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Macroeconomic Effects of Dividend Taxation with Investment Credit Limits

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ABSTRACT: We analyze the effects of dividend taxation in a general equilibrium business cycle model with an occasionally-binding investment credit limit. Permanent dividend tax reforms distort capital investment decisions in the binding long-run equilibrium, but are neutral otherwise. Temporary unexpected tax cuts stimulate short-term real activity in the credit-constrained economy, yet produce contractionary macroeconomic outcomes in the slack regime. The occasionally-binding constraint reconciles the `traditional' and `new' views of dividend taxation, and highlights the importance of measuring the firm's initial borrowing position before enacting tax reforms. Finally, permanently lower dividend taxes dampen financial business cycles, and help to explain macroeconomic asymmetries.

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1 Introduction

The key question addressed in this paper is: what are the long- and short-term macroeconomic implications of dividend tax reforms? Existing studies present mixed answers to this old yet still highly topical and politically contentious question. Proponents of the 'new' view of dividend taxation argue that permanent dividend tax changes are fully capitalized in share prices and have no impact on capital formation when firms rely on retained earnings to finance new investment (King (1974, 1977), Auerbach (1979), Bradford (1981), and McGrattan and Prescott (2005)). Even in the short-run, Desai and Goolsbee (2004), Chetty and Saez (2005), and Yagan (2015) estimate that the large U.S. 2003 dividend tax cut caused little to zero change in near-term corporate investment and mainly resulted in inflated dividend payouts. By contrast, under the 'traditional' view, the marginal source of funds is new equity. A dividend tax cut therefore raises the return to capital that is used to distribute dividends, and has a positive impact on aggregate investment (Harberger (1962), Feldstein (1970), and Poterba and Summers (1983, 1985)). Part of Auerbach and Hassett's (2006) empirical results are implicitly consistent with this view. These authors document that the U.S. 2003 tax reform had a positive impact on share prices of high dividend-paying stocks, implying a lower marginal cost of equity finance and an improvement in aggregate investment. In a recent paper, Jacob (2021) finds that the lower dividend tax implemented in Sweden from 2006 also resulted in an overall expansionary effect on the economic activity, driven primarily by increased investment from firms with limited internal funds.[1]

We contribute to this enduring debate on dividend taxation by examining the macroeconomic consequences of such tax in a general equilibrium business cycle model with a representative corporate firm subject to an *occasionally-binding* investment borrowing constraint and capital adjustment costs. The forward-looking firm undertakes investment with a view to maximizing shareholder value. In this setup, dividend taxes and the investment loan-to-value (LTV) ratio jointly determine the tightness of the collateral constraint and the firm's financial position. The constraint tightness, in turn, dictates whether dividend taxation conform to the 'traditional' or the 'new' view, and whether temporary dividend tax cuts have an expansionary or contractionary economic impact in the near-term. A key insight of this paper is that a decline in the dividend tax rate improves the collateralized value of capital, encourages investment, and spurs the economic activity *up to the point* where the initially binding investment debt limit turns slack. Further, the tight connection between corporate payout taxes and the occasionally-binding collateral constraint significantly alters the propagation of aggregate financial shocks, and can account for observed business cycle asymmetries. Previous dynamic general equilibrium frameworks analyzing shareholder taxation under various equity, payout, and liquidity restrictions find that debt financing per-se is largely irrelevant in explaining real dynamics following temporary and permanent dividend tax reforms

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[1] Poterba and Summers (1985), Sinn (1991), Auerbach (2002), and Auerbach and Hassett (2003) further elaborate on the implicit assumptions underlying each view.

(see Gourio and Miao (2010, 2011) and Santoro and Wei (2011)). However, when a Kiyotaki and Moore (1997)-type financial constraint directly ties *investment loans* to the value of the collateralized capital stock, dividend taxes produce non-trivial effects on the credit market conditions and the real economy in both the deterministic steady state and the dynamic setting.

Our results and intuition can be explained as follows. In the non-stochastic steady state, a permanent cut (hike) in dividend taxation raises (lowers) the capital stock when the economy is credit-constrained, corresponding with the 'traditional' view of dividend taxation. In this liquidity-constrained environment, the tightness of the borrowing constraint drives a wedge between the internal and external valuation of the firm. A dividend tax cut elevates the market value of the existing capital stock that can be used to support additional investment loans and relax the tightness of the credit friction. As asset prices rise, the household-shareholder accepts a lower effective rate of return, thereby reducing the cost of capital and prompting the firm to raise the capital-to-labor ratio and output. In an unconstrained regime, constant dividend tax adjustments are irrelevant for the marginal investment decisions because they symmetrically impact the marginal cost and marginal benefit of investment, as postulated by the 'new' view. We show that large tax cuts in the steady state can shift the firm's financial position from being constrained to unconstrained, thus nullifying the real long-run effects of further tax reductions or rising LTV ratios.

Turning to the short-run, a temporary and unexpected tax relief expands capital accumulation, investment, labor, and output upon impact when the collateral constraint is initially binding in the steady state. The tax reduction immediately relaxes the firm's borrowing constraint that becomes slack during the period of the fiscal reform. Moreover, as the value of capital improves and with better access to external borrowing, the firm increases investment and limits dividend payouts at the time when the reform is implemented. Nevertheless, part of the instantaneous jump in investment and output is dampened due to the persistent expected duration of the slack regime where the firm is incentivized to pay out a higher dividend from internal funds and moderate capital investment. In fact, if the economy indefinitely faces an unconstrained credit regime, the firm accelerates dividend payments instead of raising investment resulting in a severe economic contraction. The occasionally-binding borrowing limit merges the different views of dividend taxation, and highlights the importance of measuring the firm's initial steady state credit position prior to implementing dividend tax policies. We also capture the asymmetric macroeconomic effects induced by same size tax cuts and hikes given the direct relationship between dividend taxation and the shifting nature of the credit friction.

The final results concern the propagation of calibrated stochastic financial shocks in permanently high and low dividend tax environments. A permanently low tax regime makes the economy less prone to business cycle fluctuations instigated by aggregate financial shocks to the LTV ratio. Intuitively, comparing binding steady states with different tax setups, the investment-to-output ratio is higher when the dividend tax rate is lower. Furthermore, a low dividend tax rate brings the economy closer the non-binding steady state equilibrium. Thus, for a given financial innovation

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that temporarily loosens the borrowing constraint, the economy hovers around the slack regime for a longer time period the smaller is the long-run dividend tax burden. When the constraint is slack and asset prices remain relatively high, the firm pays out more dividends from retained earnings. This mitigates the initial otherwise more significant surge in investment prevailing in the higher tax environment that is associated with the tighter credit regime. Lastly, a low long-run dividend tax rate gives rise to strong asymmetric macroeconomic responses following favorable and unfavorable LTV shocks of the same magnitude.

The papers most closely connected to ours are by Gourio and Miao (2010, 2011). In Gourio and Miao's (2010) heterogenous firm setup, tax cuts reduce frictions in the reallocation of capital, thereby raising long-run investment and productivity. The authors show that the 'traditional' view at the aggregate level is pertained only with the assumption of heterogenous firms facing different dividend distribution, equity issuance, and liquidity constrained regimes. Specifically, different firms respond to a tax relief in non-identical ways depending on which financial regime they face.[2] Otherwise, the 'new' view always holds in steady state within a representative firm framework even in the presence of various financial market imperfections.[3] By contrast, our model encompasses both dividend tax views within a representative agent setup that emphasizes the importance of the investment-credit friction in determining the long-run efficacy of invariable dividend tax reforms. In their companion paper, Gourio and Miao (2011) argue that the macroeconomic upshots of dividend tax reforms depend crucially on whether tax cuts are permanent or temporary. Contributing to this line of work, we claim that an occasionally-binding investment borrowing constraint matters, and can *reverse* the transitional dynamics of real variables relative to a setup without such financial friction following an interim tax adjustment. Importantly, the nature of the credit limit in our theoretical framework allows for temporary unexpected dividend tax cuts to have expansionary near-term effects. Finally, employing a representative agent model enables to disentangle the direct potentially distortionary effects of dividend taxation from distributional and reallocation issues that arise otherwise, and which are not necessarily supported by the data (see Yagan (2015)).

Considered more broadly, our article relates to the growing dynamic general equilibrium literature examining the interactions between corporate tax policies, investment, asset prices, and the economic activity (McGrattan and Prescott (2005), House and Shapiro (2006), Santoro and Wei (2011), Miao and Wang (2014), Erosa and González (2019), and Anagnostopoulos, Atesagaoglu, and Eva Cárceles-Poveda (2022)). While these papers go a step further by examining the implications of a richer set of corporate taxes rather than merely dividend payout taxes, they abstract from investment debt limits. These models therefore do not directly capture the distortions arising from the wedge between the internal and external valuations of capital, nor the tight link between the credit tightness, dividend taxes, and the LTV ratio. Such elements are important in bridging the

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[2] In a partial equilibrium life-cycle model, Korinek and Stiglitz (2009) also illustrate that firms respond differently to anticipated dividend tax changes depending on their age and financing position over the life-cycle.

[3] In a model with incomplete markets and heterogeneous households, Anagnostopoulos, Cárceles-Poveda, and Lin (2012) show that dividend tax cuts lead to a decrease in capital and investment in the steady state.

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gap between the different views of dividend taxation and understanding the effects of temporary dividend tax shocks in a representative agent business cycle model. Atesagaoglu (2012) examines the consequences of permanent tax reductions on U.S. corporate debt in a dynamic general equilibrium setup where the firm's ability to borrow is constrained by its future stock market value. Contributing to this article which precludes business cycle variations and occasionally-binding constraints, we study the macroeconomic impact of both permanent and temporary dividend tax reforms as well as the interactions between payout taxes and financial shocks while allowing for credit regime switching.

We also contribute to the vast literature that highlights the role of financial frictions and collateral shocks in explaining the real business cycle. Jermann and Quadrini (2012), Liu, Wang, and Zha (2013), Iacoviello (2015), and Becard and Gauthier (2022), among others, conclude that LTV shocks can explain large chunks of the actual business cycle. Our results suggest that dividend taxes considerably alter the degree of credit market imperfections and the propagation of aggregate financial disturbances. Relative to the literature studying macroeconomic asymmetries in the presence of occasionally-binding collateral constraints (e.g., Guerrieri and Iacoviello (2017) and Jensen, Petrella, Ravn, and Santoro (2020)), we emphasize the importance of dividend taxation in explaining these asymmetrical business cycle traits.[4] To our knowledge, this paper is the first to show how fluctuations arising from estimated positive and negative LTV shocks are influenced by the long-run design of dividend taxation.

The outline of the paper is as follows. Section 2 describes the baseline model and details the equilibrium conditions. Section 3 provides the analytical and quantitative results in both the steady state and the dynamic setups. Section 4 concludes.

2   The Model

Consider an infinite-horizon discrete-time business cycle model augmented for an occasionally-binding investment credit limit and dividend taxation. The economy is populated by a continuum of measure one of identical households-shareholders and perfectly-competitive corporate firms who own the capital stock. There is also a government that levies taxes and maintains a balanced budget through lump-sum transfers. We now turn to describe in more detail the main features of the economy and its equilibrium properties.

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[4]Jensen, Petrella, Ravn, and Santoro (2020) explain business cycle asymmetries by a secular process of financial liberalization that started in the U.S. during the 1980s.

2.1 Households

The representative household derives utility from consumption (C_t) and experiences disutility associated with labor (N_t) according to the following separable utility function:

$$U_t(C_t, N_t) = \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t [\ln(C_t) - hN_t], \tag{1}$$

where $\mathbb{E}_t$ represents the expectation operator, $\beta \in (0,1)$ is the discount factor, and $h > 0$ is the weight attached to the disutility from labor.

Each household supplies labor N_t to a firm and receives its after-tax wage bill $(1 - \tau_t^N)W_t N_t$, where W_t is the real wage and τ_t^N denotes the labor income tax. Households own all the initial corporate shares S_t, with the price per stock (equity wealth) given by q_t. The equity price describes the market valuation of assets outside the firm and is synonymous to the firm's value. Ownership of the firm's stocks entitles the household to earn an after-tax dividend per share of $\bar{D}_t \equiv (1 - \tau_t^D) D_t^a$, with τ_t^D standing for the dividend tax and D_t^a the dividend net of corporate tax. At the beginning of the period, the household also lends B_t to the firm at an intraperiod gross rate of R_t.[5] The household's budget constraint is:

$$C_t + q_t S_{t+1} + B_t \leq (1 - \tau_t^N) W_t N_t + [(1 - \tau_t^D) D_t^a + q_t] S_t + R_t B_t + T_t, \tag{2}$$

with T_t denoting lump-sum transfers from the government. For $S_t > 0$, and taking taxes, dividends, equity prices, loan interest rate, and the real wage as given, maximization of (1) subject to (2) yields the respective first-order conditions with respect to C_t, S_{t+1}, B_t, and N_t:

$$U'_{C,t} \equiv \Lambda_t = C_t^{-1}, \tag{3}$$

$$q_t = \beta \mathbb{E}_t \frac{C_{t+1}^{-1}}{C_t^{-1}} [(1 - \tau_{t+1}^D) D_{t+1}^a + q_{t+1}], \tag{4}$$

$$R_t = 1, \tag{5}$$

$$C_t^{-1}(1 - \tau_t^N) W_t = h, \tag{6}$$

where Λ_t is the Lagrange multiplier on the household's budget constraint or the marginal utility of consumption. Equation (4) is a typical stock Euler equation, which shows that the firm's external value is equal to the present discounted value of the future share price and the dividend net of corporate and dividend taxation. Equation (5) dictates the interest rate on lending to the firm, which is zero in net terms due to the intratemporal nature of corporate debt in this model. Condition (6) determines the optimal labor supply that varies along the extensive margin as in Hansen (1985).

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[5] Our main results and insights would remain unaffected if the firm instead issued interperiod corporate debt to the household.

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Using (4), we retrieve the usual definition of the gross after-tax return to the firm's asset:

$$R_{t+1}^q \equiv \frac{\left[\left(1 - \tau_{t+1}^D\right) D_{t+1}^a + q_{t+1}\right]}{q_t} = \frac{C_t^{-1}}{\beta \mathbb{E}_t C_{t+1}^{-1}}. \tag{7}$$

Iterating forward on (7) and using the transversality condition yields the discounted share price equation only as a function of the after-tax dividend:

$$q_t = \mathbb{E}_t \sum_{j=1}^{\infty} \left\{ \left[\prod_{i=0}^{j-1} \frac{1}{R_{t+i+1}^q}\right] \left(1 - \tau_{t+j}^D\right) D_{t+j}^a \right\}. \tag{8}$$

2.2 Production and Investment Policy

A representative corporate firm hires labor N_t, owns the capital stock K_t, and combines these two inputs to produce output Y_t according to the following constant returns to scale (CRS) technology:

$$F(A_t, K_t, N_t) = Y_t = A_t K_t^\alpha N_t^{1-\alpha}, \tag{9}$$

with $\alpha \in (0, 1)$ standing for the share of capital in production, and A_t denoting a common economy-wide technology shock. The law of motion for the technology shock is:

$$A_t = (A)^{1-\rho^A} (A_{t-1})^{\rho^A} \exp\left(\sigma^A \varepsilon_t^A\right), \tag{10}$$

where A is the steady state level of technology, ρ^A is the degree of persistence, and ε_t^A is a mean zero random shock with a normal distribution and a constant standard deviation denoted by σ^A.[6]

The firm accumulates capital according to:

$$K_{t+1} = (1 - \delta) K_t + I_t - \Phi\left(\frac{I_t}{K_t}\right), \tag{11}$$

where $\delta \in (0, 1)$ is the capital depreciation rate, and I_t denotes investment. Following Lucas and Prescott (1971) and Christiano, Eichenbaum, and Rebelo (2011), we introduce a quadratic capital adjustment cost $\Phi\left(\frac{I_t}{K_t}\right) = \frac{\gamma}{2}\left(\frac{I_t}{K_t} - \delta\right)^2 K_t$ that is denominated in units of current capital. The parameter $\gamma > 0$ governs the magnitude of adjustment costs to capital accumulation, with the increasing and concave function $\Phi\left(\frac{I_t}{K_t}\right)$ satisfying: $\Phi'(\cdot) > 0$, $\Phi''(\cdot) \geq 0$, $\Phi(\delta) = 0$, and $\Phi'(\delta) = 0$. Thus, the firm must pay an increasing and convex cost of net investment, measured by deviations of I_t from the amount of investment required to replace depreciated capital. Relative to the steady state where $I/K = \delta$, positive or negative alterations in net investment result in a cost that makes capital depreciate faster. The functional form for $\Phi(\cdot)$ is chosen such that the steady state equilibrium is unchanged.

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[6]Steady state variables are denoted without the time subscript.

Without loss of generality, we assume that the total number of shares S_t is normalized to 1, with the firm having no access to issuing new stocks. To finance new capital investment and dividend distributions, the firm can use internal funds (retained earnings) or external debt financing from the household.[7] In the case of the latter, the total investment loan is tied to the value of the collateralized capital stock. Particularly, for $R_t = 1$ and $B_t = I_t$ we consider the following occasionally-binding borrowing constraint:

$$I_t \leq \theta_t Q_t K_t, \tag{12}$$

where Q_t is the inside value of the firm's capital stock (Tobin's (1969) Q, derived below), and $\theta_t \in (0,1)$ is the proportion of capital used as collateral in order to obtain the investment loan, or alternatively the loan-to-value (LTV) ratio. The above collateral constraint can be motivated by a costly contract enforcement problem stating that if the firm cannot pay its debt, the creditor can take over the firm and seize its' assets (Kiyotaki and Moore (1997) and Wang and Wen (2012)). As it is costly to liquidate capital after seizure, the lender retrieves only a fraction θ_t of the collateral asset value. Moreover, we allow for aggregate stochastic changes in the firm's funding conditions and the associated degree of credit market frictions by assuming that θ_t varies according to the following $AR(1)$ process:

$$\theta_t = (\theta)^{1-\rho^\theta} (\theta_{t-1})^{\rho^\theta} \exp\left(\sigma^\theta \varepsilon_t^\theta\right), \tag{13}$$

with θ representing the steady state borrowing limit or the average stance of credit availability, ρ^θ the degree of persistence, and ε_t^θ a mean zero random shock with a normal distribution and a constant standard deviation denoted by σ^θ. We interchangeably refer to this stochastic process as a financial, credit, LTV, or collateral shock, in the vein of Jermann and Quadrini (2012), Liu, Wang, and Zha (2013), and Perri and Quadrini (2018), among many others.

The firm's before-tax dividend in period t is:

$$D_t^b = Y_t - W_t N_t - I_t + B_t - R_t B_t, \tag{14}$$

where corporate profits are defined as $\pi_t = Y_t - W_t N_t$. Denoting τ_t^K as the corporate tax rate and using the intratemporal debt assumption with $R_t = 1$, the after-corporate tax dividend is:

$$D_t^a = \left(1 - \tau_t^K\right)\left(Y_t - W_t N_t\right) - I_t. \tag{15}$$

Therefore, it is clear that investments and debt are expensed out of profits after corporate taxes are levied. With a dividend tax τ_t^D, the firm maximizes the following present discounted value of

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[7]Debt and retained earnings are considered to be cheaper and thus more important sources of finance than new equity issuance (see also Sinn (1991) and Atesagaoglu (2012)).

the after-tax dividend payout $\bar{D}_t$:

$$\max_{N_t, K_{t+1}, I_t} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\Lambda_t}{\Lambda_0} \left(1 - \tau_t^D\right) \left[\left(1 - \tau_t^K\right) (Y_t - W_t N_t) - I_t\right], \tag{16}$$

subject to (9), (11), and (12). The term $\beta^t (\Lambda_t/\Lambda_0)$ represents the firm's stochastic discount factor and $\Lambda_t = C_t^{-1}$ is the marginal utility of household's consumption. The Lagrangian for the firm's optimization problem is:

$$\mathbb{L}_t = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\Lambda_t}{\Lambda_0} \left\{ \begin{array}{c} \left(1 - \tau_t^D\right) \left[\left(1 - \tau_t^K\right)(Y_t - W_t N_t) - I_t\right] \\ +\lambda_t \left[(1 - \delta) K_t + I_t - \Phi\left(\frac{I_t}{K_t}\right) - K_{t+1}\right] + \phi_t \left[Q_t \theta_t K_t - I_t\right] \end{array} \right\},$$

with λ_t denoting the Lagrange multiplier on the capital accumulation constraint (11), and ϕ_t the Lagrange multiplier on the borrowing constraint (12). The firm's first-order conditions with respect to the choice of input factors (N_t, K_{t+1}) and investment (I_t) are:

$$F'_{N,t} = W_t, \tag{17}$$

$$\lambda_t = \beta \mathbb{E}_t \frac{\Lambda_{t+1}}{\Lambda_t} \left\{ \begin{array}{c} \left(1 - \tau_{t+1}^D\right) \left(1 - \tau_{t+1}^K\right) F'_{K,t+1} \\ +\lambda_{t+1} \left[(1 - \delta) - \Phi'_K\left(\frac{I_{t+1}}{K_{t+1}}\right)\right] + \phi_{t+1} Q_{t+1} \theta_{t+1} \end{array} \right\}, \tag{18}$$

$$Q_t \equiv \lambda_t = \frac{\left(1 - \tau_t^D\right) + \phi_t}{\left(1 - \Phi'_I\left(\frac{I_t}{K_t}\right)\right)}. \tag{19}$$

The corresponding complementary slackness condition is:

$$\phi_t \left(\theta_t Q_t K_t - I_t\right) = 0; \quad \phi_t \geq 0. \tag{20}$$

Given the quadratic form of the capital adjustment cost, we rearrange equation (19) to obtain an explicit Q-theoretic investment function:

$$\frac{I_t}{K_t} = \frac{1}{\gamma} \left(1 - \frac{\left(1 - \tau_t^D\right) + \phi_t}{Q_t}\right) + \delta. \tag{21}$$

In a world with capital adjustment costs but without collateral constraints and dividend taxation, investment exceeds the depreciation rate when the value of newly installed capital, as measured by Tobin's Q, is greater than 1. As is well known, Q_t represents the shadow price of capital that equals the Lagrange multiplier on the capital accumulation constraint. If $\gamma > 0$ and the marginal source of investment is new borrowing, the $Q-$theory equation implies that I_t is increasing in Q_t, and decreasing in the tightness of the borrowing constraint ϕ_t. Intuitively, investment is determined at the point where the firm is indifferent between investing in an additional unit of capital with price

$\left(1 - \Phi_I'\left(\frac{I_t}{K_t}\right)\right) Q_t$ after adjustment costs, and paying out dividends to the household with value $\left(1 - \tau_t^D\right)$. The presence of an occasionally-binding collateral constraint ($\phi_t \geq 0$) raises the marginal cost of investment, leading the firm to accelerate dividend distributions in order to maintain the equality between the return to investment inside and outside the firm. Put differently, to achieve a higher level of investment, the shadow value of capital must increase in line with the marginal cost of investment.

Now, combine (18) with (19), and use (9), to derive the optimal physical capital Euler equation:

$$\frac{\left(1 - \tau_t^D\right) + \phi_t}{1 - \gamma\left(\frac{I_t}{K_t} - \delta\right)} = \beta \mathbb{E}_t \frac{\Lambda_{t+1}}{\Lambda_t} \left\{ \begin{array}{c} \left(1 - \tau_{t+1}^D\right)\left(1 - \tau_{t+1}^K\right) \alpha \frac{Y_{t+1}}{K_{t+1}} \\ + \left(\frac{\left(1 - \tau_{t+1}^D\right) + \phi_{t+1}}{1 - \gamma\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)}\right)\left[(1 - \delta) + \frac{\gamma}{2}\left(\left(\frac{I_{t+1}}{K_{t+1}}\right)^2 - \delta^2\right) + \phi_{t+1}\theta_{t+1}\right] \end{array} \right\}.$$
(22)

The left-hand side of (22) represents the current value of Q_t, whereas the right-hand side measures the discounted value sum of the future marginal product of capital net of corporate and dividend taxation, the reselling value of non-depreciated capital, future adjustment costs, and the option value of capital used as a collateral asset. Notably, for the credit-constrained firm, acquiring a marginal unit of investment via borrowing raises the anticipated value of capital and acts to relax the borrowing limit in the next period. The marginal benefit from a higher collateralized capital stock that can be used to secure future loans is represented by the term $\mathbb{E}_t \left(Q_{t+1}\phi_{t+1}\theta_{t+1}\right)$. The firm equates between the marginal cost and the expected marginal gains from investment, both of which are altered by the collateral constraint and dividend taxation.

To highlight the link between the 'traditional' and 'new' views of dividend taxation through the investment credit limit, observe from (22) that even a *constant* dividend tax rate ($\tau_t^D = \tau_{t+1}^D = \tau^D$) produces *asymmetric* effects on the marginal cost and benefit of investment when $\phi_t > 0$. Conversely, for $\phi_t = 0$ and $\tau_t^D = \tau_{t+1}^D = \tau^D$, the dividend tax drops out from (22), leaving the capital-investment outcome unchanged as implied from the 'new' view. Intuitively, the collateral constraint multiplier drives a wedge between the frictionless valuation of capital outside the firm, $\left(1 - \tau_t^D\right)$, and the Tobin's Q augmented for the adjustment costs in the credit-constrained economy (see (19)). When the marginal source of funds is determined by new external financing, a permanently lower dividend tax raises Q_t and the return to investment, which, in turn, lifts I_t. This connection between investment financing via debt and dividend taxation is in the spirit of the 'traditional' view.[8] Below we derive the conditions under which the borrowing constraint is binding or non-binding, and show how the representative corporate firm responds differently to dividend tax changes depending on the value of θ and the initial steady state dividend tax rate.

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[8] Santoro and Wei (2011) show in their appendix that proportional dividend taxes obey the 'new' view even in the presence of constrained debt financing that takes a general form: $B_t \leq \theta_t Q_t K_t$, where $Q_t = 1$. In our model, debt is used to finance *new investment* which directly supports capital accumulation (i.e., $B_t = I_t$ and $Q_t \neq 1$). A more explicit investment debt function like in our paper restores the distortionary effects of proportional dividend taxes so long as $\phi_t > 0$.

2.3 Government

The government sets the labor income, corporate, and dividend income tax rates. Total revenue from the various taxes is used to finance lump-sum transfers to households subject to the following balanced budget:

$$T_t = \tau_t^N W_t N_t + \tau_t^K \left(Y_t - W_t N_t\right) + \tau_t^D D_t^a. \tag{23}$$

We examine a fiscal policy disturbance in the form of a dividend tax shock only, while holding the corporate and labor income tax rates constant at their steady state values: $\tau_t^K = \tau^K$ and $\tau_t^N = \tau^N$. Indeed, the aim of our paper is to analyze the macroeconomic effects of dividend taxation in the presence of an investment credit limit.[9]

2.4 Competitive Equilibrium

In a competitive equilibrium, the markets for labor, capital, dividends, debt, and stocks clear with $S_t = 1$ for all t. For the goods market clearing condition, we combine (2), (9), (11), (15), and (23) to obtain the economy-wide resource constraint:

$$A_t K_t^\alpha N_t^{1-\alpha} = Y_t = C_t + K_{t+1} - (1-\delta) K_t + \frac{\gamma}{2} \left(\frac{I_t}{K_t} - \delta\right)^2 K_t. \tag{24}$$

The optimal conditions associated with the household's, firm's, and government's behavior characterize the competitive general equilibrium summarized by (24) and the following equations:

$$\left(1 - \tau_t^N\right)\left(1 - \alpha\right)\frac{Y_t}{N_t} = hC_t, \tag{25}$$

$$q_t = \beta \mathbb{E}_t \frac{C_{t+1}^{-1}}{C_t^{-1}} \left\{ \left(1 - \tau_{t+1}^D\right)\left[\left(1 - \tau_{t+1}^K\right)\alpha Y_{t+1} - I_{t+1}\right] + q_{t+1} \right\}, \tag{26}$$

$$Q_t = \beta \mathbb{E}_t \frac{C_{t+1}^{-1}}{C_t^{-1}} \left\{ \begin{array}{c} \left(1 - \tau_{t+1}^D\right)\left(1 - \tau_{t+1}^K\right)\alpha \frac{Y_{t+1}}{K_{t+1}} \\ + Q_{t+1}\left[(1-\delta) + \frac{\gamma}{2}\left(\left(\frac{I_{t+1}}{K_{t+1}}\right)^2 - \delta^2\right) + \phi_{t+1}\theta_{t+1}\right] \end{array} \right\}, \tag{27}$$

$$Q_t = \frac{\left(1 - \tau_t^D\right) + \phi_t}{1 - \gamma\left(\frac{I_t}{K_t} - \delta\right)}, \tag{28}$$

$$K_{t+1} = \left[(1-\delta) + \frac{I_t}{K_t} - \frac{\gamma}{2}\left(\frac{I_t}{K_t} - \delta\right)^2\right] K_t, \tag{29}$$

$$\phi_t \left(\theta_t Q_t K_t - I_t\right) = 0; \quad \phi_t \geq 0. \tag{30}$$

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[9] As the focus of the paper is on the direct distortionary impact of dividend taxation on the economic activity, we also abstract from government spending financed by taxation.

Definition 1 *(Competitive Equilibrium) Given the initial level of the capital stock (K_0) and shock processes $\{\theta_t, A_t\}_{t=0}^{\infty}$, a competitive equilibrium for the economy with an occasionally-binding credit constraint ($\phi_t \geq 0$) is defined as a sequence of dividend tax policies $\{\tau_t^D\}_{t=0}^{\infty}$, price vectors $\{q_t, Q_t\}_{t=0}^{\infty}$, and private sector allocations $\{Y_t, C_t, N_t, K_{t+1}, I_t\}_{t=0}^{\infty}$, that satisfy equations (24)-(30).*

3 Results

This section describes the main results of the paper. We first present the analytical properties of the deterministic steady state equilibrium, and analyze the long-run effects of the collateral constraint and dividend taxation on capital, investment, asset prices, and output. We then quantitatively examine the interactions between the occasionally-binding credit limit and key macroeconomic variables following unexpected temporary dividend tax shocks. Finally, we inspect the propagation mechanisms of financial shocks in high and low dividend tax environments. To quantitatively solve and estimate the stochastic model with an occasionally-binding collateral constraint, we employ the OccBin algorithm developed by Guerrieri and Iacoviello (2015), and confirm the simulated results with Holden's (2016) DynareOBC procedure.

3.1 The Long-Run Effects of Collateral Constraints and Dividend Taxation

In the non-stochastic steady state, all variables are constant and denoted without the time subscript. A detailed calibration part is presented later in the section before the short-run analysis, but in order to produce some of the figures in this subsection that support the theoretical arguments, we set $\beta = 0.97$, $\delta = 0.12$, $A = 1$, $N = 0.3$, and $\alpha = 0.30$. We also fix $\tau^K = 0.35$ and $\tau^N = 0.28$, which approximately correspond with average long-run effective U.S. corporate and labor income tax rates, respectively.[10]

Proposition 1 *The dividend tax rate τ^D and the borrowing limit θ determine whether an economy is subject to a constrained or a slack equilibrium. In particular:*

(i) If

$$0 < \theta^B < \frac{\delta}{(1 - \tau^D)}, \tag{31}$$

then there exists a unique steady state constrained equilibrium (denoted by superscript B for 'binding') with

$$\phi = \frac{\delta}{\theta^B} - (1 - \tau^D) > 0. \tag{32}$$

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[10]We choose $h = 1.98$ such that $N = 0.3$ in the deterministic steady state. This is consistent with the average fraction spent on market work (see also Gourio and Miao (2011) and Jermann and Quadrini (2012)). The rate of depreciation in the capital stock and share of capital in production are set in line with Gomes (2001), and are broadly consistent with the data. While some recent studies suggest that α has increased over time, keeping this value at a slightly lower value helps to obtain a closer match between cyclical output volatility in the model and the data. Otherwise, our results remain robust to different plausible values of α as well as to any reasonable parameterization of τ^K and τ^N. The value chosen for β is standard for annually calibrated business cycle models.

(ii) If

$$\theta^{NB} \geq \frac{\delta}{(1 - \tau^D)}, \tag{33}$$

then there exists a unique steady state unconstrained equilibrium (denoted by superscript NB for 'non-binding') with $\phi = 0$.
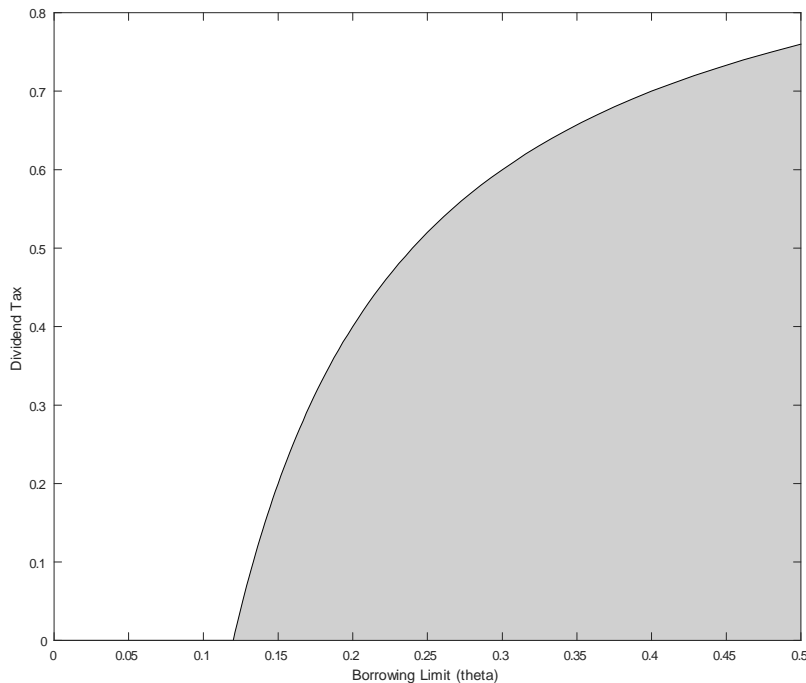
Proof 1. *See Appendix* ∎

Figure 1: Constrained (white) and unconstrained (grey) equilibrium regions.

Figure 1 provides a visual representation of Proposition 1. The threshold between the constrained and the unconstrained equilibria lies in the region of empirically-plausible values of τ^D and θ.[11] The Lagrange multiplier ϕ is decreasing in the fraction of the value of capital that can be borrowed against, as a rise in θ makes the borrowing constraint less binding. Without dividend taxation, we must set $\theta^B < \delta$ for the collateral constraint to bind. Introducing dividend taxation breaks down this relationship by lowering the market valuation of capital, and reducing the value of the collateralized capital stock, both of which result in the tightening of the borrowing constraint. Put differently, a hike in the dividend tax rate and/or a fall in the LTV ratio can move the long-run

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[11]Covas and Den Haan (2011) document that θ ranged from 0.1 to 0.4 for various sizes of firms over the period 1980-2006. Wang and Wen (2012) calibrate $\theta = 0.08$.

unconstrained equilibrium regime to a constrained one. The two regions create two different steady states that yield distinct values of the capital stock, Tobin's Q, and equity prices. This is formally expressed in the following proposition.

Proposition 2 *The steady state values of the capital stock, Tobin's Q, and equity prices depend on the value of ϕ and therefore on whether the economy faces a constrained or an unconstrained credit regime. Specifically:*

(i) If $\phi > 0$ (i.e., binding region), the capital stock, Tobin's Q, and equity prices are given by:

$$\left(\frac{K}{N}\right)^B = \left\{ \frac{\alpha\left(1-\tau^K\right)}{\left[1 + \frac{\phi}{(1-\tau^D)}\right]\left(\beta^{-1}-1\right) + \delta} \right\}^{\frac{1}{1-\alpha}},\tag{34}$$

$$Q^B = \left(1-\tau^D\right) + \phi = \frac{\delta}{\theta^B},\tag{35}$$

$$q^B = \frac{\delta}{\theta^B}K^B.\tag{36}$$

(ii) If $\phi = 0$ (i.e., slack region), capital stock, Tobin's Q, and equity prices are determined by:

$$\left(\frac{K}{N}\right)^{NB} = \left[\frac{\alpha\left(1-\tau^K\right)}{\left(\beta^{-1}-1\right)+\delta}\right]^{\frac{1}{1-\alpha}},\tag{37}$$

$$Q^{NB} = \left(1-\tau^D\right),\tag{38}$$

$$q^{NB} = \left(1-\tau^D\right)K^{NB}.\tag{39}$$

Proof 2. *See Appendix* ∎

The credit constraint ϕ acts to raise the firm's marginal cost and Q by lifting borrowing costs, and driving a wedge between the internal and external valuations of capital. In order to maintain the same level of wealth, the shareholder requires an equity premium as reflected by the *effective* augmented rate of return on stocks $\left[1 + \phi\left(1-\tau^D\right)^{-1}\right]\left(\beta^{-1}-1\right)$, that is increasing in the tightness of the borrowing constraint. In the binding steady state environment, a higher ϕ raises the spread between the frictionless share return, equal to the household's rate of time preference $\left(\beta^{-1}-1\right)$, and the stock return in the credit-constrained economy. As a result, the firm reduces the capital stock and investment, and increases dividend distributions when financial frictions become more prevalent; i.e., $\left(\frac{K}{N}\right)^B < \left(\frac{K}{N}\right)^{NB}$ for $\phi > 0$.

In the frictionless economy, the wedge between the physical capital stock and its market valuation is determined by the dividend tax only as seen from (39). A cut in τ^D raises the stock price proportionally and increases the value of the household's wealth. The household is willing to hold more wealth as long as the rate of return is equal to the time preference rate. As a consequence,

share prices rise, while the capital stock, investment, and output remain the same. This conforms with the 'new' view of dividend taxation, wherein a change in the dividend tax rate impacts the firm's sources and uses of funds symmetrically, as also shown by McGrattan and Prescott (2005) and Santoro and Wei (2011).

Nevertheless, when the collateral constraint binds, a change in τ^D alters the effective rate of return on stocks required by the household, thereby resulting in a direct impact on the firm's capital and investment decisions. Here, the physical capital Euler equation (22) and its steady state representation in (34) are distorted by the combination of $\phi > 0$ and τ^D. A dividend tax cut that, *ceteris paribus,* raises asset prices, reduces the cost of capital $\left[1 + \phi \left(1 - \tau^D\right)^{-1}\right] \left(\beta^{-1} - 1\right)$, and stimulates K and consequently I. Intuitively, the tax relief limits the tightness of the borrowing constraint and facilitates additional lending for investment purposes. Furthermore, the upward pressure on Q stemming from a positive ϕ is offset by any decrease in τ^D such that the book value of capital remains unchanged at δ/θ^B following a tax reform in the binding long-run equilibrium (observe (35)). Equity prices, on the other hand, rise in response to the tax reduction due to the positive relationship between q and K (see (36)).

Our model therefore produces distortionary steady state effects of dividend taxation without having to assume internally growing firms over the life-cycle and/or heterogenous firms facing different finance regimes as in Korinek and Stiglitz (2009), Gourio and Miao (2010), and Erosa and González (2019). The steady state values of δ, θ, and τ^D determine whether the representative firm is subject to a binding or non-binding credit constraint, which, in turn, dictates to what extent dividend tax adjustments affect the economic activity. The above discussion and the steady state implications of dividend tax reforms are summarized in the subsequent proposition.

Proposition 3 *A cut (hike) in the dividend tax rate increases (lowers) the stock of capital and welfare when the economy is credit-constrained, conforming the 'traditional' view of dividend taxation. In an unconstrained economy, dividend taxes are irrelevant for the marginal investment decisions and welfare, as hypothesized by the 'new' view of dividend taxation.*

Figure 2 visualizes the changes in the steady state values of the capital-to-labor ratio, Tobin's Q, equity prices, and welfare when the tax rate is varied between 0 and 50 percent under three distinct borrowing scenarios.
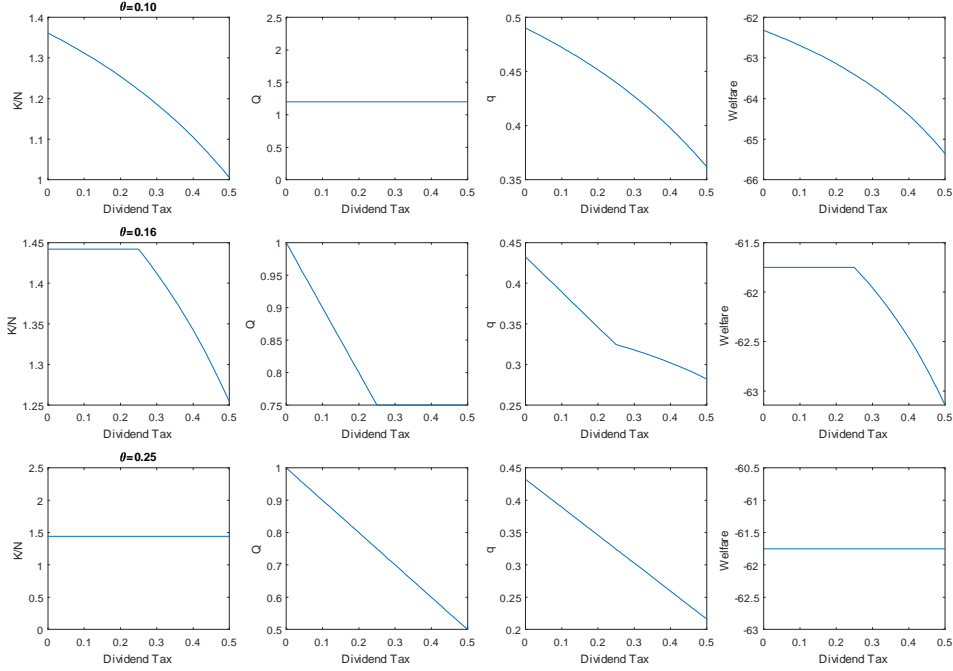
Figure 2: Steady state values of the capital-to-labor ratio, Tobin's Q, equity prices, and welfare when the dividend tax rate is varied between 0 and 50 percent under three different borrowing regimes.

In the constrained equilibrium ($\theta = 0.10$), a fall in the dividend tax elevates the capital stock and share prices, but leaves Tobin's Q unchanged (see the first row of Figure 2). As capital is the main driver of output and welfare in neoclassical production economies, tax reductions are thus welfare enhancing in the binding regime.[12] By contrast, in the slack equilibrium ($\theta = 0.25$), where the firm finances investment via retained earnings, a tax on dividends only influences Q and q, leaving capital, investment, and welfare unchanged (see the third row of Figure 2). For the intermediate case ($\theta = 0.16$) and as observed from the second row of Figure 2, the economy finds itself in a constrained equilibrium when the dividend tax rate is greater than 25 percent. If tax cuts occur from those initially relatively higher tax rates, K/N and steady state welfare increase until reaching their levels in the slack regime and remain unchanged thereafter (as also postulated from Propositions 1 and 2). In all credit regimes and from a qualitative perspective, the capital-to-labor ratio and welfare respond in an identical fashion to dividend tax adjustments.

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[12] The steady state welfare measure is given by: $\left(\ln\left(C\right) - hN\right)/\left(1 - \beta\right)$, where $C = \left(1 - \tau^N\right)\frac{(1-\alpha)}{h}\left(\frac{K}{N}\right)^{\alpha}$ from (24) and (25).

3.2 Quantitative Analysis and Short-Run Model Dynamics

3.2.1 Calibration

The time period in the model is one year. The baseline parameterization used to analyze the short-run dynamics is summarized in Table 1. We largely follow the calibration of general equilibrium models that are calibrated at an annual frequency, and which include investment frictions and/or various forms of taxation (e.g., Gomes (2001), McGrattan and Prescott (2005), Gourio and Miao (2010, 2011), and Anagnostopoulos, Cárceles-Poveda, and Lin (2012)). Specifically, some parameter values are borrowed from the literature whereas others are calibrated or estimated in order to approximately match some model moments with those observed in the U.S. data.

Table 1 - Benchmark Calibration		
Parameter	**Value**	**Description**
β	0.97	Discount factor
h	1.98	Labor disutility parameter
δ	0.12	Capital depreciation rate
α	0.30	Capital share in production
A	1.00	Average productivity parameter
θ^B	0.16	Borrowing limit in the benchmark binding equilibrium
θ^{NB}	(0.185,1)	Borrowing limit range in the non-binding equilibrium
τ^N	0.28	Labor income tax rate
τ^K	0.35	Corporate tax rate
τ^D	0.35	Dividend tax rate
γ	12.0	Capital adjustment cost parameter
ρ^θ	0.76	Degree of persistence - Financial shock
σ^ϑ	0.088	Standard deviation - Financial shock

From Proposition 1, the region under which the collateral constraint is binding in steady state depends crucially on empirically-plausible ranges for the borrowing limit, the dividend tax rate, and the depreciation rate. Setting $\delta = 0.12$ to match the average nonresidential investment rate found in the data, and using condition (31), we fix $\theta^B = 0.16$ and $\tau^D = 0.35$ such that the benchmark economy confronts a constrained steady state equilibrium with $\phi = 0.10$ (see also (32) and Figure 1).[13] Examining the time series of the investment rate and Tobin's Q from 1980 to 2020, and using our steady state propositions, we find that θ over the sample term ranges from a minimum value of 0.10 to a maximum value of 0.25 with an average of 0.16.[14] These estimates lie within range of Jermann and Quadrini (2012) and Covas and Den Haan (2011). The steady state dividend tax rate

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[13] Average aggregate U.S. statistics are extracted from the Federal Reserve Economic Data (FRED) data produced by the St. Louis Fed, OECD data, and IMF data.

[14] Note that we have used these values in the earlier steady state analysis.

of 35 percent is fairly consistent with the U.S. average dividend income tax rate that includes both federal and state taxes.

Our choice of parameters imply a steady state investment to GDP ratio of 15.03 percent, an average dividend to GDP ratio of 4.47 percent, and $Q^B = 0.75$. All these statistics are pretty close to their long-run data counterparts. Notice that with the initial dividend tax rate fixed at 0.35, the frictionless steady state model with $\phi = 0$ yields $Q^{NB} = 0.65$. Therefore, the binding collateral constraint in steady state helps to obtain a higher and more data-consistent estimate for Q.[15] Nevertheless, to examine the dynamic responses following temporary dividend tax changes, we compare the case where the initial position of the economy is in a binding steady state equilibrium to the situation in which the long-run collateral constraint is slack. In the latter and for $\delta = 0.12$ and $\tau^D = 0.35$, we can choose any value $\theta^{NB} \geq 0.185$ so that $\phi = 0$ in line with condition (33).

Turning to the adjustment cost parameter, estimates of γ vary significantly in the literature, where its magnitude is typically calibrated using equation (21) in order to match the elasticity of the investment rate with respect to Tobin's Q with its data equivalent. This investment Q regression elasticity may range from a mean of 0.0423, as computed by Hayashi (1982), to 0.23, as calibrated by Jermann (1998). In a model like ours, the investment Q elasticity is equal to the inverse of the adjustment cost coefficient.[16] We pick $\gamma = 12$, corresponding with an elasticity of 0.083, as an intermediate compromise value. Including capital adjustment costs helps to better relate the model-implied volatility and hump-shape movements in aggregate investment and output with the data.

Finally, using standard Bayesian estimation techniques, we calibrate the persistence parameter and standard deviation of the financial shock to reproduce the standard deviation of the nonresidential investment rate found in the data for the period 1980-2020.[17] The *annually* estimated occasionally-binding model implies choosing $\rho^\theta = 0.76$ and $\sigma^\theta = 0.088$.[18] Table 2 reports the standard deviations and autocorrelations of key variables in our model and how they fare with their respective equivalents in the data.

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[15]The Q ratio in the U.S. has increased on average from 1996 to 2020 with a mean of 1.12 compared to 0.55 during 1980-1995.

[16]Elberly, Rebelo, and Vincent (2012) find that the investment Q elasticity is 0.06, implying a capital adjustment cost parameter of 17 (see also Christiano, Eichenbaum, and Rebelo (2011), and Andrei, Mann, and Moyen (2019) who estimate $\gamma = 16$).

[17]As the focus of the stochastic part of the paper is on LTV shocks, we abstract from additionally calibrating and analyzing the technology shock and keep it constant with $A_t = A = 1$. We could calibrate the moments of the productivity shock to match the standard deviation of another variable of interest, but this nevertheless would not have any material impact on our analysis.

[18]Similar shock moments to our Bayesian piecewise-linear estimation results are obtained by constructing a detrended time series for θ_t using a Solow (1957)-residual-style regression approach. Guerrieri and Iacoviello (2017) also find that the differences in estimates between piecewise-linear and linear models are *not* significantly large.

Table 2 - Comparing Model and Data: Business Cycle Moments

	$\sigma\left(\frac{I_t}{K_t}\right)$	$\text{corr}\left(\frac{I_t}{K_t}, \frac{I_{t-1}}{K_{t-1}}\right)$	$\sigma\left(\frac{I_t}{Y_t}\right)$	$\sigma\left(Y_t\right)$	$\sigma\left(\frac{\bar{D}_t}{Y_t}\right)$
Model	0.07	0.689	0.069	2.169	0.232
Data	0.07	0.783	0.068	2.029	0.310

Model standard deviations are computed from 10,000 simulations keeping θ_t stochastic.

All statistics are annualized, detrended, and measured in percentage terms.

Data statistics are computed from detrended annual series (1980-2020) extracted from the FRED database.

3.2.2 Temporary Dividend Tax Shocks

In the first counterfactual policy experiment, we compare the behavior of the unconstrained economy model with the occasionally credit-constrained model following a dividend tax rate cut of 10 percentage points; from an initial 35 percent to 25 percent. The tax adjustment in both scenarios occurs in period 1, is assumed to be temporary, and lasts for 8 periods. After the 8 periods, τ_t^D reverts to its previous long-run level. Suppose the tax policies are unanticipated initially, but once they occur, the agents have perfect foresight about their future paths. Despite largely being extended in early 2013, the original 2003 U.S. dividend tax relief was set to expire in 2012, highlighting the temporary yet persistent nature of such fiscal reform. The experiments conducted in this section allow us to study the strikingly different implications of transitional dividend tax reforms caused by the investment credit constraint and the economy's initial steady state credit position.

The dynamics of the key variables following the temporary tax cut are shown in Figure 3. In the unconstrained regime, a transitional dividend tax shock generates a collapse in investment and therefore in capital accumulation and output. These results are largely in line with the findings of Gourio and Miao (2011), who also show that firms distribute large dividends and cut back on capital investment in response to a temporary dividend tax cut. Furthermore, from equations (27) and (28) with $\phi_t = 0$, Tobin's Q initially rises upon the impact of the tax reduction placing some upward pressure on I_t in period 1. However, Q_t starts to decrease until period 8 and then slowly converges to its steady state because τ_t^D rises back permanently to its original level at the start of period 9. Investment follows an opposite path to Q_t as the effect of increasing dividends in response to the tax cut dominates the otherwise positive relationship between investment and its shadow price. Due to an intertemporal substitution effect, consumption slightly increases in the first period, declines from periods 2 to 8, and starts to revert to its long-run level as soon as the tax shock ends. Given condition (25) and with capital predetermined at the start date of the tax reform, employment shrinks, which, in turn, amplifies the decrease in output.[19] In view of the expected tax policy reversal from period 9, the firm responds by sharply cutting dividends and accelerating investment

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[19]Gourio and Miao (2011) find that employment and investment move in the opposite direction of output in the immediate periods following the tax shock.

in period 8. This leads to a slower rate of decline in Q_t in the subsequent year. To summarize, lower temporary dividend taxes have an overall strong short-run *contractionary* impact on the real economy.
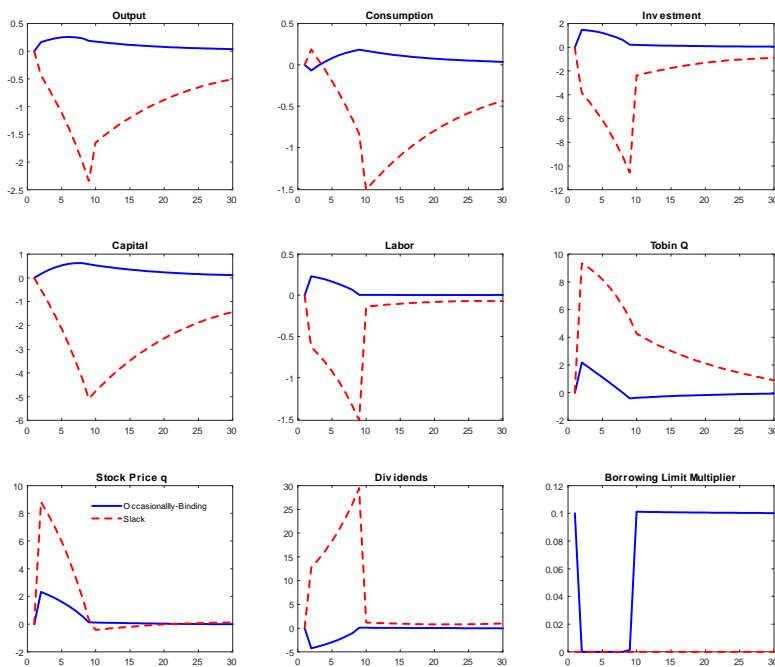

Figure 3: Dynamic responses following an unexpected temporary dividend tax cut
in the occasionally-binding and permanently slack models. Except for the
borrowing limit multiplier that is calculated in levels, all other variables are
measured in percentage deviations from the different steady states corresponding
with the different credit regimes.

On the other hand, under the occasionally-binding credit regime, the same dividend tax cut results in an investment, capital, and output rise. The aforementioned large dividend payout prevailing in the unconstrained model is counteracted by the relaxation in the tightness of the collateral constraint (ϕ_t) that is directly impacted by the fall in τ_t^D. Intuitively, the lower dividend tax raises Q_t and increases the value of the firm's collateralized capital stock. With an initially binding steady state collateral constraint, the firm can therefore engage in additional borrowing and raise its investment in physical capital. The temporary 10 percentage point tax cut renders a slack credit constraint during periods 1 to 8 followed by an immediate jump to the originally positive long-run level of ϕ_t in period 9. The firm takes advantage of the interim relaxed credit environment

to make further investments and to limit dividend payouts in the first period. However, from periods 2 to 8 and as the capital stock is expected to improve, which allows the firm to borrow against future earnings, dividend distributions increase while investment declines. Once the tax relief expires, both these variables slowly return to their steady states. Notice also that while consumption falls below its steady state in the first period due to intertemporal substitution, this variable overall exhibits lumpiness and remains above its long-run level throughout most of the duration of the tax reform and beyond. Overall, easing the tightness of the investment credit limit in relation to the binding steady state results in dividend taxes inducing short-run *expansionary* effects on the real economic activity.[20]

Unlike our paper, Gourio and Miao (2011) in their extended model with debt financing do not predict that investment rises in the period when the dividend tax cut occurs. In fact, their model suggests that the transitional dynamics of real variables with and without debt are very similar. When the debt limit applies directly to investment in physical capital like in our framework, the short-term macroeconomic effects of temporary dividend tax reforms become more consistent with the 'traditional' view of dividend taxation. Output, labor, and investment also exhibit a procyclical relationship on impact regardless of the economy's original position.

Finally, in relation to the earlier dividend tax literature without financial frictions or with frictions that are always binding, the model presented here captures the non-linearities and asymmetries associated with the occasionally-binding nature of the investment credit constraint. Figure 4 shows the dynamic responses following a 10 percentage point tax cut and hike relative to the binding steady state equilibrium. The tax rise tightens the credit constraint and brings about a magnified decline in investment, labor, and output when compared to the dynamics following the same size tax cut that temporarily switches the credit regime from binding to slack. Albeit quantitatively modest, our model does capture the potentially asymmetric dynamic responses of financial and real variables following unexpected temporary dividend tax changes (see also Boissel and Matray (2022)).

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[20]Smaller adjustment costs quantitatively exacerbate the dynamic reactions of real and financial variables in both the occasionally-binding and permanently slack environments. Nonetheless, these costs, so long as positive, do not change any of the qualitative policy implications that arise from this experiment. Extra simulations of tax shocks with different parameterization of γ are available upon request.
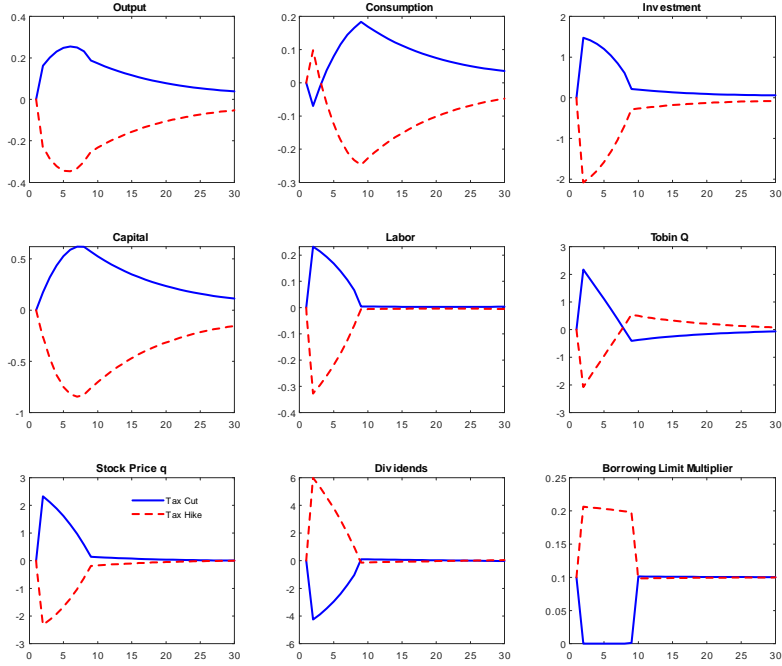
Figure 4: Dynamic responses following an unexpected temporary dividend tax cut
and hike relative to the common binding steady state regime. Notice that the solid
line is the same as the solid line in Figure 3.

3.2.3 Financial Shocks

We now turn to study the transmission channels of LTV shocks and how these are altered by the long-run dividend tax rate and capital adjustment costs.

   Positive LTV Shock under High and Low Tax Environments.- Figure 5 displays the impulse responses of the key variables to a positive one-standard deviation shock to θ_t. We compare the dynamics of the model under the relatively high steady state dividend tax benchmark system $(\tau^D = 0.35)$, with the fluctuations that arise in a lower long-run tax environment $(\tau^D = 0.28)$.
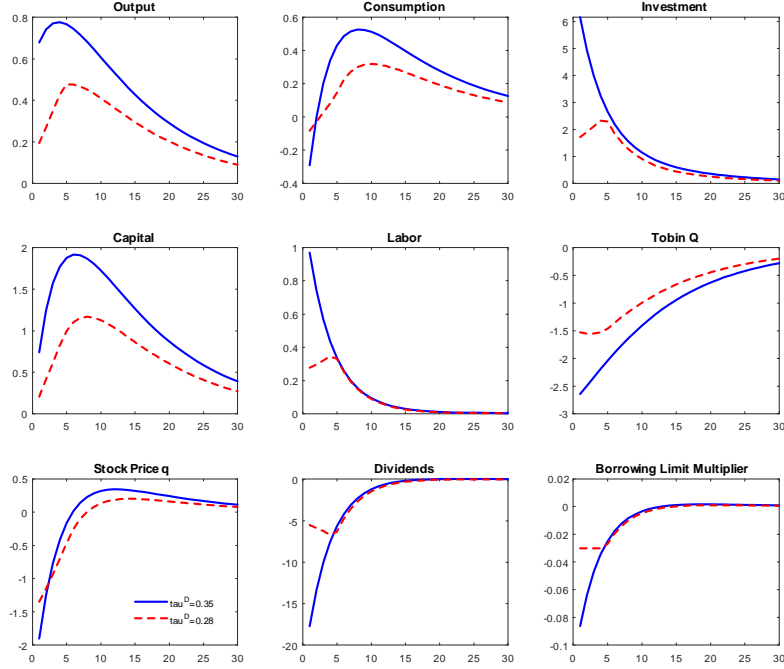
Figure 5: Impulse responses following a one-standard deviation positive LTV shock. The vertical axes measure percentage deviations from the different steady states corresponding with the high and low dividend tax rates.

Under both fixed tax regimes, the collateral constraint is initially binding in the steady state. However, for $\tau^D = 0.28$ and our baseline calibration, the long-run value of ϕ is 0.03, as opposed to $\phi = 0.10$ when $\tau^D = 0.35$. Thus, for the same given shock size and volatility, the borrowing constraint becomes slack more frequently in the lower tax world, thereby resulting in an immediate strong attenuation impact on all macroeconomic and financial variables.[21]

The general equilibrium effects of the financial shock can be explained as follows: as θ_t rises, ϕ_t falls and the collateral constraint becomes looser. Inside and outside asset prices Q_t and q_t decline as capital becomes less valuable as a collateralized asset used for the purpose of obtaining investment loans. At the same time, the laxer lending constraint allows the firm to take on more debt and consequently to raise investment in physical capital, producing a cutback in dividend payouts. Furthermore, consumption slightly drops upon the impact of the shock, given that the household substitutes away from spending and into further investment in the firm. Nonetheless, as

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[21]From our benchmark calibration and condition (32), notice that permanently lowering τ^D to a rate equal or below 0.25 results in a slack collateral constraint in steady state. Therefore, the positive collateral shock considered in this section would *not* have any impact on the real and financial variables for $\tau^D \leq 0.25$.

investment and the capital stock improve, consumption gradually grows in a hump-shape fashion followed by a slow return to its steady state. Hence, labor initially jumps, which together with the increase in physical capital, raise the level of output.

The looser credit regime that prevails when $\tau^D = 0.28$ supports a higher steady state stock price, and larger fractions of investment and capital out of GDP.[22] Because q_t and I_t play an important role in smoothing consumption, the higher values obtained for these variables when ϕ is lower, imply significantly muted responses to a given credit shock. Importantly, the borrowing limit multiplier hovers at zero for 5 periods in the low tax environment, while staying consistently positive in the high tax regime, despite the temporary credit loosening. When the constraint is slack and asset prices remain relatively higher, the firm pays out dividends from retained earnings and limits capital investment. In particular, dividends distributions fall by less, while the investment response exhibits lumpiness and smaller volatility in relation to the dynamics under $\tau^D = 0.35$. Moreover, in the slack regime, the investment limit affects the firm only through expectations. The longer is the duration of the slack constraint, the more the firm discounts the borrowing constraint. Accordingly, the responses of real and financial variables are not as dramatic as the reactions observed in the higher tax regime. The upshot is that a permanently relaxed dividend tax system makes the economy less prone to business cycle fluctuations instigated by positive financial disturbances.[23] Considered more broadly, potential excessive debt levels associated with surging investment in the short-run can be largely contained by a permanently reduced dividend tax rate that brings the economy closer to a slack credit regime.

Asymmetric Effects of Financial Shocks in a Low Tax Environment.- Our final counterfactual exercise concerns the asymmetric dynamic responses of key variables following positive and negative LTV shocks of the same magnitude. We assume a relatively low steady state dividend tax burden of 28 percent to highlight the results presented in Figure 6.

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[22]Recall that steady state Q is independent of the dividend tax rate when the borrowing constraint is binding (see Proposition 2 and specifically (35)).

[23]In experiments not reported here, we also find that a relatively reduced constant tax rate mitigates to some degree real fluctuations following adverse financial shocks that tighten the borrowing constraint and that do not result in temporary credit regime switching. However, asset prices and dividends become somewhat more volatile in this case. The attenuation mechanism on real variables caused by the lower steady state tax is also present following positive technology shocks, though to a smaller extent. These additional simulations are available upon request.
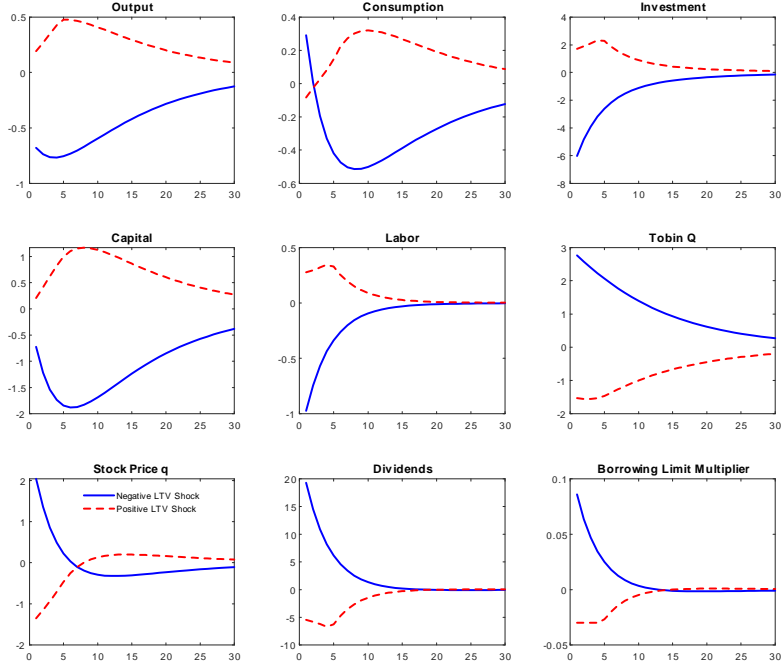
Figure 6: Impulse responses following a one-standard deviation positive and negative LTV shocks under $\tau^D = 0.28$. The vertical axes measure percentage deviations from the common binding steady state regime.

After a favorable LTV shock and under the low dividend tax regime, the initially binding credit constraint turns slack and attenuates the otherwise more sizeable fluctuations arising in the credit-constrained model (see Figure 5). An adverse financial shock, on the other hand, tightens the investment credit limit and reduces the collateral capacity of the liquidity-constrained firm. The firm accordingly distributes more dividends and cuts back on investment, translating into a sharp deterioration in business activity and elevated asset prices. Following one-standard deviation unfavorable and favorable financial disturbances, it can easily be shown that the Lagrange multiplier on the collateral constraint invariably stays positive when the long-run tax rate is 35 percent. In this case, the model produces symmetric macroeconomic reactions given the absence of regime switching. Put differently, a permanently lower dividend tax system that pushes the economy closer to a slack credit environment can explain substantial macroeconomic asymmetries, conditional on same size credit shocks moving in opposite directions.[24]

The Role of Capital Adjustment Costs.- As a sensitivity analysis, we examine the role of adjust-

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[24]On the asymmetric macroeconomic effects of aggregate shocks and associated business cycle skewness, see also Guerrieri and Iacoviello (2017) and Jensen, Petrella, Ravn, and Santoro (2020).

ment costs in explaining the attenuation mechanism following financial shocks caused by the lower long-run dividend tax rate. We consider the same experiment as analyzed in Figure 5, with the exception that the adjustment costs are now considerably lower and set to $\gamma = 3$. The dynamics of the model following the positive one-standard deviation credit shock in both steady state dividend tax systems are displayed in Figure 7.
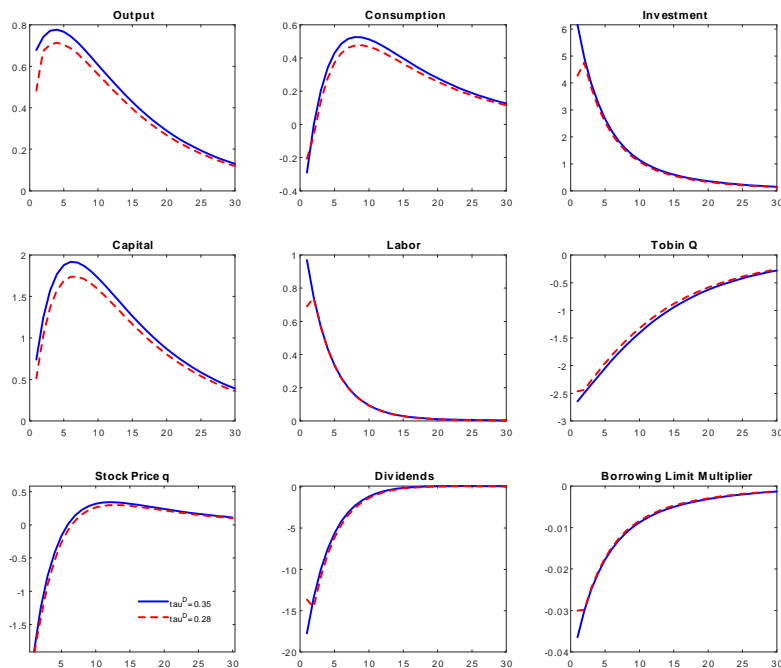

Figure 7: Impulse responses following a positive one-standard deviation LTV shock with $\gamma = 3$. The vertical axes measure percentage deviations from the different steady states corresponding with the high and low dividend tax rates.

The *qualitative* macroeconomic implications resulting from the financial disturbance remain the same when $\gamma = 3$. In particular, enacting a permanently lower dividend tax rate mitigates financial business cycles. From a *quantitative* perspective, higher capital adjustment costs help to smooth the reaction of aggregate investment and the responses of all other variables to the shock when the collateral constraint is occasionally-slack (compare dashed line in Figure 5 with dashed line in Figure 7).

However, during the period in which the investment borrowing constraint is always binding, a larger γ makes virtually no difference to the model dynamics, except for the reaction of the credit multiplier which falls by less when $\gamma = 3$ (compare solid line in Figure 5 with solid line in Figure 7).

Intuitively, the firm maximizes investment according to condition (19) such that any rise in ϕ_t that lowers investment is largely counteracted by overall smaller adjustment costs, that, in turn, limit the decline in K_t and I_t. In the credit-constrained regime, adjustment costs play a minimal role in explaining the behavior of key variables, in contrast to the different dynamics that occur in the slack regime. Overall, setting $\gamma = 12$ in the occasionally-binding model magnifies the differences between the fluctuations emerging in the high and low tax systems.

4   Conclusions

We have devised a representative agent business cycle framework that connects the 'traditional' and the 'new' views of dividend taxation through an occasionally-binding investment credit limit. Dividend tax reforms produce contrasting effects on the economic activity depending on the steady state and the temporary finance regime faced by the corporate firm. In the long-run, dividend taxes distort the real economy when the collateral constraint binds, but have zero real impact when the firm finances investment from retained earnings only. The interplay between dividend taxation and the LTV ratio determines the effectiveness of tax cuts in stimulating real variables in the deterministic steady state. In the short-run, dividend taxation has strong implications in terms of investment decisions, asset pricing, employment, and production. Unexpected temporary dividend tax reductions increase aggregate real quantities in the near-term when the firm relies on credit to finance investment. Conversely, once the credit regime turns slack, the lower dividend tax rate induces a contractionary impact on the business activity. The initial credit position of the firm is crucial for understanding the efficacy of dividend tax reforms. Moreover, the stochastic model reveals that a permanently lower tax regime considerably attenuates the responses of real and financial variables to favorable LTV shocks, and helps to explain increasingly asymmetric macroeconomic dynamics following positive and negative disturbances of the same magnitude.

We see three important directions for future research. First, despite the relative simplicity and familiarity of the otherwise standard dynamic general equilibrium setup presented in this article, incorporating household and firm heterogeneity would allow us to understand the distributional effects of dividend taxation from both positive and normative perspectives. Second, our model focuses merely on dividend taxes and their interactions with occasionally-binding credit limits. A warranted extension would be to enable firms to finance investment through both debt and equity, with occasionally-binding restrictions applied to both forms of funding. Then, the model could be used to understand the conditions under which one or both of the constraints become binding or slack, and how these frictions are affected by a richer set of corporate taxes as well as LTV ratios. Third, we may consider how collection of dividend taxes finances public expenditures and debt in times of persistently large government deficits. In this regard, analyzing the linkages between financial frictions, various corporate taxes, fiscal deficits, and the economic activity should be high on the research agenda.

Appendix

This appendix provides proofs to Propositions 1 and 2 that are presented in the main text.

Proof of Proposition 1

From the steady state versions of (28), (29), (30), and $\phi > 0$ we have:

$$I = \delta K = \theta \left(1 - \tau^D + \phi\right) K,$$

or after re-arranging $\phi = \frac{\delta}{\theta} - \left(1 - \tau^D\right)$. It is straightforward to verify that $\phi > 0$ if and only if $\theta < \frac{\delta}{(1-\tau^D)}$, while $\phi = 0$ if and only if $\theta \geq \frac{\delta}{(1-\tau^D)}$.

Proof of Proposition 2

i) As shown in Proposition 1, the borrowing constraint binds when $\phi > 0$ or $\theta < \frac{\delta}{(1-\tau^D)}$. For $\phi > 0$, solving equations (24) with (26)-(30) in steady state yields:

$$q = \frac{\beta \left(1 - \tau^D\right)}{(1 - \beta)} \left[\left(1 - \tau^K\right) \alpha \left(\frac{N}{K}\right)^{1-\alpha} - \theta Q\right] K, \tag{A1}$$

$$Q = \frac{\beta}{\{1 - \beta \left[(1 - \delta) + \phi\theta\right]\}} \left(1 - \tau^D\right) \left(1 - \tau^K\right) \alpha \frac{N^{1-\alpha}}{K^{1-\alpha}}, \tag{A2}$$

$$Q = \left(1 - \tau^D\right) + \phi. \tag{A3}$$

Substituting $\phi = \frac{\delta}{\theta} - \left(1 - \tau^D\right) > 0$ or $\theta\phi = \delta - \theta \left(1 - \tau^D\right)$ in (A1)-(A3) produces conditions (34)-(36).

ii) The borrowing constraint is slack when $\phi = \frac{\delta}{\theta} - \left(1 - \tau^D\right) = 0$ or $\theta = \frac{\delta}{(1-\tau^D)}$. Moreover, from the complementary slackness condition, the collateral constraint is slack when $I < \theta Q K$. Applying $I = \delta K$, $\phi = 0$, and $Q = \phi + \left(1 - \tau^D\right)$ we obtain: $\theta \geq \frac{\delta}{(1-\tau^D)}$. Substituting $\phi = 0$ in (A1)-(A3) then yields (37)-(39).

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