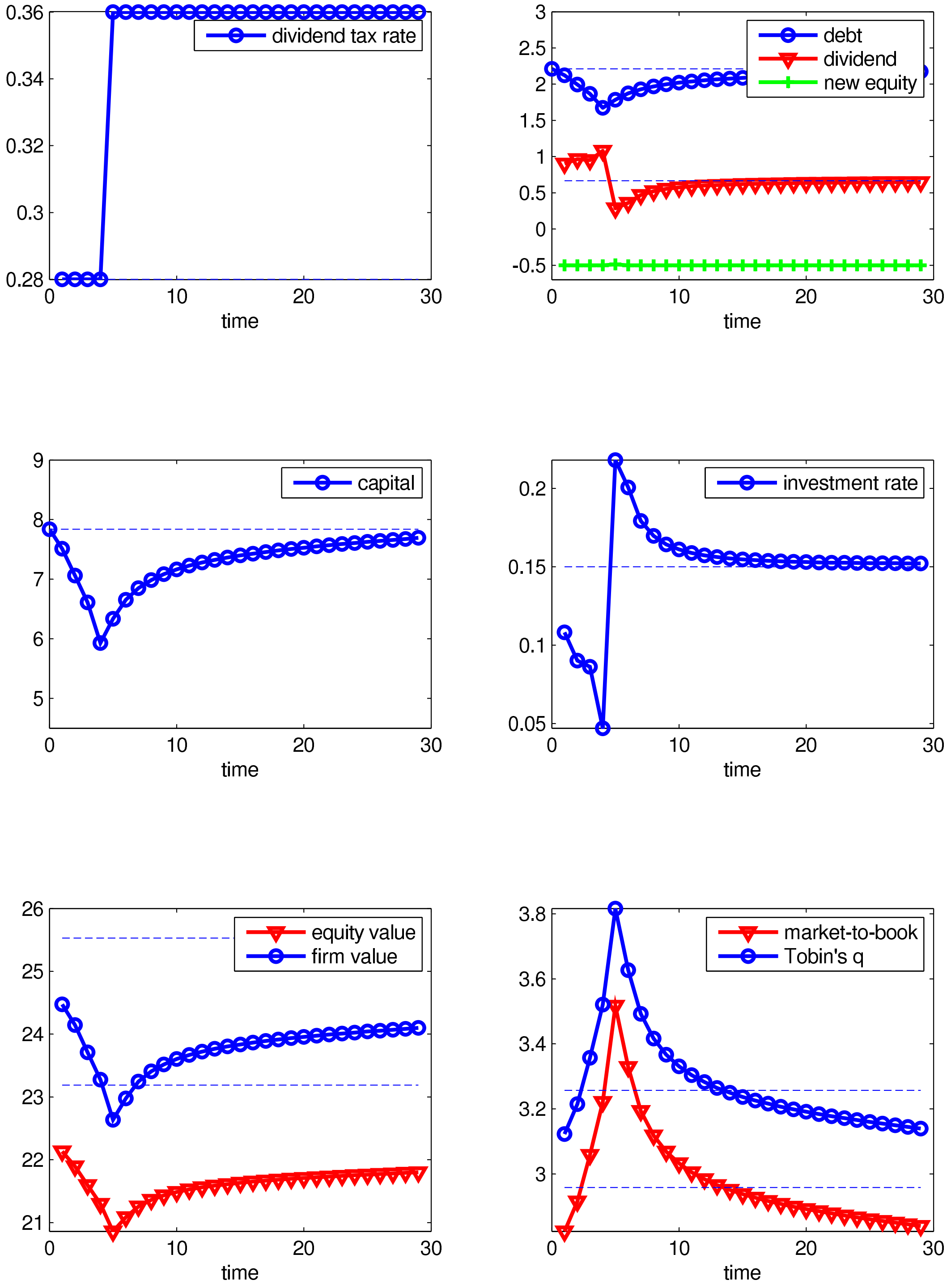


Figure 8: **Transitional dynamics following an anticipated permanent dividend tax increase from 0.28 to 0.36 starting from period 5.** The firm is mature and initially in the steady state. The dashed lines plot the initial steady state values for the baseline model.