The Macroeconomic Effects of Business Tax Cuts

Filippo Occhino*

September 2022

Abstract

This paper studies the macroeconomic effects of business tax cuts using a dynamic general equilibrium model that incorporates debt and equity financing, interest deductibility, and accelerated depreciation of capital. The tax cuts stimulate persistently business investment and output, but the size of the effects is rather small. Other tax policy tools, such as increases in depreciation allowances and investment tax credits, are more efficient at stimulating investment. Debt financing, the tax treatment of investment, and the persistence of the tax cuts play crucial roles for the estimates.

Keywords: Debt financing, interest deductibility, accelerated depreciation, tax shields.

JEL Classification Numbers: E32, E62, H25, H30.

*Department of Economics, Finance, and Quantitative Analysis, Coles College of Business, Kennesaw State University. E-mail: focchino@kennesaw.edu. I thank the Bagwell Center for the Study of Markets and Economic Opportunity for generous funding.

1 Introduction

In 2017, Congress passed the Tax Cuts and Jobs Act, a tax reform that included a permanent cut in the income tax rate for corporations from 35 percent to 21 percent, and a smaller temporary cut in the income tax rate for pass-through businesses. More recently, in the President's Budget for fiscal year 2023, President Biden proposed that Congress partially reverse the corporate tax cut, raising the corporate tax rate to 28 percent. These are examples of changes in business income tax rates. What are the macroeconomic effects of such changes?

In this paper, I study the macroeconomic effects business tax cuts using a dynamic general equilibrium model that incorporates key features of business financing and tax legislation: debt and equity financing, interest deductibility, and accelerated depreciation of capital. These features play a key role for the effects of tax changes on investment: While in standard models a cut in the business income tax rate always raises investment, in models with debt financing, interest deductibility, and accelerated depreciation, it raises equity-financed investment but may lower debt-financed investment (Fullerton 1999).

The reason why debt financing and capital depreciation are so important for the effects of tax cuts has to do with the tax treatment of investment and interest expenses. A business tax cut has two partial-equilibrium effects on business investment, working in opposite directions. On the one hand, to the extent that businesses cannot immediately deduct their investment expenses, a business income tax discourages investment, so a cut in the tax rate stimulates investment. On the other hand, to the extent that businesses finance their investment through debt and deduct the associated interest expenses, a cut in the tax rate reduces the tax shield provided by interest deductibility and discourages investment. The balance of these two partial-equilibrium effects depends on how fast businesses can depreciate their capital for tax purposes, and whether they finance their investment through equity or debt. Besides these partial-equilibrium effects, the overall macroeconomic effect of the tax cut on investment depends on the additional effect on the capital structure and financing of businesses and on the general equilibrium effects on interest rates, the wage rate, and labor.

In this paper, I study the overall effect of a business tax cut on investment using a dynamic general equilibrium model that captures the just-described partial-equilibrium and general-equilibrium channels. The model builds upon Occhino (2022), adding the choice by businesses to finance their investment with a mix of debt and equity. Using plausible values for the share of financial capital that is debt (21 percent) and for capital depreciation, the model predicts that a 1 percentage point permanent cut in the business income tax rate raises business investment by 0.25 percent in the initial year, with the effect persisting over time. The effect on output is small, only 0.05 percent, although it increases over time.

The rather small macroeconomic effects of the tax cut are due to the facts that businesses partly finance their investment through debt and accounting depreciation is faster than economic depreciation. In the model, the effects of a tax cut depend on business financing and capital depreciation in a way consistent with theory. Since the tax distorts investment, a tax cut stimulates it. However, interest deductibility and accelerated depreciation provide tax shields that reduce the tax distortion. A tax cut lowers the tax shields, and this channel mitigates the stimulative effects of the tax cut. The higher the share of financial capital that is debt and the faster the capital depreciation allowed by the tax system, the smaller the stimulative effects of the tax cut.

Because the stimulative effects of tax cuts are rather small, other tax policy tools are more efficient at stimulating investment. Both an increase in depreciation allowances and an increase in investment tax credits require a smaller decrease in the business tax liability and government tax revenue to generate the same increase in investment. Stated alternatively, these policies generate a larger increase in investment with the same decrease in business tax liability and government tax revenue.

This paper contributes to two strands of literature. First, it belongs to the literature that uses dynamic general equilibrium models to study the macroeconomic effects of tax changes (for instance, House and Shapiro 2006, Fernández-Villaverde 2010, Sims and Wolff 2018, and Occhino 2022). Relative to Occhino (2002), in this paper businesses finance investment with a mix of debt and equity, which is important to estimate the effects of business tax cuts on investment. Relative to the other papers in the literature, this paper models debt financing, interest deductibility and accelerated depreciation of capital, which is also crucial for the estimates.

Second, this paper contributes to the empirical literature that estimates the tax multiplier and, more generally, the macroeconomic effects of tax changes (for instance, Blanchard and Perotti 2002, Mountford and Uhlig 2009, Romer and Romer 2010, Barro and Redlick 2011, Favero and Giavazzi 2012, Mertens and Ravn 2013 and 2014, and Caldara and Kamps 2017.) This literature estimates the effect of changes in the tax liability, not necessarily changes in the tax rate. In particular, to focus on business income taxes, Mertens and Ravn (2013) estimate the effect of exogenous changes in the corporate income tax liability. However, the exogenous tax changes that they consider in their study are mostly driven by increases in depreciation allowances and investment tax credits—Changes in the corporate income tax rate play some role for only 3 of the 16 exogenous tax changes. Hence, their estimates mainly refer to the effect of changes in depreciation allowances and investment tax credits, not changes in the corporate income tax rate. My paper shows that the macroeconomic effects of changes in the corporate tax rate can be very different (even the opposite when investment is financed only through debt) from the effect of changes in depreciation allowances and investment tax credits, so it can be very different from the effect of changes in the tax liability estimated by this empirical literature.

In the rest of the paper, Section 2 details the model and explains why the effect of tax cuts depends on business financing and capital depreciation; Section 3 describes the calibration, results, and sensitivity analysis; and Section 4 concludes.

2 Model

In the model, there is a continuum of representative households of measure one, a continuum of representative firms of measure one, and a government. Firms are owned by agents that are distinct from households and maximize their own utility function. Households supply labor and financial capital to firms. Firms invest, produce, and pay income taxes. The government uses household lump-sum taxes to balance its intertemporal budget constraint.

2.1 Firms

Business financing, interest deductibility, and capital depreciation play a crucial role for the effects of business tax cuts on investment. I model these features assuming that firms pay taxes on their income after deducting accounting depreciation and interest expenses. Accounting depreciation, which refers to the way capital is depreciated for tax purposes, is assumed to be faster than economic depreciation, which refers to the way economic capital depreciates over time. Firms finance their investment with a mix of debt and equity, but only debt provides a tax shield: While the debt interest expenses can be deducted from business taxable income, the equity return cannot be deducted.

The representative firm begins period t with economic capital, k_t (capital, for short). The firm hires labor, l_t, at the wage rate, w_t, produces, and sells output

$$y_t \equiv Af(k_t, l_t), \tag{1}$$

where $A > 0$, $f(k, l) \equiv k^{\alpha} l^{1-\alpha}$, and $\alpha \in (0, 1)$. The firm invests x_t, so capital evolves according to:

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

where $\delta \in (0, 1)$ is the economic depreciation rate.

Accounting depreciation is modeled as in Occhino (2022). For tax purposes, capital is depreciated at the accounting depreciation rate $\tilde{\delta} \in [\delta, 1)$. The case $\tilde{\delta} > \delta$ captures the fact that the tax system allows the use of an accelerated method to depreciate assets, for instance, the double declining balance method.

In addition, a fraction $\kappa_t \in [0, 1]$ of investment expenses can be deducted immediately from taxable income, in the same period in which the investment expenses are incurred. The case $\kappa_t > 0$ captures several provisions of the current tax system: the half-year convention that allows to deduct immediately half year of depreciation; the current temporary 100 percent bonus depreciation of equipment that allows to deduct immediately all investment expenses in equipment; the current treatment of investment expenses in R&D that allows to deduct immediately all investment expenses in R&D.

Because of the difference between accounting depreciation and economic depreciation, we need to keep track of accounting capital separately from economic capital: Let $\tilde{k}_t$ be the accounting capital at the beginning of period t. Then, accounting depreciation is

$$D_t = \tilde{\delta}\tilde{k}_t + \kappa_t x_t, \tag{3}$$

and accounting capital evolves according to:[1]

$$\tilde{k}_{t+1} = (1 - \tilde{\delta})\tilde{k}_t + (1 - \kappa_t)x_t. \tag{4}$$

Turning to the financing side, let v and e_t be, respectively, the inside equity and outside equity outstanding at the beginning of period t, and let

$$E_t \equiv v + e_t \tag{5}$$

be total equity, the sum of inside and outside equity. The constant $v > 0$ represents the inside equity owned by the business owners, while e_t, represents the outside equity

[1] In the case that $\tilde{\delta} = \delta$ and $\kappa_t = \kappa$ for all t, the model becomes simpler and easier to solve: Accounting capital becomes proportional to economic capital ($\tilde{k}_t = (1 - \kappa)k_t$ for all t), and $\tilde{k}_t$ can be dropped from the list of state variables.

issued by the firm to finance investment—Myers (2000) is the seminal article modeling the outside equity financing decision by insiders such as managers and entrepreneurs. The firm finances its investment with a mix of debt, b_t, and outside equity, e_t. While debt includes all financial assets whose return can be deducted from taxable income, outside equity includes all financial assets whose return cannot be deducted from taxable income, for instance preferred equity. Let r_t and r_t^e, be, respectively, the interest rate on debt and the rate of return on equity. Every period, the firm repays $(1 + r_t)b_t + (1 + r_t^e)e_t$, and issues new debt, b_{t+1}, and outside equity, e_{t+1}.

I model the firm's financing choice after the trade-off theory of capital structure. On the one hand, debt provides a tax benefit—The firm can deduct the interest expenses incurred on their debt, $r_t b_t$, but not the return on equity, $r_t^e e_t$. On the other hand, debt generates distress and bankruptcy costs. I model these costs as an increasing, convex function of the share of financial capital that is debt. Let

$$a_t \equiv b_t + v + e_t \tag{6}$$

be the firm's total financial capital, the sum of debt and total equity, and let

$$\theta_t \equiv \frac{b_t}{a_t} \tag{7}$$

be the share of financial capital that is debt, so

$$b_t \equiv \theta_t a_t, \tag{8}$$

$$e_t \equiv (1 - \theta_t)a_t - v. \tag{9}$$

The bankruptcy costs are:

$$\text{Bankruptcy Costs} \equiv w(\theta_t)a_t \tag{10}$$

where $w(\theta) \equiv \Psi\theta^{1+1/\psi}$, $\Psi > 0$, and $\psi > 0$. A higher debt share of financial capital, θ_t, raises the tax benefits of debt but also raises the bankruptcy costs. The firm chooses the mix of debt and equity, θ_t, balancing the benefits and costs of debt financing.

Taxable income, I_t, is obtained deducting labor costs, accounting depreciation, and interest expenses from revenue:

$$I_t = y_t - w_t l_t - D_t - r_t b_t. \tag{11}$$

The last two terms generate the tax shields associated with, respectively, capital depreciation and interest deductibility.

The firm pays income taxes at the tax rate $\tau_t > 0$, but receives an investment tax credit equal to a fraction $\chi_t \in [0, 1)$ of its investment expenses, so the tax liability is equal to

$$X_t = \tau_t I_t - \chi_t x_t. \tag{12}$$

The dividend distributed by the firm is obtained summing revenue and cash flow from financing and subtracting labor costs, investment, the tax liability, and the bankruptcy costs:

$$d_t = y_t - w_t l_t - x_t - X_t + [b_{t+1} + e_{t+1} - (1 + r_t)b_t - (1 + r^e_t)e_t] - w(\theta_t)a_t \tag{13}$$

Substituting the expressions for D_t, I_t and X_t from (3), (11), and (12) into (13), we obtain:

$$\begin{aligned} d_t =& y_t - w_t l_t - x_t - \tau_t(y_t - w_t l_t - \tilde{\delta}\tilde{k}_t - \kappa_t x_t - r_t b_t) + \chi_t x_t + b_{t+1} + \\ & e_{t+1} - (1 + r_t)b_t - (1 + r^e_t)e_t - w(\theta_t)a_t \\ d_t =& (1 - \tau_t)(y_t - w_t l_t) - (1 - \tau_t\kappa_t - \chi_t)x_t + \tau_t\tilde{\delta}\tilde{k}_t + b_{t+1} + \\ & e_{t+1} - [1 + r_t(1 - \tau_t)]b_t - (1 + r^e_t)e_t - w(\theta_t)a_t. \end{aligned}$$

Then, substituting the expressions for y_t, b_t, and e_t from (1), (8), and (9), we obtain:

$$\begin{aligned} d_t =& (1 - \tau_t)[Af(k_t, l_t) - w_t l_t] - (1 - \tau_t\kappa_t - \chi_t)x_t + \tau_t\tilde{\delta}\tilde{k}_t + \theta_{t+1}a_{t+1} + \\ & (1 - \theta_{t+1})a_{t+1} - v - [1 + r_t(1 - \tau_t)]\theta_t a_t - (1 + r^e_t)[(1 - \theta_t)a_t - v] - w(\theta_t)a_t \\ d_t =& (1 - \tau_t)[Af(k_t, l_t) - w_t l_t] - (1 - \tau_t\kappa_t - \chi_t)x_t + \tau_t\tilde{\delta}\tilde{k}_t + a_{t+1} - \\ & [1 + \theta_t r_t(1 - \tau_t) + (1 - \theta_t)r^e_t + w(\theta_t)]a_t + r^e_t v. \end{aligned} \tag{14}$$

The optimization problem solved by the owner of the representative firm is:

$$\max_{\left\{d_t, l_t, x_t, k_{t+1}, \tilde{k}_{t+1}, a_{t+1}, \theta_{t+1}\right\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t u(d_t) \tag{15}$$

subject to (2), (4), and (14),

given initial values for the state variables $k_0, \tilde{k}_0, a_0, \theta_0$; where $\beta \in (0,1)$ is the discount factor, $u(d)$ is such that $u'(d) \equiv d^{-\gamma}$, $\gamma > 0$ is the relative risk aversion, and E_0 is the expectation operator.

Let λ_t, μ_t and ν_t be the Lagrange multipliers associated, respectively, with the constraints (14), (2), and (4). The first-order conditions with respect to d_t, l_t, x_t, k_{t+1}, $\tilde{k}_{t+1}$, a_{t+1}, and θ_{t+1} are, respectively:

$$\begin{aligned}
\beta^t u'(d_t) &= \lambda_t \\
A\frac{\partial f(k_t, l_t)}{\partial l_t} &= w_t \\
\lambda_t(1 - \tau_t \kappa_t - \chi_t) &= \mu_t + (1 - \kappa_t)\nu_t \\
\mu_t &= E_t \left\{ \lambda_{t+1}(1 - \tau_{t+1}) A \frac{\partial f(k_{t+1}, l_{t+1})}{\partial k_{t+1}} + \mu_{t+1}(1 - \delta) \right\} \\
\nu_t &= E_t \left\{ \lambda_{t+1} \tau_{t+1} \tilde{\delta} + \nu_{t+1}(1 - \tilde{\delta}) \right\} \\
\lambda_t &= E_t \left\{ \lambda_{t+1} \left[1 + \theta_{t+1} r_{t+1}(1 - \tau_{t+1}) + (1 - \theta_{t+1}) r^e_{t+1} + w(\theta_{t+1}) \right] \right\} \\
0 &= E_t \left\{ \lambda_{t+1} \left[r_{t+1}(1 - \tau_{t+1}) - r^e_{t+1} + w'(\theta_{t+1}) \right] \right\}.
\end{aligned}$$

The next-to-last equation shows that the weighted average cost of capital is:

$$WACC_{t+1} \equiv \theta_{t+1} r_{t+1}(1 - \tau_{t+1}) + (1 - \theta_{t+1}) r^e_{t+1} + w(\theta_{t+1}). \tag{16}$$

The first two terms on the right-hand side have the standard interpretation as the weighted average cost of debt and equity, where the weights are equal to, respectively, θ_{t+1} and $1 - \theta_{t+1}$, and the cost of debt is reduced by the tax benefit associated with interest deductibility. The last term represents the increase in the cost of capital due to bankruptcy costs.

The last equation shows that, for given rates of return, r_{t+1} and r^e_{t+1}, firm owners increase the debt share of financial capital, θ_{t+1}, in response to an increase in the tax rate, τ_{t+1}. This is intuitive, as the increase in the tax rate raises the tax shield provided by interest deductibility and increases the tax benefit of debt.

2.2 Households

Households consume c_t, receive a constant endowment of goods, y^H, supply labor, n_t, and receive wages, $w_t n_t$. They supply financial capital in the form of debt, b_{t+1}, and equity e_{t+1}, to firms, and lend B_{t+1} to the government. They receive the gross return from firms and the government, and pay lump-sum taxes to the government, T_t. The households' budget constraint is, then:

$$c_t + b_{t+1} + e_{t+1} + T_t + B_{t+1} = y^H + w_t n_t + (1 + r_t)b_t + (1 + r^e_t)e_t + (1 + r^B_t)B_t. \tag{17}$$

The households' optimization problem is:

$$\max_{\{c_t, n_t, e_{t+1}, b_{t+1}, B_{t+1}\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \tilde{\beta}^t [u(c_t) - v(n_t)] \tag{18}$$

subject to (17),

where the utility function $u(c)$ is the same as the one for firm owners, $v(n) \equiv \Phi n^{1+1/\varphi}$, $\Phi > 0$, $\varphi > 0$, and $\tilde{\beta} > 0$.

The first-order conditions are:

$$\frac{v'(n_t)}{u'(c_t)} = w_t \tag{19}$$

$$1 = E_t \left\{ \frac{\tilde{\beta} u'(c_{t+1})}{u'(c_t)} (1 + r_{t+1}) \right\} \tag{20}$$

$$1 = E_t \left\{ \frac{\tilde{\beta} u'(c_{t+1})}{u'(c_t)} (1 + r^e_{t+1}) \right\} \tag{21}$$

$$1 = E_t \left\{ \frac{\tilde{\beta} u'(c_{t+1})}{u'(c_t)} (1 + r^B_{t+1}) \right\} \tag{22}$$

which imply that, in a linear approximation of the equilibrium, the rates of return on debt, equity, and government debt are equal:

$$r_{t+1} = r^e_{t+1} = r^B_{t+1}. \tag{23}$$

2.3 Government

The government receives a constant endowment of goods, y^G, issues debt, B_{t+1}, and collects tax revenue from firms, X_t, and from households, T_t. It uses the proceeds to finance government spending, G, and repay gross-of-interest debt to households:

$$G + (1 + r^B_t)B_t = y^G + X_t + T_t + B_{t+1}. \tag{24}$$

I assume that the household lump-sum taxes, T_t, respond to changes in government debt and adjust so that government debt is stationary and an equilibrium exists. Provided that an equilibrium exists, the timing of the adjustment in T_t affects only the evolution of government debt and does not matter for the dynamics of the other variables—Ricardian equivalence applies because households hold all the government debt.

2.4 Equilibrium conditions

Let

$$C_t \equiv d_t + c_t \tag{25}$$

be the aggregate private consumption, the sum of the consumption of the business owners and the households, and let

$$Y_t \equiv y_t + y^H + y^G \tag{26}$$

be GDP, the sum of the output of businesses, households, and the government.

The equilibrium condition for the goods market equates the sum of private and public consumption, investment and bankruptcy costs to GDP, while the equilibrium condition for the labor market equates labor demand and labor supply:

$$C_t + G + x_t + w(\theta_t)a_t = Y_t \tag{27}$$

$$l_t = n_t. \tag{28}$$

2.5 Why the effect of tax cuts depends on debt financing and accelerated depreciation

The model captures why debt financing and the accelerated depreciation of capital are crucial for the effects of tax changes on investment.

A tax cut has two main partial-equilibrium effects, working in opposite directions. First, to the extent that investment expenses cannot be deducted immediately, a business income tax acts as a tax on investment, so a tax cut lowers the user cost of capital and stimulates investment. This effect is strong when accounting depreciation is as fast as economic depreciation ($\kappa = 0$ and $\tilde{\delta} = \delta$) and becomes weaker when businesses can deduct investment expenses early on through accelerated depreciation, bonus depreciation, or other forms of depreciation faster than the economic depreciation of capital ($\kappa > 0$ and $\tilde{\delta} > \delta$). In the limit, if all investment expenses can be immediately deducted (full expensing of investment, $\kappa = 1$), this effect disappears, as can be shown in standard models of investment.

Second, to the extent that businesses finance their investment through debt, the deductibility of interest expenses provides a tax shield that increases with the tax rate, so a tax rate cut lowers the tax shield, raises the user cost of capital, and discourages investment. This effect is strong when investment is financed through debt ($\theta = 1$) and becomes weaker when the debt share decreases. In the limit, if all investment is financed through equity ($\theta = 0$), this effect disappears.

The overall effect of a tax cut depends on how fast businesses can deduct investment expenses, and whether investment is financed through debt or equity. A tax cut tends to stimulate investment if accounting depreciation is slow and the debt share is low, while it tends to discourage investment if accounting depreciation is fast and the debt share is high.[2]

Appendix A illustrates how the effect of a tax cut on investment depends on debt financing and accelerated depreciation studying the steady state of a simplified, partial-equilibrium version of the model. It shows that a tax cut stimulates investment when investment is financed through equity ($\theta = 0$) or when investment expenses cannot be immediately deducted ($\kappa = 0$). The stimulative effect of a tax cut on investment decreases and turns contractionary as θ and κ increase. A tax cut discourages investment, when investment is financed through debt ($\theta = 1$) or when investment expenses can be immediately deducted ($\kappa = 1$).

3 Results

3.1 Parameters and steady-state values

Parameters and steady-state values are listed in Table 1.

A few standard parameter values are set in line with the literature. One period corresponds to one year. The households' preferences discount factor is set to $\tilde{\beta} = 0.96$, implying that the rates of return on debt, equity, and government debt are approximately equal to 4 percent. Given other parameter values, the preferences discount factor of firm owners is set to satisfy the firm's first-order conditions in steady state, $\beta = 0.9619$. The relative risk aversion is $\gamma = 2$. The Frisch elasticity of labor supply is $\varphi = 0.5$, and the utility-function parameter $\Phi = 37.1278$ is set so

[2] Fullerton (1999) is the standard reference that shows how interest deductibility and accelerated depreciation allowances can lead to negative effective marginal tax rates on investment. "Thus we get a zero marginal effective tax rate either with expensing or with debt finance. As a consequence, we get a negative effective tax rate with expensing and debt finance" (Fullerton 1999).

that $l = 1/3$ in steady state. The exponent of the production function is $\alpha = 0.33$, and the economic depreciation rate is $\delta = 0.1$.

The steady-state level of GDP is normalized to $Y = 1$. The remaining production parameters are set equal to $y^H = 0.125$ $y^G = 0.125$, and $A = 1.3092$, which implies $y = 0.75$, to match the fact that in 2013 the household, government and business sectors accounted for, respectively, 12.5%, 12.5%, and 75% of gross value added (IRS, SOI Tax Stats - Integrated Business Data, Table 1, and BEA, National Income and Product Accounts, Table 1.3.5).

The tax policy parameters are set at their values before the 2017 tax reform. The steady-state tax rate is set to $\tau = 35\%$, equal to the corporate tax rate before the 2017 tax reform.

The first-year expensing fraction κ is set considering separately the different types of investment. Before the 2017 tax reform, all investment expenses in R&D could be immediately deducted, only 50 percent of investment expenses in equipment and software could be immediately deducted (bonus depreciation), and no investment expenses in structures could be immediately deducted. According to the BEA's NIPA accounts, investment in R&D, equipment, software, and structures represent, respectively, 17%, 42%, 20%, and 21% of private fixed nonresidential investment. This leads to set the fraction of investment expenses that can be immediately deducted to $\kappa = 1 \times 0.17 + 0.5 \times (0.42 + 0.2) + 0 \times 0.21 = 0.48$.

The accounting depreciation rate is set equal to double the economic depreciation rate, $\tilde{\delta} = 0.2$, to capture the fact that most businesses use accelerated depreciation (double declining balance method changing to straight line method at the point at which depreciation deductions are maximized).

The investment tax credit fraction captures the R&D tax credit (Research and Experimentation Tax Credit), which is approximately equal to 6 percent of R&D investment expenses (Office of Tax Analysis 2016 and Barro and Furman 2018). Since investment in R&D is 17 percent of private fixed nonresidential investment, I set

$\chi = 0.17 \times 0.06 = 0.01$.

The steady-state total financial capital is set equal to the present discounted value of the firm $a = 1.28$. To determine the steady-state equity and debt, I turn to the available data on corporations. Corporate debt has been approximately 27 percent of corporate equity in 2014-2017 (Debt as a Percentage of the Market Value of Corporate Equities, Nonfinancial Corporate Business, Federal Reserve, FRED), so I set the share of financial capital that is debt equal to $\theta = 0.27/(1 + 0.27) = 0.21$. That implies $E = 1.01$ and $b = 0.27$. Then, I normalize the steady-state outside equity to zero, $e = 0$, so the inside equity is $v = 1.01$.

To set the bankruptcy costs exponent parameter ψ, notice that, using $r = r^e$ in equilibrium, the firm's first-order conditions imply

$$\begin{aligned} r\tau &= w'(\theta) = \Psi(1 + 1/\psi)\theta^{1/\psi} \\ \log(r) + \log(\tau) &= \log\left(\Psi(1 + 1/\psi)\right) + (1/\psi)\log(\theta) \\ \log(\theta) &= \psi\log(r) + \psi\log(\tau) - \psi\log\left(\Psi(1 + 1/\psi)\right) \end{aligned}$$

so ψ is the elasticity of the debt share θ to the business tax rate τ. Then, to calibrate ψ, I look at the response of θ to the 2017 tax reform, which cut the corporate tax rate by 40 percent, from 35 percent to 21 percent. The debt share was about 0.21 in 2017, hardly changed in the following three years, but then declined by 19 percent (to 0.17). This evidence suggests setting $\psi = 0.19/0.4 = 0.475$. I will also look at the case where the debt share is constant and does not respond to changes in the tax rate ($\psi \to 0$), and the case of unit elasticity ($\psi = 1$). The bankruptcy costs scale parameter $\Psi = 0.1255$ is set to satisfy the firm's first-order conditions. As a result, the steady-state bankruptcy costs are $w(\theta)a = 0.0013$.

Government spending, G, is set to 18 percent of GDP. The household lump-sum taxes, $T = 0.066$, are set so that government debt, B, is equal to 76 percent of GDP, to match gross federal debt held by the public as a percentage of GDP in 2017. As a result of the calibration, investment is 17.2 percent of GDP, and consumption is 64.7

percent of GDP (4.2 percent of business owners, and 60.5 percent of households).

3.2 Macroeconomic effects of tax policy changes

Figure 1 plots the macroeconomic effects of a permanent cut in the business income tax rate, τ_t.[3] The size of the shock is 1. All variables, except for the interest rate and the debt share, are expressed in logarithms, so their responses can be interpreted as percent responses of the underlying variables to a 1 percentage point tax cut.

The solid line shows that a 1 percentage point cut in the tax rate raises business investment by 0.25 percent in the initial year, with the effect persisting over time. The increase in capital raises the marginal product of labor and stimulates the labor demand. As the real wage rate increases, labor and output increase. The effect on output is small in the initial year, only 0.05 percent, although it increases over time. The interest rate increases to encourage saving and finance the increase in investment. As a result of the permanent tax cut, the business tax liability decreases persistently. The tax cut reduces the tax advantage of debt, so businesses substitute equity-financing for debt-financing, decreasing the debt share of financial capital by 0.25 percentage points.

Figure 1 also highlights the role played by debt financing and accelerated depreciation. The dashed line indicates that the effect of the tax cut on investment is four times larger in the model without debt financing and accelerated depreciation. Section 2.5 explained why the stimulative effect of the tax cut on investment is smaller when investment is debt-financed and accounting depreciation is faster than economic depreciation. Intuitively, with accelerated depreciation and interest deductibility, the business income tax does not distort investment much, so a cut in the business income tax does not stimulate investment much either.

Digging a little deeper, most of the difference is due to accelerated depreciation,

[3]The model is solved using the Dynare software (first-order linear approximation and Klein's QZ decomposition solution method).

not debt financing. Comparing the solid and dotted lines shows that the predictions of the model with and without debt are relatively close. This is simply due to the fact that the calibrated debt share is rather small, $\theta = 0.21$. In contrast, comparing the solid and dashed-dotted lines shows that the effect on investment is much larger in the model without accelerated depreciation than in the model with accelerated depreciation.

Because the stimulative effect of the tax cut is rather small, a tax cut is a relatively inefficient policy tool to stimulate the economy. Figure 2 compares the macroeconomic effects of a permanent cut in the business income tax rate, τ_t, to two alternative policy changes: a permanent increase in the first-year expensing fraction, κ_t; and a permanent increase in the investment tax credit, χ_t. For better comparability, the size of the tax-credit shock is 0.1, while the size of the other two shocks is 1. Both an increase in the expensing fraction and an increase in the tax credit are more efficient at stimulating investment than a decrease in the tax rate: They can generate the same increase in investment with a smaller decrease in the business tax liability. Stated alternatively, they can generate a larger increase in investment with the same increase in the business tax liability. A tax cut by 1 percentage point (solid line) and an increase in the tax credits by 0.1 percentage points (dotted line) have similar macroeconomic effects, but the increase in tax credits costs three times less, as shown by the response of the tax liability X_t. Similarly, examining the responses of investment and the tax liability indicates that an increase in the first-year expensing fraction (dashed line) is somewhat more efficient at stimulating investment than a tax cut.

Finally, Figure 3 highlights the large role played by the persistence of the tax policy shocks. The figure shows the macroeconomic effects of the same policy shocks considered in Figure 2, except that the first-order autocorrelation of the policy shocks is 0.5, rather than 1. In the case of the temporary increases in the expensing fraction or tax credit, businesses have an incentive to boost current investment to take advantage of the temporary provisions. In contrast, a temporary tax cut depresses current investment and boosts future investment. The reason is that, when the tax cut is temporary, the tax rate is higher in the future than today, so the tax shields provided by interest deductibility and accelerated depreciation are higher in the future as well and businesses have an incentive to delay their investment and take advantage of the higher future tax shields.

One could also view these results as highlighting the importance of expectations for the immediate effects of tax cuts. A tax cut may have expansionary effects if businesses and the public expect it to be permanent, but contractionary effects if they expect it to be reversed soon. This view may help explain why investment did not respond much to the 2017 tax reform. Although the tax reform included some provisions (individual tax cuts stimulating the labor supply, increased bonus depreciation for equipment investment) that likely stimulated business investment, the overall response of business investment was muted. Several factors may have contributed to restrain investment, for instance, the increase in tariffs and related economic policy uncertainty in 2018. One additional factor may have been the expectation that the corporate tax cuts were going to be, at least partially, reversed. This expectation may have encouraged corporations to delay their investment and may have caused the corporate tax cuts to have contractionary, rather than expansionary, effects on investment and output (Occhino 2022).

3.3 Sensitivity analysis

The key parameters are the ones that control business financing and capital depreciation. Business financing is controlled by the steady-state debt share, θ, of financial capital, and the elasticity, ψ, of the debt share to the tax rate. Capital depreciation is controlled by the steady-state fraction, κ, of investment expenses that can be immediately expensed, and the accounting depreciation rate, $\tilde{\delta}$.

The steady-state debt share, θ, plays a large role for the effects of tax cuts. Figure 4 shows that, after a permanent tax cut, investment and output increase if investment is financed mainly through equity but decrease if investment is financed mainly through debt. Section 2.5 explained why. Intuitively, if investment is financed through equity, the income tax distorts investment and a cut in the tax rate stimulates investment. However, if investment is financed partly through debt, another mechanism is at work: Since the tax shield provided by interest deductibility increases with the tax rate, a tax rate cut lowers the tax shield, raises the user cost of capital, and works to discourage investment. When the debt share of financial capital is high enough, this mechanism can be so strong that the overall effect of a tax rate cut on investment is negative.

While the results are quite sensitive to the debt share, θ, they are almost completely insensitive to the elasticity, ψ, of the debt share θ to the tax rate τ, as shown in Figure 5. After a permanent tax cut, the tax advantage of debt decreases, so firms substitute equity for debt and decrease the debt share of financial capital θ. The higher the elasticity, ψ, the larger the decrease in the debt share θ. In theory, with a lower debt share, the tax cut should stimulate investment more. Quantitatively, however, this effect is tiny, so the model results do not depend on ψ.

The steady-state expensing fraction, κ, plays a large role for the effects of tax cuts, similarly to the debt share, θ. Figure 6 shows that, after a permanent tax cut, investment increases if the first-year expensing fraction is zero but decreases if businesses can immediately deduct all their investment expenses from their taxable income. Section 2.5 explained why and showed that, in a simplified version of the model, the expensing fraction κ and the debt share θ affect the investment response to the tax rate in a similar way. Intuitively, if businesses cannot immediately deduct any investment expenses, the income tax distorts investment and a cut in the tax rate stimulates investment. However, if businesses can immediately deduct their investment expenses, another mechanism is at work: the immediate full depreciation of capital provides a tax shield that increases with the tax rate. Then, a tax rate cut lowers the tax shield and works to discourage investment. This mechanism can be so strong that, when businesses finance their investment partly through debt and deduct their interest expenses, the overall effect of a tax rate cut on investment is negative.

The model results are also sensitive to the accounting depreciation rate, $\tilde{\delta}$, as shown in Figure 7. In many ways, the accounting depreciation rate $\tilde{\delta}$ and the first-year expensing fraction κ have similar effects on the model results. The greater the accounting depreciation rate, the faster the depreciation of capital allowed by the tax system, the smaller the tax distortion of investment. Hence, with a greater accounting depreciation rate, a tax cut has a smaller effect on the tax distortion and on investment.

Another parameter that affects the model results is the steady-state investment tax credit χ. Figure 8 shows that the stimulative effect of a tax cut on investment diminishes when the tax credit gets larger. The reason is that, as the investment tax credit gets larger, it plays a larger role for the cost of investing, while the tax rate plays a smaller role. As a result, a tax rate cut is less important for the cost-benefit analysis of investment and stimulates investment less.

The sensitivity of the model results to the other, more standard, parameters is, overall, in line with what could be expected in calibrated dynamic general equilibrium models. For instance, one parameter value that is important for the results and over which there is some uncertainty is the Frisch elasticity of labor supply, φ. As shown in Figure 9, the model response to a tax cut depends on φ in an intuitive way. Larger values of the Frisch elasticity of labor supply lead to larger effects of the tax cut on labor, which result in larger effects on output and investment as well.

As we saw in Section 3.2, one parameter that plays an important role is the first-order autocorrelation of the tax rate shock. Figure 10 documents how the model response to a tax rate cut depends on the persistence of the cut. While a permanent tax cut stimulates investment, a temporary tax cut encourages businesses to delay investment, depressing current investment and boosting future investment, as evident in the case of zero autocorrelation (dashed line). The reason is that interest deductibility and accelerated depreciation provide tax shields that increase with the tax rate. The lower the tax rate, the lower the tax shields, the higher the cost of investing. Hence, if the tax cut is temporary, the tax shields are lower today than in the future, so the cost of investing is larger today than in the future. Since the future benefit of investing is less affected by the persistence of the tax cut, a cost-benefit analysis encourages businesses to delay investing.

4 Conclusion

This paper studies the macroeconomic effects of business income tax cuts using a dynamic general equilibrium model that incorporates debt and equity financing, interest deductibility, and capital depreciation. According to the model, a 1 percentage point permanent cut in the tax rate raises business investment and output by, respectively, 0.25 percent and 0.05 percent in the initial year, with the effects persisting over time. Because the stimulative effects of the tax cut are rather small, other tax policy tools, such as increases in depreciation allowances and investment tax credits, are more efficient at stimulating investment.

Debt financing and accelerated depreciation play important roles for the estimates. Without debt financing and accelerated depreciation, the stimulative effects of a tax cut would be four times larger. The persistence of the tax cut also plays a crucial role. While a permanent tax cut stimulates investment, a temporary tax cut encourages businesses to delay investment, depressing current investment and boosting future investment. This mechanism highlights the importance of managing expectations when implementing a tax cut: a tax cut may end up having an immediate contractionary effect if the public expects it to be reversed soon.

References

Barro, Robert J., and Jason Furman, 2018. “Macroeconomic Effects of the 2017 Tax Reform.” *Brookings Papers on Economic Activity,* Spring 2018(1), 257-345. doi:10.1353/eca.2018.0003.

Barro, Robert J., and Charles J. Redlick, 2011. “Macroeconomic Effects from Government Purchases and Taxes.” *Quarterly Journal of Economics* 126(1), 51-102. doi:10.1093/qje/qjq002.

Blanchard, Olivier, and Roberto Perotti, 2002. “An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output.” *The Quarterly Journal of Economics* 117(4), 1329-1368. doi:10.1162/003355302320935043.

Caldara, Dario, and Christophe Kamps, 2017. “The Analytics of SVARs: A Unified Framework to Measure Fiscal Multipliers.” *Review of Economic Studies* 84(3), 1015-1040. doi:10.1093/restud/rdx030.

Favero, Carlo, and Francesco Giavazzi, 2012. “Measuring Tax Multipliers. The Narrative Method in Fiscal VARs.” *American Economic Journal: Economic Policy* 4(2), 69-94. doi:10.1257/pol.4.2.69.

Fernández-Villaverde, Jesús, 2010. “Fiscal Policy in a Model with Financial Frictions.” *American Economic Review: Papers & Proceedings* 100(2), 35-40. doi:10.1257/aer.100.2.35.

House, Christopher L., and Matthew D. Shapiro, 2006. “Phased-In Tax Cuts and Economic Activity.” *American Economic Review* 96(5), 1835-1849. doi:10.1257/aer.96.5.1835

Mertens, Karel, and Morten O. Ravn, 2013. “The Dynamic Effects of Personal and

Corporate Income Tax Changes in the United States." *American Economic Review* 103(4), 1212-1247. doi:10.1257/aer.103.4.1212.

Mertens, Karel, and Morten O. Ravn, 2014. "A Reconciliation of SVAR and Narrative Estimates of Tax Multipliers." *Journal of Monetary Economics* 68, S1-S19. doi:10.1016/j.jmoneco.2013.04.004.

Mountford, Andrew, and Harald Uhlig, 2009. "What Are the Effects of Fiscal Policy Shocks?" *Journal of Applied Econometrics* 24(6), 960–992. doi:10.1002/jae.1079.

Myers, Stewart C., 2000. "Outside Equity." *Journal of Finance* 55(3), 1005–1037. doi:10.1111/0022-1082.00239.

Occhino, Filippo, 2022. "The Macroeconomic Effects of the Tax Cuts and Jobs Acts" *Macroeconomic Dynamics* forthcoming. doi:10.1017/S1365100522000311.

Office of Tax Analysis, 2016. "Research and Experimentation (R&E) Credit." U.S. Department of the Treasury. https://home.treasury.gov/system/files/131/RE-Credit.pdf.

Romer, Christina D., and David H. Romer, 2010. "The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks." *American Economic Review* 100(3), 763-801. doi:10.1257/aer.100.3.763.

Sims, Eric, and Jonathan Wolff, 2018. "The State-Dependent Effects of Tax Shocks." *European Economic Review* 107, 57-85. doi:10.1016/j.euroecorev.2018.05.002.

A Analytical results for a partial-equilibrium model

Consider a fixed-labor version of the model ($l_{t+1} = l$). Suppose that the rates of return are exogenous, constant, and equal ($r_{t+1} = r^e_{t+1} = r$). Also, to simplify, the accounting depreciation rate is equal to the economic depreciation rate ($\tilde{\delta} = \delta$), the expensing fraction is constant ($\kappa_t = \kappa$), and the tax credit is equal to zero ($\chi_t = 0$). Finally, to abstract from any effect of tax changes on the capital structure, the debt share is exogenous and constant ($\theta_t = \theta$), and there are no bankruptcy costs ($\Psi = 0$). We are interested in the steady-state response of business capital k_{t+1} to a permanent change in the tax rate τ_{t+1}.

In this simplified partial-equilibrium model, the optimization of the business owner is the same as problem (15), except that l_{t+1} and θ_{t+1} are constant and are not choice variables. The first-order conditions for the other choice variables are the same as the ones of problem (15). In particular, the ones with respect to x_t, k_{t+1}, $\tilde{k}_{t+1}$, and a_{t+1} are, respectively:

$$\begin{aligned}
&\lambda_t(1-\tau_t\kappa_t-\chi_t) = \mu_t + (1-\kappa_t)\nu_t \\
&\qquad\qquad \mu_t = E_t\left\{\lambda_{t+1}(1-\tau_{t+1})A\frac{\partial f(k_{t+1}, l_{t+1})}{\partial k_{t+1}} + \mu_{t+1}(1-\delta)\right\} \\
&\qquad\qquad \nu_t = E_t\left\{\lambda_{t+1}\tau_{t+1}\tilde{\delta} + \nu_{t+1}(1-\tilde{\delta})\right\} \\
&\qquad\qquad \lambda_t = E_t\left\{\lambda_{t+1}\left[1+\theta_{t+1}r_{t+1}(1-\tau_{t+1}) + (1-\theta_{t+1})r^e_{t+1} + \Psi\theta^{\psi}_{t+1}\right]\right\}
\end{aligned}$$

Using the assumptions listed above ($l_{t+1} = l$, $r_{t+1} = r^e_{t+1} = r$, $\tilde{\delta} = \delta$, $\kappa_t = \kappa$, $\chi_t = 0$, $\theta_t = \theta$, and $\Psi = 0$):

$$\begin{aligned}
&\lambda_t(1-\tau_t\kappa) = \mu_t + (1-\kappa)\nu_t \\
&\qquad\qquad \mu_t = E_t\left\{\lambda_{t+1}(1-\tau_{t+1})A\frac{\partial f(k_{t+1}, l)}{\partial k_{t+1}} + \mu_{t+1}(1-\delta)\right\} \\
&\qquad\qquad \nu_t = E_t\left\{\lambda_{t+1}\tau_{t+1}\delta + \nu_{t+1}(1-\delta)\right\} \\
&\qquad\qquad \lambda_t = E_t\left\{\lambda_{t+1}\left[1+r(1-\theta\tau_{t+1})\right]\right\}
\end{aligned}$$

Substituting the expressions for μ_t and ν_t from the second and third equations into the first one:

$$\begin{aligned}
\lambda_t(1-\tau_t\kappa) &= E_t\left\{\lambda_{t+1}(1-\tau_{t+1})A\frac{\partial f(k_{t+1}, l)}{\partial k_{t+1}} + \mu_{t+1}(1-\delta)\right\} + (1-\kappa)E_t\left\{\lambda_{t+1}\tau_{t+1}\delta + \nu_{t+1}(1-\delta)\right\} \\
&= E_t\left\{\lambda_{t+1}(1-\tau_{t+1})A\frac{\partial f(k_{t+1}, l)}{\partial k_{t+1}} + \mu_{t+1}(1-\delta) + (1-\kappa)\lambda_{t+1}\tau_{t+1}\delta + (1-\kappa)\nu_{t+1}(1-\delta)\right\} \\
&= E_t\left\{\lambda_{t+1}(1-\tau_{t+1})A\frac{\partial f(k_{t+1}, l)}{\partial k_{t+1}} + (1-\kappa)\lambda_{t+1}\tau_{t+1}\delta + \lambda_{t+1}(1-\tau_{t+1}\kappa)(1-\delta)\right\}
\end{aligned}$$

where the last step used the first equation again, evaluated at $t+1$ rather than t.

Substituting the expression for λ_t from the last equation:

$$\begin{aligned}
&E_t\left\{\lambda_{t+1}\left[1+r(1-\theta\tau_{t+1})\right]\right\}(1-\tau_t\kappa) = \\
&E_t\left\{\lambda_{t+1}(1-\tau_{t+1})A\frac{\partial f(k_{t+1},l)}{\partial k_{t+1}} + (1-\kappa)\lambda_{t+1}\tau_{t+1}\delta + \lambda_{t+1}(1-\tau_{t+1}\kappa)(1-\delta)\right\}
\end{aligned}$$

In the steady state, $\tau_{t+1}=\tau_t=\tau$, $k_{t+1}=k$, and we can drop the expectation operators:

$$\begin{aligned}
\left[1+r(1-\theta\tau)\right](1-\tau\kappa) &= (1-\tau)A\frac{\partial f(k,l)}{\partial k} + (1-\kappa)\tau\delta + (1-\tau\kappa)(1-\delta) \\
(1-\tau\kappa)+r(1-\theta\tau)(1-\tau\kappa) &= (1-\tau)A\frac{\partial f(k,l)}{\partial k} + \tau\delta - \kappa\tau\delta + (1-\tau\kappa) - \delta + \tau\kappa\delta \\
r(1-\theta\tau)(1-\tau\kappa) &= (1-\tau)A\frac{\partial f(k,l)}{\partial k} - (1-\tau)\delta \\
\frac{r(1-\theta\tau)(1-\tau\kappa)}{1-\tau} &= A\frac{\partial f(k,l)}{\partial k} - \delta \qquad (29)
\end{aligned}$$

The last equation shows how the steady-state capital k responds to a permanent change in the tax rate τ, depending on the debt share θ and the expensing fraction κ. The right-hand side is a decreasing function of k because the marginal product of capital is decreasing. Hence, capital increases (/decreases) in response to an increase in the tax rate if the left-hand side is a decreasing (/increasing) function of τ. Equivalently, capital increases (/decreases) in response to an increase in the tax rate if the derivative of the left-hand side with respect to τ is negative (/positive).

The derivative of the left-hand side of (29) with respect to τ is:

$$\begin{aligned}
LHS_\tau &= r\frac{(1-\tau)\left[-\theta(1-\tau\kappa)-\kappa(1-\theta\tau)\right]+(1-\theta\tau)(1-\tau\kappa)}{(1-\tau)^2} \\
LHS_\tau &= r\frac{-\theta(1-\tau)(1-\tau\kappa)-\kappa(1-\tau)(1-\theta\tau)+(1-\theta\tau)(1-\tau\kappa)}{(1-\tau)^2}
\end{aligned}$$

First, let's study how the derivative changes as θ changes, for given $\kappa\in(0,1)$. The derivative can be written as:

$$\begin{aligned}
LHS_\tau &= r\frac{-\theta(1-\tau)(1-\tau\kappa)-(\kappa-\tau\kappa)(1-\theta\tau)+(1-\theta\tau)(1-\tau\kappa)}{(1-\tau)^2} \\
LHS_\tau &= r\frac{-\theta(1-\tau)(1-\tau\kappa)+(1-\theta\tau)(1-\kappa)}{(1-\tau)^2}
\end{aligned}$$

The derivative is positive for $\theta = 0$, it decreases with θ, and is negative for $\theta = 1$:

$$
\begin{aligned}
LHS_\tau|_{\theta=0} &= r\frac{(1-\kappa)}{(1-\tau)^2} > 0 \\
\frac{\partial LHS_\tau}{\partial \theta} &= r\frac{-(1-\tau)(1-\tau\kappa) - \tau(1-\kappa)}{(1-\tau)^2} < 0 \\
LHS_\tau|_{\theta=1} &= r\frac{-(1-\tau)(1-\tau\kappa) + (1-\tau)(1-\kappa)}{(1-\tau)^2} = r\frac{-1+\tau\kappa+1-\kappa}{1-\tau} = -r\kappa < 0
\end{aligned}
$$

Hence, for small values of θ (when investment is mainly financed through equity), the left-hand side of (29) is increasing in τ, capital k is decreasing in τ, and a tax cut stimulates investment. Viceversa, for large values of θ (when investment is mainly financed through debt), a tax cut discourages investment.

Next, let's study how the derivative changes as κ changes, for given $\theta \in (0, 1)$. The steps are analogous to the ones just used to study how the derivative changes as θ changes. The derivative can be written as:

$$
\begin{aligned}
LHS_\tau &= r\frac{-(\theta-\tau\theta)(1-\tau\kappa) - \kappa(1-\tau)(1-\theta\tau) + (1-\theta\tau)(1-\tau\kappa)}{(1-\tau)^2} \\
LHS_\tau &= r\frac{-\kappa(1-\tau)(1-\theta\tau) + (1-\theta)(1-\tau\kappa)}{(1-\tau)^2}
\end{aligned}
$$

The derivative is positive for $\kappa = 0$, it decreases with κ, and is negative for $\kappa = 1$:

$$
\begin{aligned}
LHS_\tau|_{\kappa=0} &= r\frac{(1-\theta)}{(1-\tau)^2} > 0 \\
\frac{\partial LHS_\tau}{\partial \kappa} &= r\frac{-(1-\tau)(1-\theta\tau) - \tau(1-\theta)}{(1-\tau)^2} < 0 \\
LHS_\tau|_{\kappa=1} &= r\frac{-(1-\tau)(1-\theta\tau) + (1-\theta)(1-\tau)}{(1-\tau)^2} = r\frac{-1+\theta\tau+1-\theta}{1-\tau} = -r\theta < 0
\end{aligned}
$$

Hence, for small values of κ (when most investment expenses cannot be deducted immediately and capital depreciation is slow), the left-hand side of (29) is increasing in τ, capital k is decreasing in τ, and a tax cut stimulates investment. Viceversa, for large values of κ (when most investment expenses can be deducted immediately and capital depreciation is fast), a tax cut discourages investment.

	Description	Value	Targeted moments and notes
$\tilde{\beta}$	household preferences discount factor	0.96	$r = r^e = r^B = 0.0417$
β	bus. owner preferences discount factor	0.9619	implied by interest and tax rates
γ	relative risk aversion	2	
φ	Frisch elasticity of labor supply	0.5	
Φ	labor disutility parameter	37.13	$l = n = 1/3$
α	production function exponent	0.33	
δ	economic depreciation rate	0.1	
Y	GDP	1	normalized
y^H	household endowment	0.125	GDP share of private non-bus. output
y^G	govt. endowment	0.125	GDP share of govt. output
A	production function scale	1.3092	$y = 0.75$ (GDP share of bus. output)
τ	bus. tax rate	0.35	pre-2017 corporate tax rate
κ	investment expensing fraction	0.48	
$\tilde{\delta}$	accounting depreciation rate	0.2	$\tilde{\delta} = 2\delta$ (accelerated depreciation)
χ	investment tax credit fraction	0.01	R&D tax credit
X	bus. tax liability	0.0201	
θ	debt share of financial capital	0.21	corporate debt and equity
a	bus. financial capital	1.28	equal to firm's value
b	debt	0.27	
E	total equity	1.01	
v	inside equity	1.01	
e	outside equity	0	
ψ	bankruptcy costs exponent	0.475	elasticity of θ to τ
Ψ	bankruptcy costs scale	0.1255	
G	govt. spending	0.18	GDP share of govt. spending
T	household lump-sum taxes	0.066	$B = 0.76$ (govt debt as a % of GDP)
C	aggregate consumption	0.647	
x	investment	0.172	
k	capital	1.72	
$\tilde{k}$	accounting capital	0.447	

Table 1: Parameters and steady-state values. *Note: The length of a period is 1 year.*

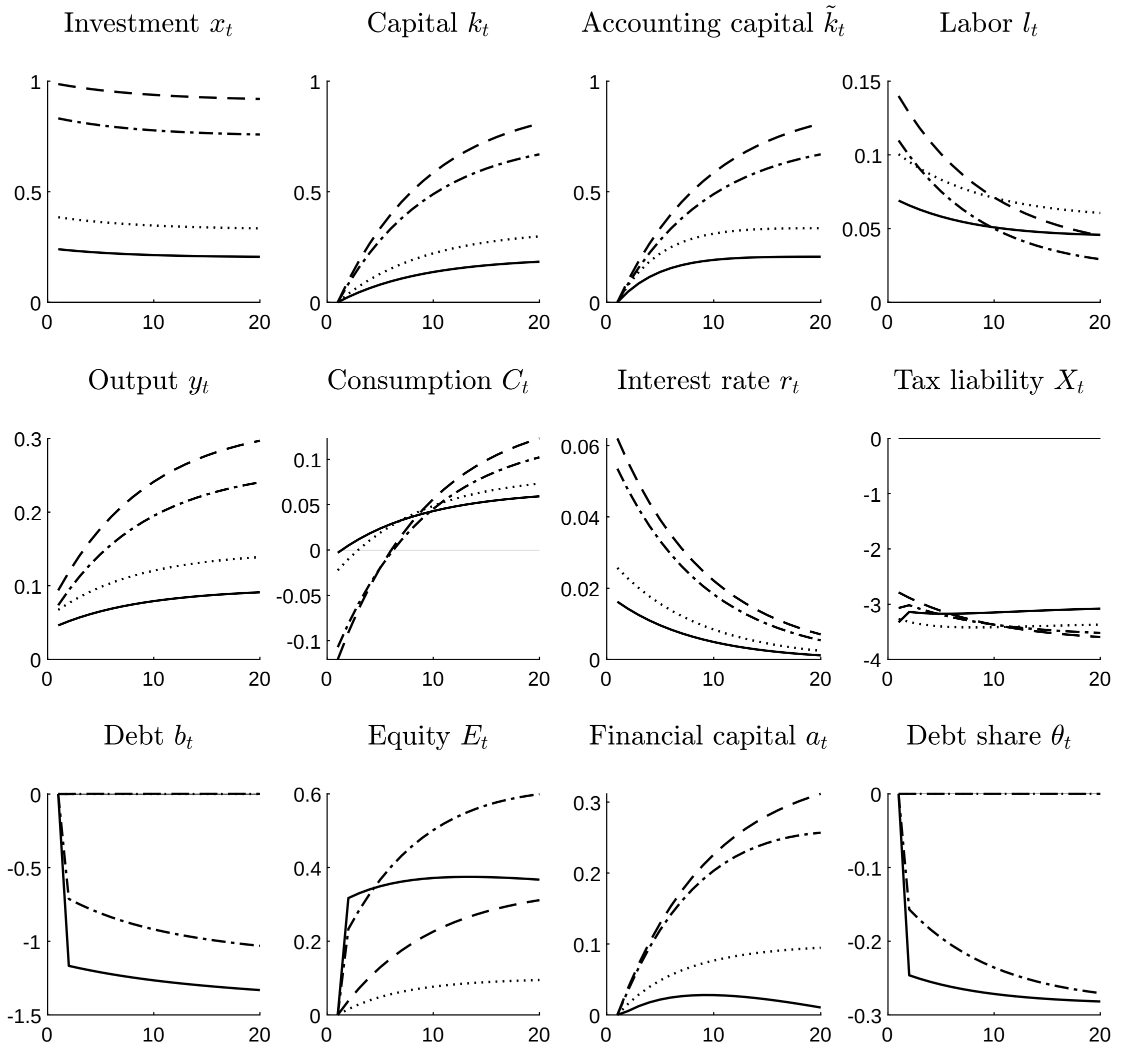

Figure 1: Effect of a permanent cut in the business income tax rate, τ_t. Role played by debt financing and accelerated depreciation. *Notes: The dashed line refers to an economy without debt and accelerated depreciation ($\theta = 0$, $\kappa = 0$, and $\tilde{\delta} = \delta = 0.1$), while the dashed-dotted line refers to the same economy with debt ($\theta = 0.21$, $\kappa = 0$, and $\tilde{\delta} = \delta = 0.1$). The solid line refers to the benchmark economy ($\theta = 0.21$, $\kappa = 0.48$, and $\tilde{\delta} = 0.2$), while the dotted line refers to the same economy without debt ($\theta = 0$, $\kappa = 0.48$, and $\tilde{\delta} = 0.2$). The size of the shock is 1. All variables, except for the interest rate and the debt share, are expressed in logarithms.*

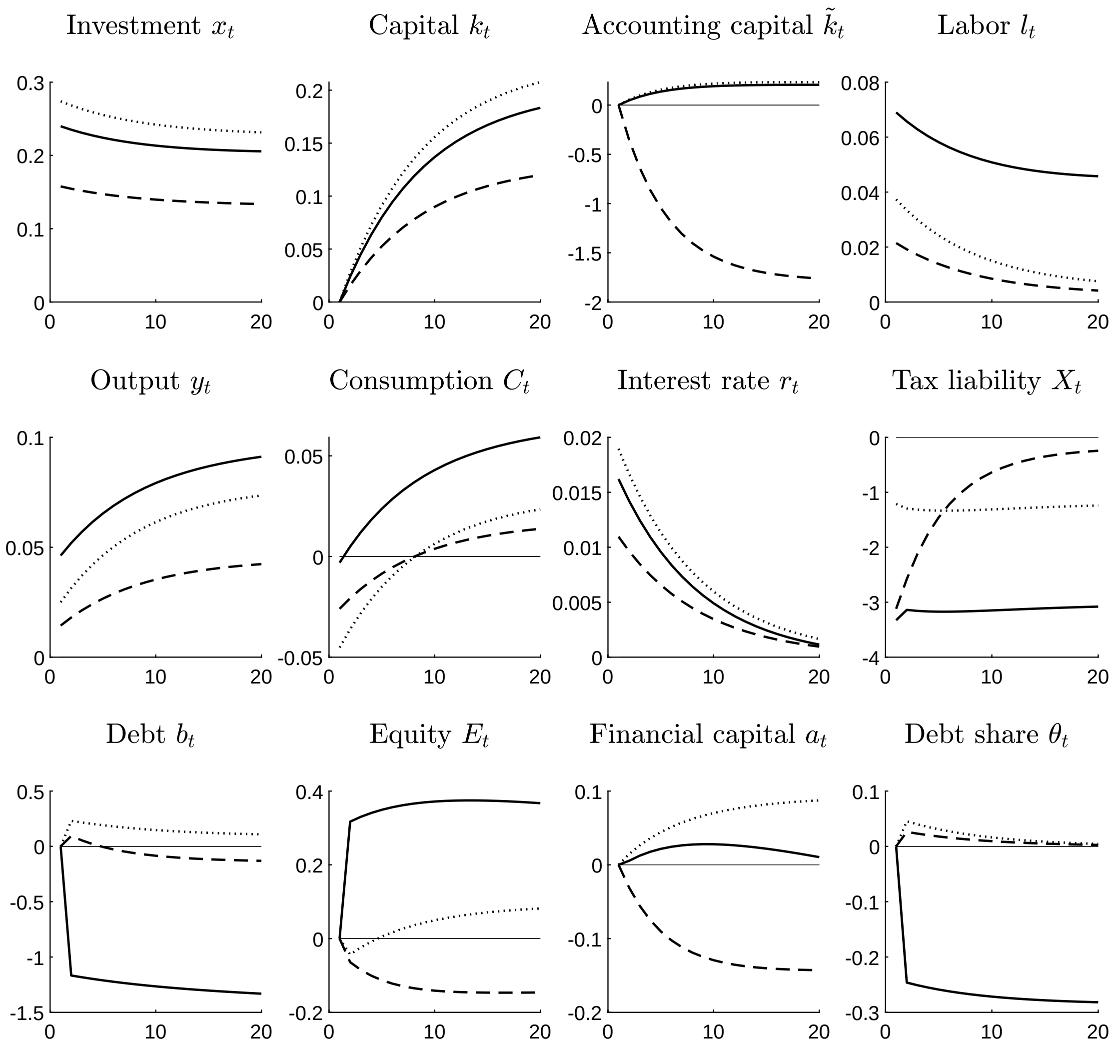

Figure 2: Effect of permanent tax policy shocks. *Notes: The solid, dashed, and dotted lines refer, respectively, to the effect of a cut in the business income tax rate τ_t, the effect of an increase in the first-year expensing fraction κ_t, and the effect of an increase in the investment tax credit χ_t. The size of the first two shocks is 1, while the size of the third shock is 0.1.*

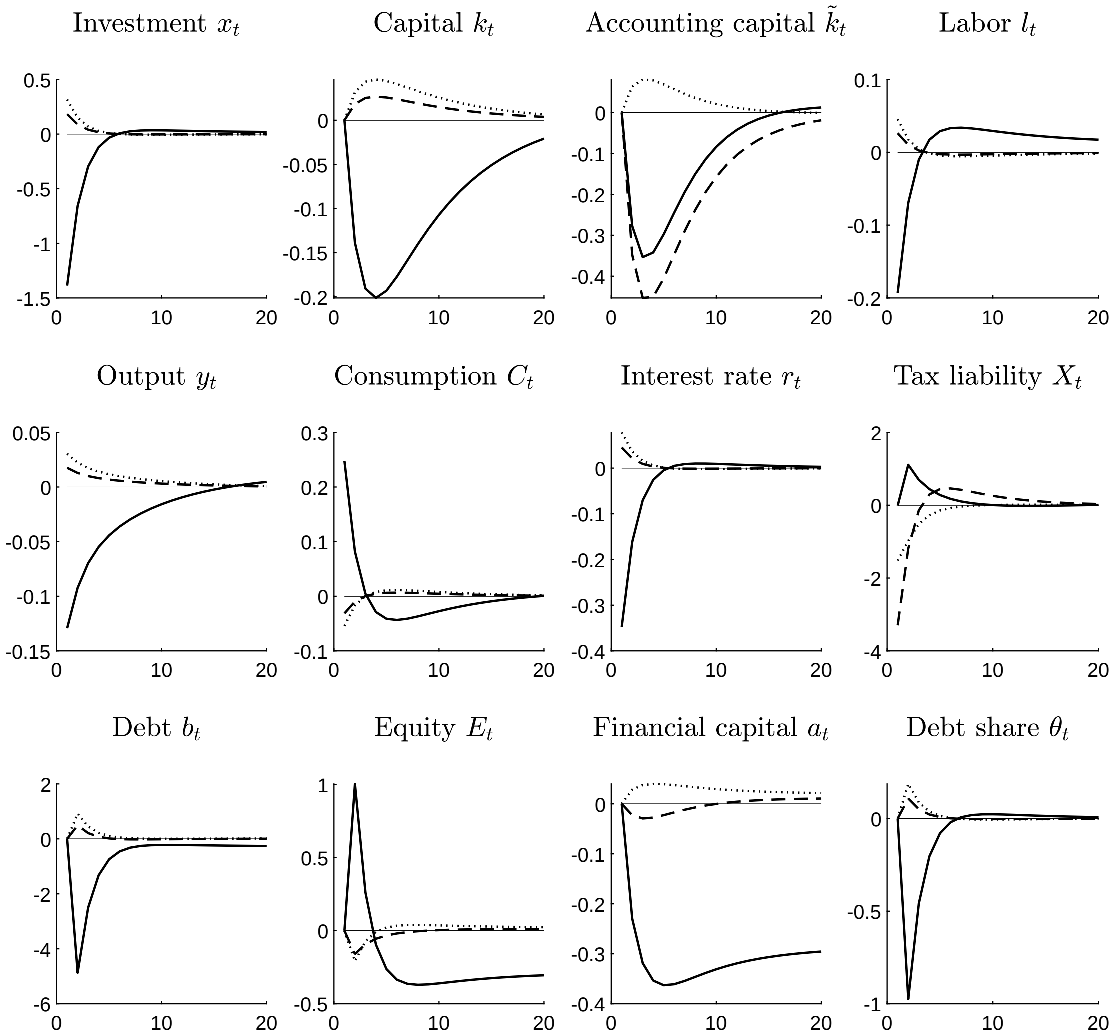

Figure 3: Effect of temporary tax policy shocks. *Notes: The solid, dashed, and dotted lines refer, respectively, to the effect of a cut in the business income tax rate* τ_t*, the effect of an increase in the first-year expensing fraction* κ_t*, and the effect of an increase in the investment tax credit* χ_t*. The size of the first two shocks is 1, while the size of the third shock is 0.1. The shocks follow a first-order autoregressive process with first-order autocorrelation equal to 0.5.*

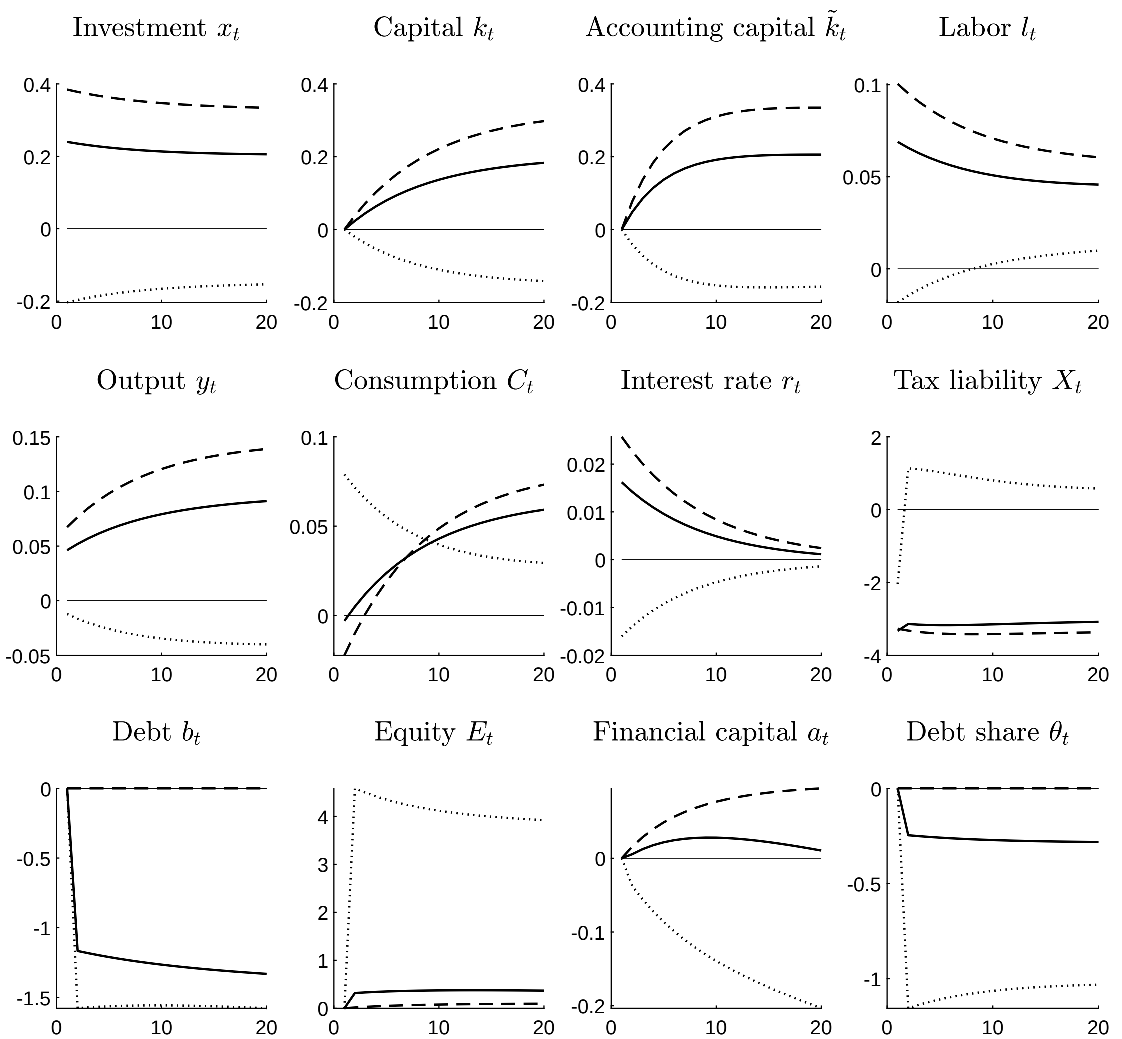

Figure 4: Effect of a permanent tax cut. Sensitivity to the steady-state debt share, θ. *Notes: The dashed, solid, and dotted lines refer, respectively, to* $\theta = 0$, $\theta = 0.21$ *(the benchmark value), and* $\theta = 0.75$.

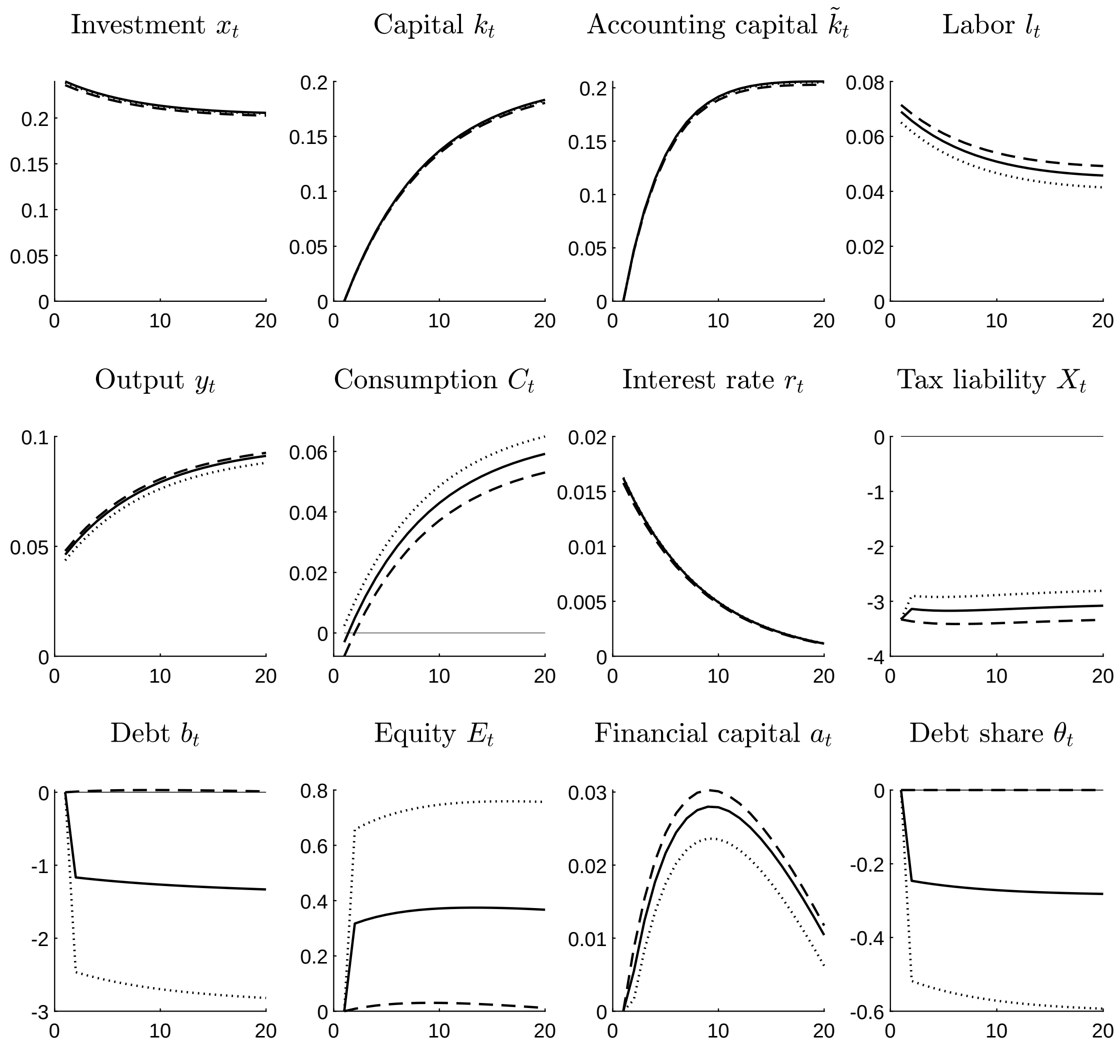

Figure 5: Effect of a permanent tax cut. Sensitivity to the elasticity, ψ, of the debt share to the tax rate. *Notes: The dashed line refers to the economy where the debt share θ_t is constant ($\psi \to 0$), while the solid and dotted lines refer, respectively, to $\psi = 0.475$ (the benchmark value) and $\psi = 1$.*

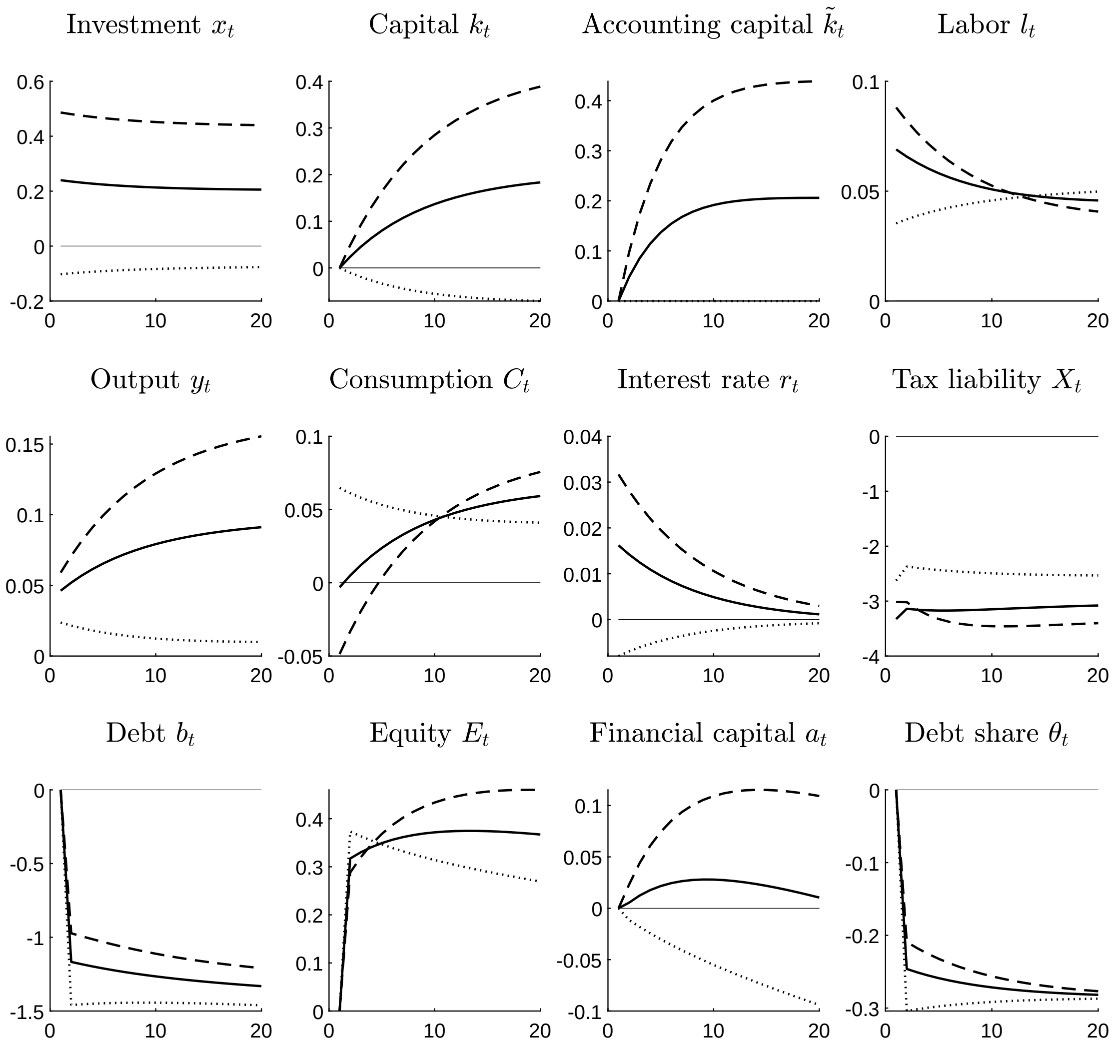

Figure 6: Effect of a permanent tax cut. Sensitivity to the first-year expensing fraction, κ. *Notes: The dashed, solid, and dotted lines refer, respectively, to* $\kappa = 0$ $\kappa = 0.48$ *(the benchmark value), and* $\kappa = 1$.

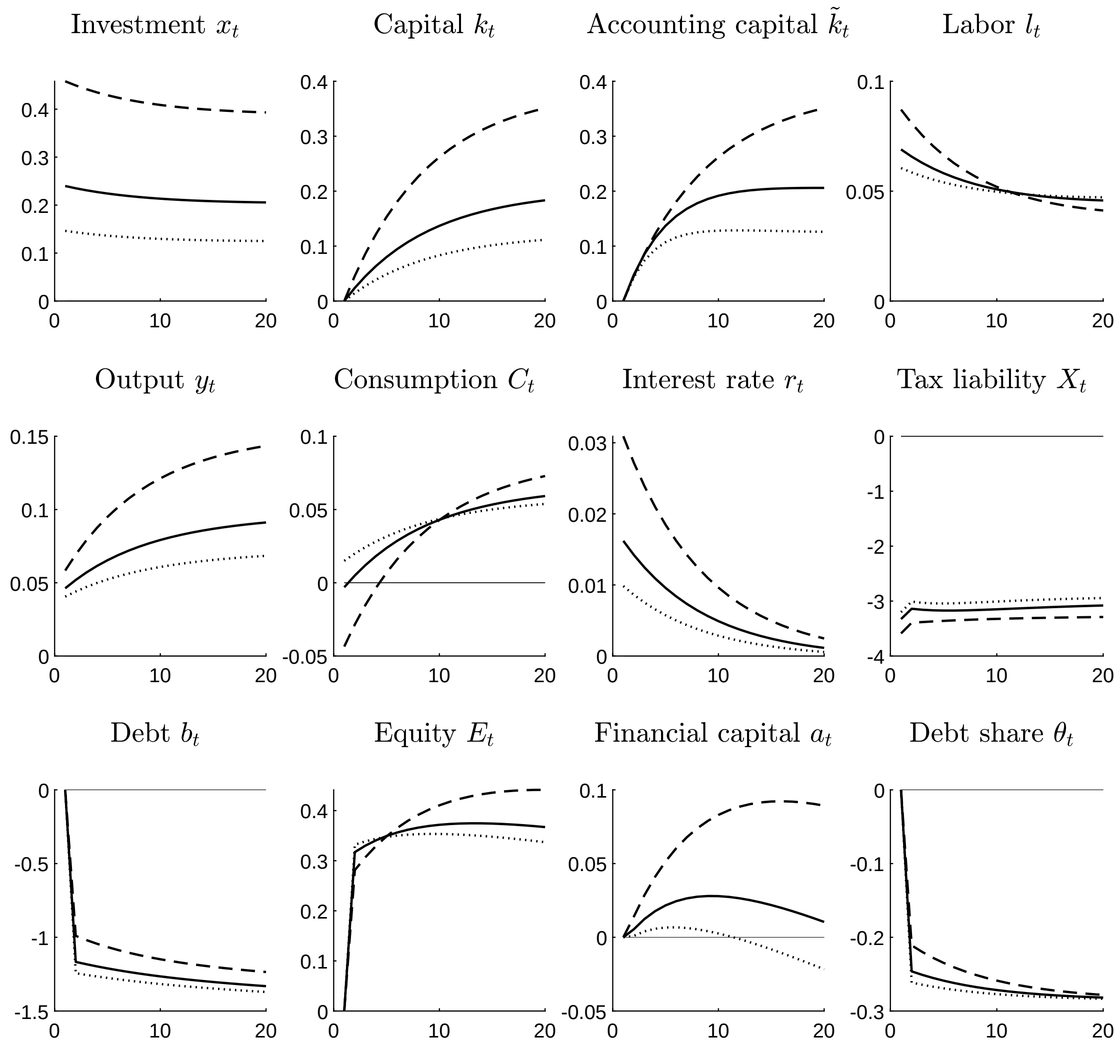

Figure 7: Effect of a permanent tax cut. Sensitivity to the accounting depreciation rate, $\tilde{\tilde{\delta}}$. *Notes: The dashed, solid, and dotted lines refer, respectively, to* $\tilde{\delta} = 0.1$, $\tilde{\delta} = 0.2$ *(the benchmark value), and* $\tilde{\delta} = 0.3$.

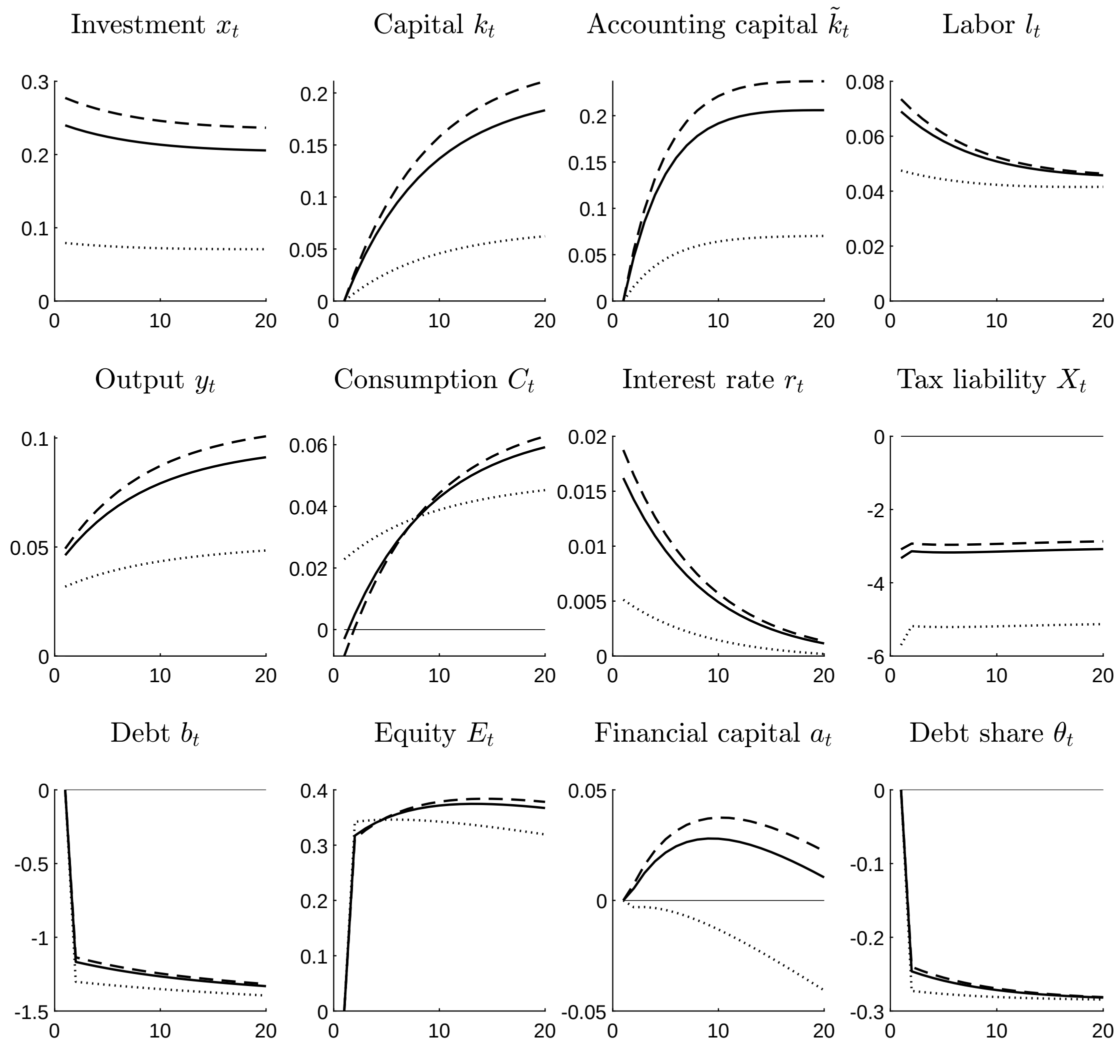

Figure 8: Effect of a permanent tax cut. Sensitivity to the investment tax credit, χ.

Notes: The dashed, solid, and dotted lines refer, respectively, to $\chi = 0$, $\chi = 0.01$ *(the benchmark value), and* $\chi = 0.05$.

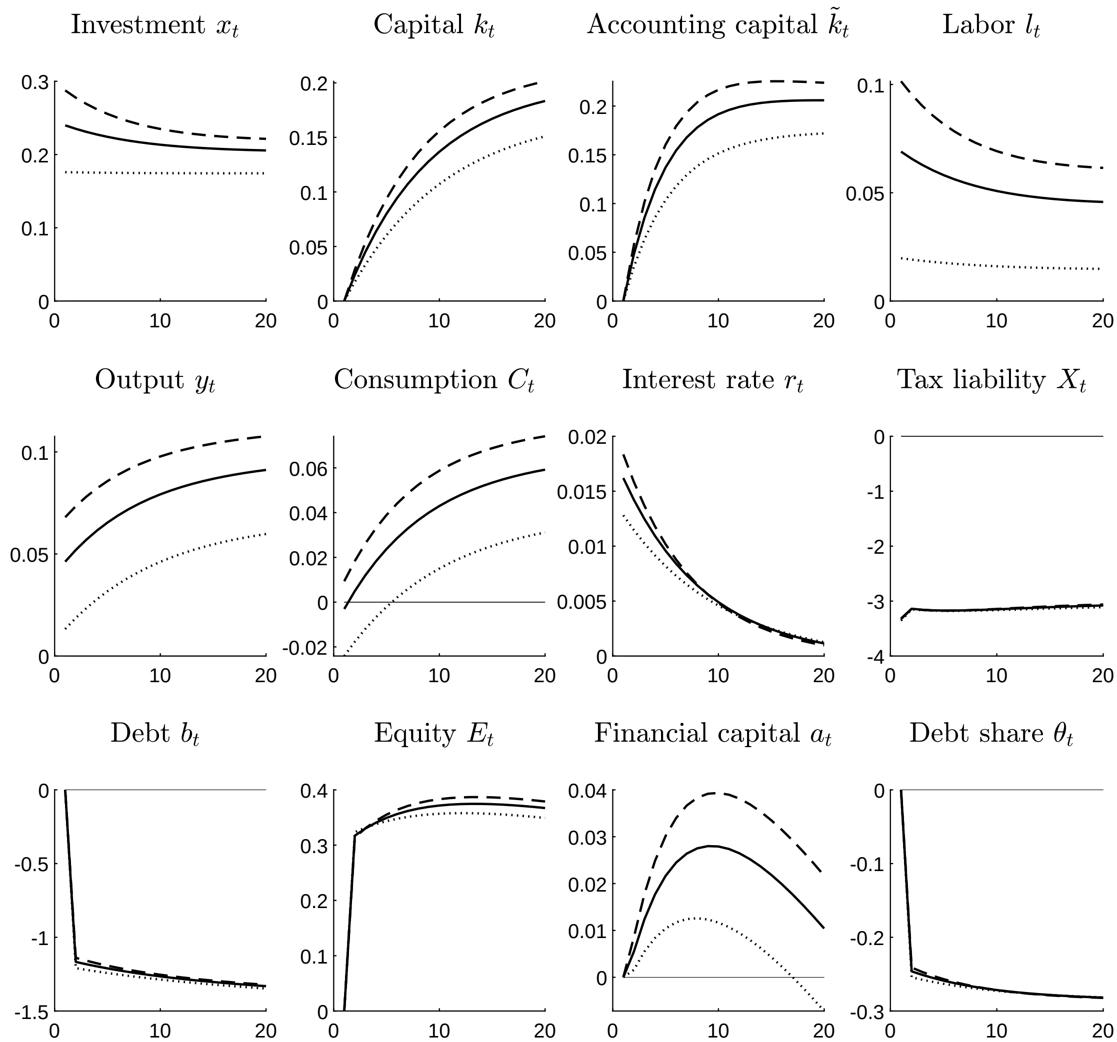

Figure 9: Effect of a permanent tax cut. Sensitivity to the Frisch elasticity of labor supply, φ. *Notes: The dotted, solid, and dashed lines refer, respectively, to* $\varphi = 0.1$, $\varphi = 0.5$ *(the benchmark value), and* $\varphi = 1$.

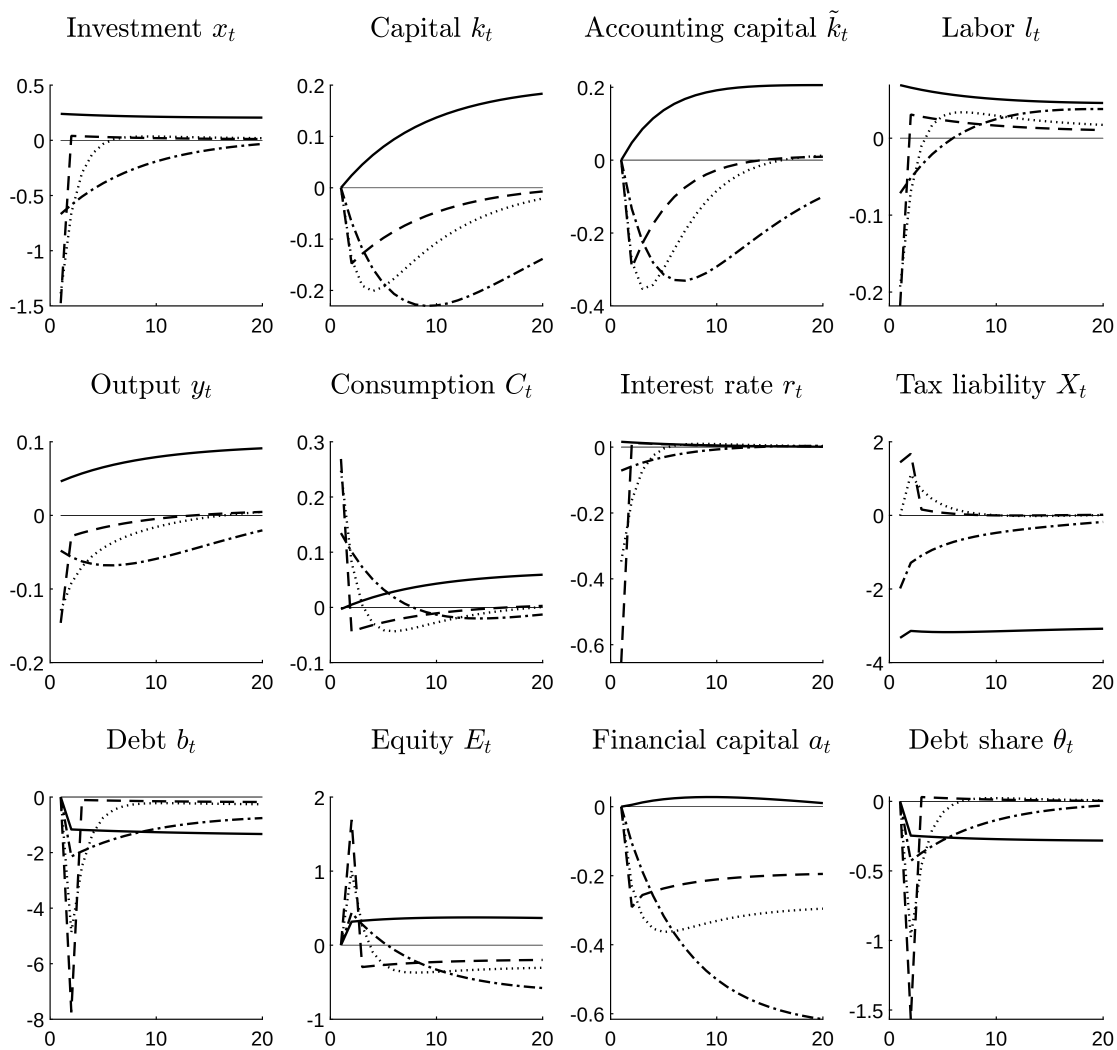

Figure 10: Effect of a tax cut. Sensitivity to the first-order autocorrelation of the tax rate shock. *Notes: The dashed, dotted, dashed-dotted and solid lines refer to a first-order autocorrelation equal, respectively, to 0, 0.5, 0.9, and 1.*