Aggregate Implications of Corporate Taxation over the Business Cycle*

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Abstract

Corporate tax deductions are widely employed as countercyclical policies, yet their impact on the business cycle and interactions with other policies remain largely understudied. I examine the cyclical implications of such deductions by developing a novel dynamic stochastic general equilibrium model in which firms face credit market imperfections and idiosyncratic productivity shocks. In my model, firms' investment decisions are distorted by collateralized borrowing and corporate taxation, and investment expenditures can be deducted from taxable income through targeted or untargeted accelerated depreciation policies. My model quantitatively replicates empirical estimates of the distribution of short-run elasticities of investment across firm size to changes in deduction policies. I show that raising deductions can reduce the severity and persistence of recessions by alleviating capital misallocation for productive firms. Applying my model to the policies in the US 2017 Tax Cuts and Jobs Act, I find that the targeted policy is 30 percent more effective than the untargeted policy in stimulating aggregate output. Furthermore, combining both policies reduces the overall effectiveness by 17 percent, revealing potential inefficiencies in current US tax policy implementation.

Keywords: Tax shields, Collateral constraint, Business cycle, Firm dynamics

JEL Codes: E22, E32, E62, H25

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1 Introduction

Incentivizing firm investment through corporate tax policy is a key fiscal policy to accelerate recoveries during economic downturns. Even outside of downturns, countries continue to engage in significant corporate tax reforms. For example, the Tax Cuts and Jobs Act (TCJA) of 2017 in the United States was the largest business tax cut in four decades, with an estimated cost of 100 to 150 billion dollars per year[1]. While individual firms' investment is sensitive to tax incentives[2],it is empirically difficult to identify the impact of an individual policy[3]. Moreover, existing quantitative models tend to abstract from heterogeneity in investment responses across firms towards different policies and the general equilibrium effects that follow changes in tax incentives on investment[4]. As I show, the heterogeneous responses to tax incentives across firms are essential to their aggregate impact, as taxes influence the allocation of capital across firms and, hence, aggregate productivity. While investment tax deductions can offset firm-level frictions, their general equilibrium effects on interest rates can induce large firms to over-invest, reducing aggregate productivity. The aggregate effects of raising tax incentives depend on the relative size of each channel on the level and allocation of capital across the underlying distribution of firms. My model demonstrates that these channels vary significantly across different US corporate tax policies, and hence changes to these policies exert materially distinct changes to aggregate outcomes both over the long run and during economic downturns.

In this paper, I develop a dynamic stochastic general equilibrium model with persistent heterogeneity across firms, collateral constraints, and corporate taxation. In addition to the standard corporate profit tax, I account for two key policies within the US corporate tax code, a targeted and untargeted one. The targeted policy (Section 179 expensing) allows firms to immediately deduct all investment expenditures if their investment is below a certain dollar

[1]The House Committee on Ways and Means (2003) explicitly states that the purpose of bonus depreciation is to "promote capital investment" and "help to spur an economic recovery". Furthermore, the Joint Committee on Taxation (2017) estimated that TCJA's adjustments to bonus depreciation would increase deficits by 86 billion dollars on 10-year tax revenue.

[2]Zwick and Mahon (2017) has estimated that the investment elasticity to increases in bonus depreciation rate ranges from -0.5 to -3.6.

[3]Ohrn (2019) reports that the Annual Survey of Manufactures (ASM) data on firm-level investment are not precise. Besides data quality concerns, Mills, Newberry and Trautman (2002) and Mills and Newberry (2005) document empirical difficulties in reconciling the difference in income for financial statements (book income) and income for tax purposes (taxable income).

[4]House and Shapiro (2008) argue that the shadow value of capital would be unchanged with temporary investment subsidies, assuming all firms are representative. However, credit constraints yield a distribution of capital shadow values; most firms' capital stocks are below their efficient level. Thus, temporary investment subsidies can change the shadow value of capital. Fernández-Villaverde (2010) treats the fiscal policy as a shock, while the statement in the House Committee on Ways and Means (2003) clearly shows that the policy is not imposed at random.

threshold. In contrast, the untargeted policy (bonus depreciation) allows all firms to deduct a bonus fraction of investment expenditure immediately, leading to a higher tax depreciation rate on capital relative to the physical depreciation rate[5].

My model captures two frictions that impede capital reallocation: financial frictions and tax wedges. Following Kiyotaki and Moore (1997), forward-looking collateral constraints limit firms' investment decisions, hindering the growth of small firms. What is novel about this setting is that it jointly accounts for these financial frictions and tax wedges, which further distort firms' investment. In addition to the distortionary effects of having a tax on coprorate profits, my model captures three elements that generate important discontinuities. First, in contrast to other studies, I impose a zero lower bound on corporate tax[6]. Second, the untargeted policy's accelerated tax depreciation generates a wedge between the purchase and resale value of capital; as the tax depreciation rate is higher than the physical capital depreciation rate, the market price of sold capital is usually higher than its value for tax purposes, due to the adjustments for claimed depreciation deduction (Hanlon, Maydew and Shevlin, 2008). These dynamics are themselves distorted by the third element, the targeted policy that allows for complete expensing of relatively small investments. Collectively, these tax policy elements yield a set of *(S,s)* decision rules for capital across firms that pay no corporate taxes, qualify for the targeted rebate, or only qualify for the untargeted rebate.

This paper is to my knowledge the first to explore how an economy with key elements of the US corporate tax system responds to shocks[7]. I show that corporate tax deductions can alleviate recessions generated by a negative shock to credit constraints, because they lower the need for borrowing. As tax incentives lower the user cost of capital, small firms rely less on debt financing to invest, further mitigating the deterioration in the aggregates and endogenous TFP. In contrast, I show that tax incentives yield nearly identical responses to standard models in the face of a negative TFP shock (Hansen, 1985; Khan and Thomas, 2013). This is because tax incentives can only indirectly offset the effects of a TFP shock on returns to investment, while they can directly alleviate the funding constraints induced by credit shocks.

[5]As discussed below, I track a distinct capital stock for tax purposes, in keeping with the regular investment depreciation scheduled firms use in practice. In the US, this is called Modified Accelerated Cost Recovery System (MACRS).

[6]The literature has typically ignored the potential of negative taxable income (e.g., Barro and Furman (2018) and Chodorow-Reich, Smith, Zidar and Zwick (2024). Models that directly impose the tax wedges on the flow profit and cost of capital imply that firms can receive government transfers simply by increasing their investment. However, in practice, taxes in any given year are nonnegative; firms can instead carry over net operating losses to deduct against future profits. This paper abstracts from loss carryover, but does capture the zero lower bound on tax liabilities.

[7]The empirical and theoretical analyses often simplify impacts of tax incentives to changes in user costs of capital (Hall and Jorgenson, 1967) and ignore how tax incentives affect firms' value and resulting misallocation of capital. The misallocation tradition comes from Summers, Bosworth, Tobin and White (1981).

Furthermore, the model demonstrates that the targeted policy offers the highest stabilizing power during recessions. I conduct both steady-state and dynamic policy experiments to quantitatively evaluate the impact of these policies. The baseline model is calibrated to match the 2015 Section 179 threshold and bonus depreciation rate in the US. To ensure a fair comparison of policy effectiveness, I design four experiments: (1) raising the Section 179 threshold, (2) increasing the bonus depreciation rate, (3) implementing both adjustments simultaneously using the values from the first two experiments, and (4) reducing the statutory tax rate. The cost of each policy is fixed at 0.3% of baseline output.

These experiments yield four main findings. First, increasing the Section 179 threshold boosts aggregate output by 1.61%, making it 30% more effective than the untargeted policy of raising the bonus depreciation rate. Second, implementing both policies simultaneously results in a larger output gain but causes a 17% decline in the marginal benefit of tax deductions compared to only raising the Section 179 threshold. This outcome aligns with empirical evidence from Ohrn (2019). Third, both policies outperform a reduction in the statutory tax rate in terms of effectiveness. Lastly, the targeted policy maintains its superior ability to mitigate aggregate fluctuations caused by negative TFP or credit shocks, outperforming the other policies in stabilizing the economy.

I offer two explanations for why Section 179 expensing more effectively supports economic recoveries during recessions more effectively accelerates economic recoveries during recessions than bonus depreciation, both related to how tax incentives shape the costs and returns of investment. First, on the cost side, I find that bonus depreciation lead to substantial increases in dividend payments, while Section 179 expensing only mildly raise it. Increasing tax incentives lead to lower user costs of capital. For smaller, credit-rationed firms, this reduction enables them to accumulate capital and expand production. In contrast, larger, financially unconstrained firms increase their dividend payments, as the could already reach their target level of capital. Since Section 179 expensing is limited to small- and medium-sized firms, while bonus depreciation also extends tax incentives to financially unconstrained firms, the latter policy results in higher dividend payment in equilibrium and hence is less effective at increasing aggregate capital investment or allocation.

On the return side, the increased effectiveness of the targeted policy can be illustrated by the distribution of excess return on investment across firms, which reflects economy-wide capital misallocation. Compared with bonus depreciation, Section 179 expensing results in less dispersion of firm investments around the economically efficient level of zero excess returns. Furthermore, high-productivity firms disproportionately respond to the Section 179 expensing by increasing investment, while the effects of bonus depreciation are more diffuse. This comes from the targeted nature of Section 179 expensing that induces self-selection so that productive firms invest more. In contrast, the untargeted policy does not trigger such a reallocation mechanism. Consequently, I find that the targeted policy generates a larger boost to GDP growth during recoveries than the untargeted policy. And when these policies are combined, they erode the effectiveness of each other. As Section 179 expensing becomes more generous, the tax base for the bonus depreciation shrinks, eroding its effectiveness.

There is a large body of literature investigating how tax incentives influence aggregate investment. The seminal work by Hall and Jorgenson (1967) was the first to evaluate a representative firm's response to tax credits through changes in the user cost of capital. My work builds on this tradition by modeling differences in user costs based on firms' investment decisions. Firms investing below the Section 179 threshold enjoy lower user costs compared to those investing above it, with the gap between these costs determined by the bonus depreciation rate. Additionally, Summers, Bosworth, Tobin and White (1981) introduced the concept of tax-adjusted Tobin's q, which assesses how tax policies influence the accumulation and valuations of capital, offering another channel through which fiscal policy impacts capital accumulation. In my model, both corporate taxes and investment subsidies affect firm value, allowing me to explore misallocation channel for tax credits.

Earlier empirical literature often concluded that investment is not responsive to tax credits. Goolsbee (1998) uses data on the prices of capital by the US Bureau of Economic Analysis (BEA) and concludes that the effect of the investment tax credit is offset by the increase in capital prices among public firms. Cummins, Hassett and Hubbard (1996) utilizes panel data among 14 OECD countries and finds that the user cost of capital and the adjustment costs can explain such unresponsiveness. House and Shapiro (2008) matches the BEA data with Internal Revenue Service (IRS) depreciation schedules and analyzes the change in bonus depreciation from 2001 to 2002. They claim that the intertemporal elasticity of investment is high under two assumptions: capital is long-lived and the investment tax credit is temporary and unexpected. Even though the conclusion by House and Shapiro (2008) highlights the importance of intertemporal substitution, they assume all tax responses are temporary price effects and not income effects, which contradicts the evidence documented in the corporate finance literature (e.g., Lamont (1997)). While these studies do not find heterogeneity in tax-term elasticity among public firms, evidence from subsequent studies shows that small and private firms are most responsive to these policies.

Recent empirical literature has utilized firm-level data and state-level policy compliance and found substantial heterogeneity in investment responses. Zwick and Mahon (2017) is the first empirical research that exploits business tax data from the IRS to estimate the heterogeneity of investment response to tax credits. They examine the impact of bonus depreciation by comparing industries that use long-lasting capital to industries that use capital with higher physical depreciation. They found that bonus depreciation increases the investment of eligible capital by 10 to 16 percent compared to ineligible capital. Also, small firms increase investment by 95 percent more than big firms. Ohrn (2018) further investigates the effect of corporate tax deductions and concludes that the investment raises by 4.7 percent for those states that comply with federal policies. In a subsequent study, Ohrn (2019) identifies potential conflicts between bonus depreciation and Section 179 expensing as mentioned before. These research provide evidence to demonstrate the strengh of my parameterized model.

Historically, theoretical explorations of firms' responses to fiscal policy changes have been studied using representative firm models. Fernández-Villaverde (2010) builds a dynamic stochastic general equilibrium (DSGE) model with a representative firm and financial constraints to analyze the response to fiscal shocks. Occhino (2022) analyzes the aggregate effects of the 2017 Tax Cuts and Jobs Act while abstracting from the heterogeneous response to tax credits, and therefore does not explore the distortion created by Section 179 expensing. Later, Occhino (2023) evaluates the effect of corporate tax cuts with accelerated depreciation, assuming that the bonus depreciation rate followed an AR(1) process. This assumption ignores the countercyclical nature of these policies and may lead to underestimation of the policy responses. My contribution is to bring heterogeneity into the theoretical analysis and quantitatively evaluate the efficacy of corporate tax deductions.

The remainder of the paper proceeds as follows. Section 2 introduces the model, and Section 3 provides useful theoretical analysis. Section 4 presents and discusses the calibration strategies and results. Section 5 presents stationary equilibrium, Section 6 investigates the long run effects of deduction policies by comparative statics, Section 7 shows results over recessions, and Section 8 concludes.

2 Model Environment

Time is discrete and infinite. I abstract from aggregate uncertainty and consider stationary equilibrium and transitional dynamics under aggregate, unanticipated exogenous shocks. There are three types of agents: firms, households, and the government. A continuum of heterogeneous firms produce homogeneous output using labor and predetermined capital stocks. Firms' capital accumulation is distorted by two key factors: corporate taxation collateral constraints. They pay corporate taxes based on their taxable income, which is defined by their flow profit after investment tax deductions. Together with persistent idiosyncratic productivities, these yield substantial heterogeneity in production.

Households are identical and infinitely lived. They pay for their consumption with their after-tax labor income, one-period shares in firms, and one-period non-contingent bonds. The government collects labor income and lump-sum taxes from households and corporate tax from firms to fund exogenous government spending and corporate tax deductions.

2.1 Firms

2.1.1 Production and financial frictions

At the beginning of each period, firms produce output y with physical capital k and labor n. The production function is $y = z\varepsilon F(k,n)$, where $F(k,n) = k^{\alpha}n^{\nu}$ with both $\alpha, \nu < 1$ and $\alpha + \nu < 1$. The z is the aggregate TFP shock that is common among firms, while ε is a firm-specific productivity shock. I assume that ε is a Markov chain, i.e., $\varepsilon \in \mathbf{E} \equiv \{\varepsilon_1, \ldots \varepsilon_{N_\varepsilon}\}$, where $\Pr(\varepsilon' = \varepsilon_j | \varepsilon = \varepsilon_i) = \pi^{\varepsilon}_{ij}$, and $\sum_{j=1}^{N_\varepsilon} \pi^{\varepsilon}_{ij} = 1$. Capital accumulation is determined by the law of motion, $k' = (1-\delta)k + I$, where $\delta \in (0,1)$ is the physical capital depreciation rate, and I denotes investment. Meanwhile, firms face a per-period probability of permanent exit $\pi_d \in (0,1)$[8].

Firms finance their investment by borrowing one-period debt from households, subject to a collateralized borrowing limit. The amount of newly-issued debt b' is priced at q, and cannot exceed θ fraction of firms' future capital choice k'; that is, $b' \leq \theta k'$[9]. The fraction θ represents the source of the credit shock. I summarize the aggregate states used in transitional equilibrium as $s = (z, \theta)$.

[8]Exogenous exit shocks, alongside one-for-one replacement with new entrants, are a tractable way of capturing firm lifecycle dynamics observed empirically (Khan and Thomas, 2013).

[9]If the fraction θ is close to the risk-free real interest rate $\frac{1}{q}$, then the collateral constraints become looser. This assumption is based on the limited enforceability of financial contracts. The forward-looking nature of collateral constraints follows the specification in theoretical literatures such as Kiyotaki and Moore (1997) and Jo and Senga (2019).

2.1.2 Deductible stocks and deduction policies

Firms are subject to corporate taxes on flow income net of operating expenses. Wage expenses can be fully deducted from firms' taxable income immediately. The deduction on investment expenditure, on the other hand, follows a depreciation schedule. As happens in practice, I allow the depreciation rate of this schedule (i.e., the tax depreciation rate) to be faster than the physical capital depreciation rate. There are two key investment deduction policies that accelerate this schedule in the economics downturns: Section 179 expensing and bonus depreciation. Section 179 expensing allows firms to immediately deduct all of the equipment expenses below a dollar threshold. For larger investment, bonus depreciation allows a firm to deduct an additional fraction of their investment expenses, and the remaining part follows the depreciation schedule.

To characterize both the schedule and the deduction policies, I introduce *deductible stock* , ψ, which tracks all depreciation deductions not realized immediately. At the beginning of each period, the deductiable stock depreciates at a rate $\delta^{\varphi} \in [\delta, 1)$, which is faster than physical capital depreciation rate. As an accounting concept, the deductible stock is not directly involved in production; instead, it affects firms' user cost of capital and cash-on-hand.

In practice, only certain investments are eligible for the corporate tax deduction, which I capture in the model by fixing ω fraction of investment as eligible. Firms can deduct a fraction ξ of current eligible investment expenses from their taxable income immediately, lowering the current-period cost of capital by $\tau^c \xi \omega$. The remaining fraction, $1 - \xi$ is accumulated to the deductible stock for future deductions. Therefore, the law of motion for deductible stock can be described as

$$\psi' = (1 - \delta^{\psi})\psi + (1 - \xi)\omega(k' - (1 - \delta)k).$$

This fraction ξ captures both deduction policies. If a firm's investment is within a threshold $(0, \bar{I}]$, then $\xi = 1$, resembling the Section 179 expensing. Otherwise, bonus depreciation allows a firm to deduct $\xi \in [0, 1]$ fraction of their investment expenses. During recessions, the government may increase either ξ or $\bar{I}$ to boost recoveries.

2.1.3 Taxable income and partial irreversibility

The taxable income, $\mathcal{I}(k', k, \psi, \varepsilon)$, is composed of flow operating profits less the deduction from investment expenditure. To be specific,

$$\mathcal{I}(k', k, \psi, \varepsilon) = \max \left\{ z\varepsilon F(k, n) - wn - \mathcal{J}(k', k)(k' - (1 - \delta)k) - \delta^{\psi}\psi, 0 \right\}, \tag{1}$$

where $\mathcal{J}(k',k)$ is the indicator function for tax policies. If a firm is eligible for Section 179 expensing, i.e., $k' - (1-\delta)k \leq \bar{I}$, then it can deduct all eligible investment immediately, $\mathcal{J}(k,k) = \omega$. Otherwise, $\mathcal{J}(k',k) = \xi\omega$. The deduction from current investment, $\mathcal{J}(k',k)(k' - (1-\delta))k$, alters the effective tax rate per unit of capital invested, and the deduction from past investments, $\delta^{\psi}\psi$, expands the firm's budget constraint.

When firms disinvest, i.e., $k' - (1-\delta)k \leq 0$, their taxable income expands due to capital gains. When firms dispose of their depreciable assets, the basis for calculating capital gain or loss is adjusted to account for previously claimed depreciation deductions[10]. In practice, the sales price of the capital is usually higher than the adjusted basis because the tax depreciation rate is faster than the physical capital depreciation rate (Hanlon, Maydew and Shevlin, 2008). To be consistent with (1), I assume the adjusted basis for one unit of capital sold is ω, and firms' taxable income is raised by $\omega(k' - (1-\delta)k)$.

My model is distinct from existing literatures in its treatment of net operating losses. In principle, the government does not provide tax rebates when firms report negative taxable income. Instead, these firms simply owe no corporate taxes[11]. Nevertheless, existing models (Barro and Furman, 2018; Chodorow-Reich, Smith, Zidar and Zwick, 2024) directly impose tax wedges, $(1-\tau^c)$, on flow profits and investment subsidies, $(1-\tau^c\omega)$, on capital costs, overlooking the possibility of negative taxable income. This simplification risks mischaracterizing the distortion of investment incentives, as it implies that firms can always receive tax rebates by increasing investment.

In light of this observation, I derive the upper bound for k' choice such that the firm is paying positive corporate tax,

$$\bar{k}(k,\psi,\varepsilon) \equiv \frac{z\varepsilon f(k,n) - wn - \delta^{\psi}\psi}{\mathcal{J}(k',k)\omega} + (1-\delta)k.$$

Firms that invest at least $\bar{k}$ pay no corporate tax, and their capital and bond decisions are different from firms that pay corporate tax.

As shown in figure 1, the tax base threshold $\bar{k}$ and the policy threshold $\bar{I}$ divide the idiosyncratic state space into three regions. If a firm's capital choice k' exceeds $\bar{k}$, the firm does not pay corporate taxes (north east lines region), and I refer to these firms as N-type (not paying corporate taxes). Similarly, if the firm's k' falls between the policy threshold $(1-\delta)k + \bar{I}$ and $\bar{k}$, the firm pays corporate taxes and invests above the policy threshold (horizontal lines region),

[10] See IRS Publication 544.

[11] In the United States, firms can carry forward the net operating losses to offset taxable income in future years (IRS Publication 542). However, such carryforwards never result in a tax rebate from the government. Therefore, I assume that carrying forward operating losses is not permitted.

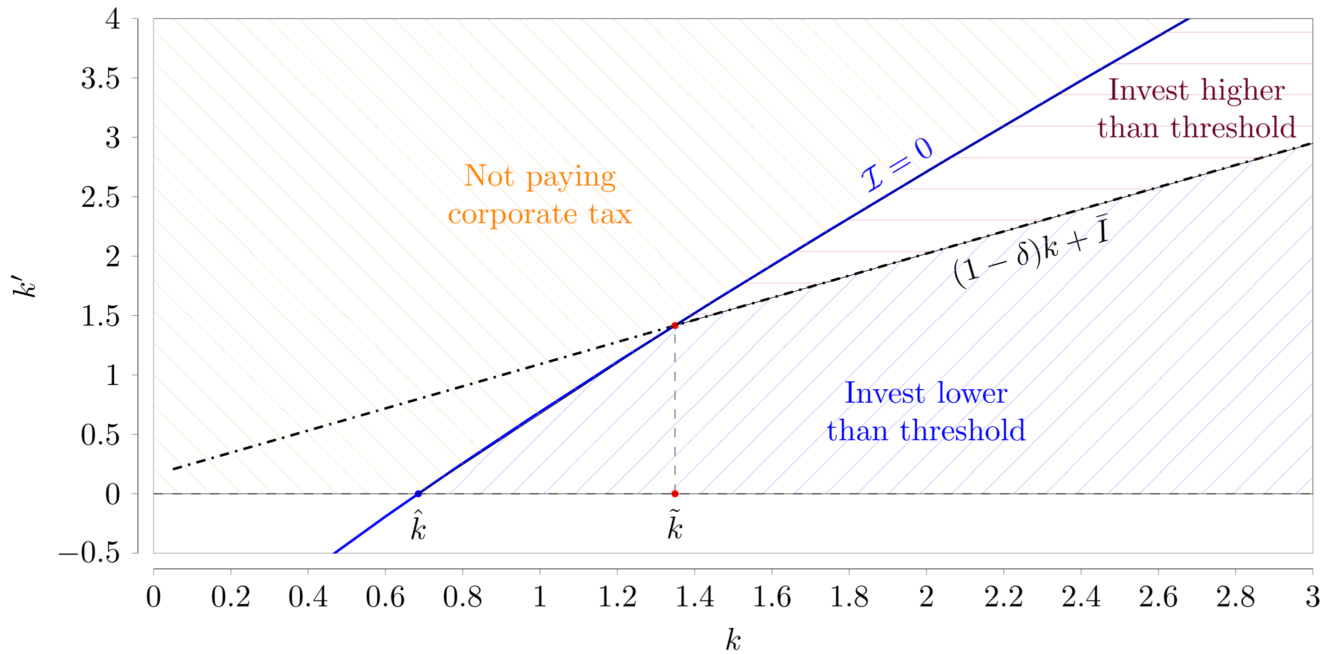


Figure 1: Capital choice state space

which I label as H-type firms (higher than the policy threshold). Finally, if the firm invests below the policy threshold or disinvests (north west lines region), I categorize them as L-type firms (lower than the policy threshold).

Given these tax wedges on profits and investment rebates, the firm's problem is not everywhere differentiable. However, firms' decisions across the three state space regions can be categorized by thresholds off the firm's current capital stock k. The intersection of both the tax base threshold and policy threshold, $\bar{k} = (1-\delta)k + \bar{I}$, leads to the first cutoff on capital stock $\tilde{k}$,

$$\tilde{k} = \left(\frac{\delta^{\psi}\psi + \mathcal{J}(k',k)\bar{I}}{A(w) z^{\frac{1}{1-\nu}} \varepsilon^{\frac{1}{1-\nu}}} \right)^{\frac{1-\nu}{\alpha}},$$

where $A(w) = \left[\left(\frac{\nu}{w(s,\mu)} \right)^{\frac{\nu}{1-\nu}} - w(s,\mu) \left(\frac{\nu}{w(s,\mu)} \right)^{\frac{\nu}{1-\nu}} \right]$. Firms with large enough capital stock, $k > \tilde{k}$, can choose to invest in all three types. Firms with $k \leq \tilde{k}$, however, can only choose to be N-type or L-type, as investing higher than $\bar{I}$ is equivalent to not paying corporate tax. Similarly, let $\hat{k}$ be the intersection between $\bar{k}$ and $k' = 0$. Firms with capital stock k lower than $\hat{k}$ will not pay corporate tax for any k' choice.

Firms' budget constraints given corporate taxes are defined as

$$D = (1-\tau^c)(z\varepsilon F(k,n) - wn) - b + qb' - (1 - \tau^c \mathcal{J}(k',k))(k' - (1-\delta)k) + \tau^c \delta^{\psi} \psi.$$

If the government decreases the corporate tax τ^c to zero, the model falls back to the standard heterogeneous-firm business cycle model. When $\mathcal{I}(k', k, \psi, \varepsilon)$ is positive, I combine the common terms and rewrite the budget constraint as

$$D = (1-\tau^c)(z\varepsilon F(k,n) - wn) - b + qb' - (1-\tau^c \mathcal{J}(k',k))(k' - (1-\delta)k) + \tau^c \delta^{\psi} \psi.$$

Notice that one unit of investment now costs $1-\tau^c\mathcal{J}(k',k)$ unit of final goods after deduction. In this manner, investment incentives through taxable income deductions reduce the relative price of capital.

2.1.4 Firms' problem

At the beginning of each period, a firm is defined by four states:

1. its predetermined capital stock $k \in \mathbf{K} \subset \mathbb{R}_+$,
2. its level of one-period bond $b \in \mathbf{B} \subset \mathbb{R}$,
3. its deductible stock from investment $\psi \in \mathbf{\Psi} \subset \mathbb{R}_+$, and
4. its realized idiosyncratic productivity $\varepsilon \in \mathbf{E}$.

The distribution of firms is represented by a probability measure $\mu(k, b, \psi, \varepsilon)$, defined over the Borel σ-algebra generated by the open sets of the product space $\mathcal{S} = \mathbf{K} \times \mathbf{B} \times \mathbf{\Psi} \times \mathbf{E}$. Given all individual states, the firm maximizes the expected discounted value function by choosing current employment level n, future capital stock k', and next-period debt level b'. For each unit of labor employed, the firm pays competitive wage $w(s, \mu)$, which depends on aggregate exogenous state and the distribution of firms. The firm can issue one-period debt at a risk-free price q, subject to the collateral constraint $b' \leq \theta k'$.

Let $v^0(k, b, \psi, \varepsilon; s, \mu)$ denote the expected discounted value of a firm at the beginning of the period before the realization of the exogenous exit shock π_d, and $v(k, b, \psi, \varepsilon; s, \mu)$ be the continuation value after the exit shock. If exiting, the firm chooses labor demand n, sells capital, and repays debts. The functional equation is

$$\begin{aligned} v^0(k,b,\psi,\varepsilon;s,\mu) = \pi_d \max_n \left\{ z\varepsilon F(k,n) - wn - b + (1-\delta)k - \tau^c \mathcal{I}(0,k,\psi,\varepsilon) \right\} \\ + (1-\pi_d) v(k,b,\psi,\varepsilon;s,\mu) \end{aligned} \tag{2}$$

Conditional on survival, the continuation problem is a discrete choice among three options,

$$v(k,b,\psi,\varepsilon;s,\mu) = \max \left\{ v^H(k,b,\psi,\varepsilon;s,\mu), v^L(k,b,\psi,\varepsilon;s,\mu), v^N(k,b,\psi,\varepsilon;s,\mu) \right\}., \tag{3}$$

where $v^L(k,b,\psi,\varepsilon;s,\mu)$ denotes the value of investing below the threshold level $\bar{I}$, $v^H(k,b,\psi,\varepsilon;s,\mu)$ represents the value of investing larger than $\bar{I}$, and $v^N(k,b,\psi,\varepsilon;s,\mu)$ denotes the value if the firm is not paying tax.

In either case, the firm is maximizing the current dividend D and expected discounted future firm value. Let $Q(s,\mu)$ denote the stochastic discounting factor for firms' next-period value. The dynamic problem for those firms that undertake investments larger than $\bar{I}$ is

$$v^H(k,b,\psi,\varepsilon_i;s,\mu) = \max_{D,k',b',n} D + Q(s,\mu)\sum_{j=1}^{N_\varepsilon} \pi_{ij}^{\varepsilon} v^0(k',b',\psi',\varepsilon_j;s',\mu'), \tag{4}$$

subject to

$$\begin{aligned} 0 \leq D = {} & (1-\tau^c)(z\varepsilon F(k,n) - wn) - b \\ & + qb' - (1-\tau^c\omega\xi)(k' - (1-\delta)k) + \tau^c\delta^\psi\psi. \end{aligned} \tag{5}$$

$$k' \in ((1-\delta)k + \bar{I}, \bar{k}) \text{ and } k > \hat{k} \tag{6}$$

$$b' \leq \theta k' \tag{7}$$

$$\psi' = (1-\delta^\psi)\psi + (1-\xi)\omega(k' - (1-\delta)k) \tag{8}$$

$$\mu' = \Gamma(s,\mu) \tag{9}$$

If we rewrite the above problem with $\xi = 1$, then we get the problem for firms that undertake investment below $\bar{I}$,

$$v^L(k,b,\psi,\varepsilon_i;s,\mu) = \max_{D,k',b',n} D + Q(s,\mu)\sum_{j=1}^{N_\varepsilon} \pi_{ij}^{\varepsilon} v^0(k',b',\psi',\varepsilon_j;s',\mu'), \tag{10}$$

subject to

$$\begin{aligned} 0 \leq D = {} & (1-\tau^c)(z\varepsilon F(k,n) - wn) - b \\ & + qb' - (1-\tau^c\omega)(k' - (1-\delta)k) + \tau^c\delta^\psi\psi. \end{aligned} \tag{11}$$

$$k' < (1-\delta)k + \bar{I} \text{ and } k > \tilde{k} \tag{12}$$

$$b' \leq \theta k' \tag{13}$$

$$\psi' = (1-\delta^\psi)\psi \tag{14}$$

$$\mu' = \Gamma(s,\mu) \tag{15}$$

Notice that the law of motion of deductible stock is also changed with $\xi = 1$.

Similarly, if we rewrite the H-type firms' problem with $\tau^c = 0$, then we get the N-type firms' problem as

$$v^N(k, b, \psi, \varepsilon_i; s, \mu) = \max_{D,k',b',n} D + \beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon V^0(k', b', \psi', \varepsilon_j; s', \mu'), \tag{16}$$

subject to

$$0 \le D = z\varepsilon F(k, n) - wn - b + qb' - (k' - (1-\delta)k) \tag{17}$$

$$k' \ge \max(\bar{k}, 0) \tag{18}$$

$$b' \le \theta k' \tag{19}$$

$$\psi' = (1 - \delta^\psi)\psi + (1 - \mathcal{J}(k', k))\omega(k' - (1-\delta)k) \tag{20}$$

$$\mu' = \Gamma(s, \mu) \tag{21}$$

Since cash-on-hand does not affect current production and labor is frictionless, the firm's employment decision only depends on its predetermined capital, idiosyncratic productivity, and the aggregate state. Denote the policy functions associate to firm's employment by $N(k, \varepsilon; s, \mu)$, future capital by $K(k, b, \psi, \varepsilon; s, \mu)$, future debt by $B(k, b, \psi, \varepsilon; s, \mu)$, dividend by $D(k, b, \psi, \varepsilon; s, \mu)$, and remaining tax benefit be $\Psi(\psi, K(k, b, \psi, \varepsilon; s, \mu), k; s, \mu)$. I characterize these policy functions in section 3.

2.2 Household

I assume there is a unit measure of identical households in the model. In each period, households maximize their lifetime utility by choosing consumption, c, labor supply, n^h, future firm shareholdings, λ', and future bond holding, a':

$$\begin{aligned} V^h(\lambda, a; s, \mu) = & \max_{c, n^h, a', \lambda'} \left\{ u(c, 1 - n^h) + \beta V^h(\lambda', a'; s', \mu') \right\} \\ & \text{s.t.} \quad c + qa' + \int \rho_1(k', b', \psi', \varepsilon'; s', \mu') \lambda'(d[k' \times b' \times \psi' \times \varepsilon']) + T \qquad , \\ & \qquad \le (1 - \tau^n) w(\mu) n^h + a + \int \rho_0(k, b, \psi, \varepsilon; s, \mu) \lambda(d[k \times b \times \psi \times \varepsilon]) \end{aligned} \tag{22}$$

where $\rho_0(k, b, \psi, \varepsilon; s, \mu)$ is the dividend-inclusive price of the current share, $\rho_1(k', b', \psi', \varepsilon'; s', \mu')$ is the ex-dividend price of the future share, τ^n is the labor tax rate, and T is the lump-sum tax imposed by the government. Let $C^h(\lambda, a; s, \mu)$ be the equilibrium consumption function, and $N^h(\lambda, a; s, \mu)$ is the labor supply function. Similarly, let $A^h(\lambda, a; s, \mu)$ denote the households' decision for bonds, and $\Lambda(\lambda, a; s, \mu)$ is the choice of firm shares.

2.3 Government

In my model economy, the government collects corporate taxes from firms and labor income taxes from households to fund exogenous government spending G. The corporate tax revenue R is defined as

$$R = \int_{\mathcal{S}} \Bigg\{ \tau^c \Big[\max\{z\varepsilon F(k, N(k,\varepsilon;s,\mu)) - w(s,\mu)N(k,\varepsilon;s,\mu) - \mathcal{J}(K(k,b,\psi,\varepsilon;s,\mu),k) \\ \times (K(k,b,\psi,\varepsilon;s,\mu) - (1-\delta)k) - \delta^{\psi}\psi, 0\} \Big] \Bigg\} \mu(d[k \times b \times \psi \times \varepsilon]), \tag{23}$$

The government balances its budget following the following formula,

$$G = \tau^n w N^h(\lambda, a; s, \mu) + R + T, \tag{24}$$

where T is the lump-sum tax on households for raising bonus depreciation ξ or Section 179 threshold $\bar{I}$.

2.4 Recursive Equilibrium

A *recursive competitive equilibrium* is a set of functions including prices $(p, w, q, \rho_0, \rho_1)$, quantities $\left(N, K, \Psi, B, D, C^h, N^h, A^h, \Lambda\right)$, a distribution $\mu(k, b, \psi, \varepsilon)$, and $\left(v^0, v^L, v^H, v, V^h\right)$ that solves firms' and households' optimization problems and clears the markets for assets, labor, and output in the following conditions.

1. v^0, v^L, v^H, and v solve (2), (3), (4), and (10). The associated policy functions for firms are (N, K, Ψ, B, D).
2. V^h solves (22), and the associated policy functions for households are (C^h, N^h, A^h, Λ)
3. Labor market clears, i.e., $N^h(\lambda, a; s, \mu) = \int_{\mathcal{S}} N(k, \varepsilon; s, \mu)\mu(d[k \times b \times \psi \times \varepsilon])$.
4. Goods market clears, i.e.,

$$C^h(\mu, a; s, \mu) = \int_{\mathcal{S}} \Bigg\{ z\varepsilon F(k, N(k,\varepsilon;s,\mu) - (1-\pi_d)\left[K(k,b,\psi,\varepsilon;s,\mu) - (1-\delta)k\right] \\ + \pi_d((1-\delta)k - k_0) \Bigg\} \mu(d[k \times b \times \psi \times \varepsilon]) - G,$$

where k_0 is the capital allocated to entrants. The tax function $\mathcal{J}(k', k)$ enters the aggregate resource constraints through government spending G.

5. The government balances its budget in (24).
6. The distribution of firms in steady state, $\tilde{\mu}(k, b, \psi, \varepsilon)$, is a fixed point of Γ function. $\Gamma(s, \mu)$ is consistent with policy functions (K, B, Ψ) and law of motion of ε.

3 Analysis

Before solving the recursive competitive equilibrium, I reformulate the firm's problem by exploiting the optimality conditions implied by the household's problem. In equilibrium, the wage w is pinned down by the marginal rate of substitution between consumption and leisure, that is,

$$w(s, \mu) = \frac{D_2 u(c, 1-n^h)}{(1-\tau^n) D_1 u(c, 1-n^h)}.$$

Similarly, the bond price q equals the inverse of the expected real interest rate. As there is no aggregate uncertainty in the economy, the expected real interest rate is $\frac{1}{\beta}$. The stochastic discounting factor $Q(s, \mu)$ equals to household's discounting factor,

$$Q(s, \mu) = \beta \frac{D_1 u(c', 1-n^{h'})}{D_1 u(c, 1-n^h)}.$$

Without the loss of generality, I define $p(s, \mu)$ to be the marginal utility of consumption, $D_1 u(c, 1-n^h)$. The $p(s, \mu)$ represents the output price that is used to evaluate the firm's current dividend.

After incorporating the household's optimality condition into the prices that firms face, I define a new value V as the product of $p(s, \mu)$ and v, and rewrite dynamic problem (2), (3), (4), and (10):

$$\begin{aligned} V^0(k, b, \psi, \varepsilon; s, \mu) = p(s, \mu)\pi_d \max_n \Big\{ z\varepsilon F(k, n) - wn - b + (1-\delta)k - \tau^c \mathcal{I}(0, k, \psi, \varepsilon) \Big\} \\ + (1-\pi_d) v(k, b, \psi, \varepsilon; s, \mu) \end{aligned} \tag{25}$$

where

$$V(k, b, \psi, \varepsilon; s, \mu) = \max \Big\{ V^H(k, b, \psi, \varepsilon; s, \mu), V^L(k, b, \psi, \varepsilon; s, \mu), V^N(k, b, \psi, \varepsilon; s, \mu) \Big\} ., \tag{26}$$

The dynamic problem for firms who invest larger than the Section 179 deduction is

$$V^H(k, b, \psi, \varepsilon_i; s, \mu) = \max_{D,k',b',n} p(s, \mu)D + \beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon V^0(k', b', \psi', \varepsilon_j; s', \mu'), \tag{27}$$

subject to constraints (5)-(9). The counterpart for firms that undertake investment below the Section 179 deduction is

$$V^L(k, b, \psi, \varepsilon_i; s, \mu) = \max_{D,k',b',n} p(s, \mu)D + \beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon V^0(k', b', \psi', \varepsilon_j; s', \mu'), \tag{28}$$

subject to constraints (11)-(15). Moreover, the value function for firms not paying corporate tax is

$$V^N(k, b, \psi, \varepsilon_i; s, \mu) = \max_{D,k',b',n} p(s, \mu)D + \beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon V^0(k', b', \psi', \varepsilon_j; s', \mu') \tag{29}$$

subject to constraints (17)-(21).

I start my analysis by deriving the optimal labor choice $N(k, \varepsilon)$. Since there is no friction in the labor market, a firm's labor demand is independent of intertemporal choices. In other words, the optimal labor choice can be derived by solving $\pi(k, \varepsilon) \equiv \max_n z\varepsilon F(k, N(k, \varepsilon)) - wN(k, \varepsilon)$ and get

$$N(k, \varepsilon) = \left(\frac{\nu z \varepsilon k^\alpha}{w} \right)^{\frac{1}{1-\nu}}.$$

Thus, the flow profit $\pi(k, \varepsilon)$ is rewritten as

$$\pi(k, \varepsilon) = A(w) z^{\frac{1}{1-\nu}} \varepsilon^{\frac{1}{1-\nu}} k^{\frac{\alpha}{1-\nu}}, \tag{30}$$

where $A(w) = \left[\left(\frac{\nu}{w} \right)^{\frac{\nu}{1-\nu}} - w \left(\frac{\nu}{w} \right)^{\frac{1}{1-\nu}} \right]$.

To characterize a firm's intertemporal decision, I follow Khan and Thomas (2013) and Jo and Senga (2019) and separate firms into *unconstrained* and *constrained*. Financial frictions limit firms' ability to finance externally, and thus they have to accumulate financial savings, $b < 0$, to fund their investment. Unconstrained firms are those that have already accumulated enough financial savings such that the collateral constraints will never bind in all possible states. Thus, they are indifferent between paying dividends and financial savings. Following Khan and Thomas (2013), I resolve this indeterminacy by requiring unconstrained firms to adopt *minimum saving policy*, i.e., they prioritize dividend payment and accumulate the lowest financial saving b' to stay unconstrained. In section 3.2, I detail the minimum saving policy.

3.1 Decisions among unconstrained firms

Let W function be the value function for unconstrained firms. The start-of-period value before the realization of exit shocks, W^0, is

$$W^0(k,b,\psi,\varepsilon;s,\mu) = p(s,\mu)\pi_d \max_n \left\{ z\varepsilon F(k,n) - wn - b + (1-\delta)k - \tau^c \mathcal{I}(0,k,\psi,\varepsilon) \right\} + (1-\pi_d)W(k,b,\psi,\varepsilon;s,\mu).$$

Upon survival, unconstrained firms undertake binary choice similar to (3),

$$W(k,b,\psi,\varepsilon;s,\mu) = \max\left\{ W^H(k,b,\psi,\varepsilon;s,\mu), W^L(k,b,\psi,\varepsilon;s,\mu), W^N(k,b,\psi,\varepsilon;s,\mu) \right\}.$$

As the capital decision of the unconstrained firm is orthogonal to its bond decision, I express the firm's current value as $W(k,b,\psi,\varepsilon;s,\mu) = W(k,0,\psi,\varepsilon;s,\mu) - pb$ and the start-of-period value as $W^0(k,b,\psi,\varepsilon;s,\mu) = W^0(k,0,\psi,\varepsilon;s,\mu) - pb$. Given these transformation, I rewrite (4), (10), and (16) as

$$\begin{aligned}
W^H(k,b,\psi,\varepsilon_i;s,\mu) &= p(1-\tau^c)\pi(k,\varepsilon) - pb + p(1-\tau^c\omega\xi)(1-\delta)k + p\tau^c\delta^\psi\psi \\
&\quad + \max_{k'\in[(1-\delta)k+\bar{I},\bar{k})} \left\{ -p(1-\tau^c\omega\xi)k' + \beta\sum_{j=1}^{N_\varepsilon} \pi^\varepsilon_{ij} W^0(k',0,\psi',\varepsilon_j;s',\mu') \right\}, \\
W^L(k,b,\psi,\varepsilon_i;s,\mu) &= p(1-\tau^c)\pi(k,\varepsilon) - pb + p(1-\tau^c\omega)(1-\delta)k + p\tau^c\delta^\psi\psi \\
&\quad + \max_{k'\le\bar{I}+(1-\delta)k} \left\{ -p(1-\tau^c\omega)k' + \beta\sum_{j=1}^{N_\varepsilon} \pi^\varepsilon_{ij} W^0(k',0,\psi',\varepsilon_j;s',\mu') \right\}, \\
W^N(k,b,\psi,\varepsilon_i;s,\mu) &= p\pi(k,\varepsilon) - pb + p(1-\delta)k \\
&\quad + \max_{k'\ge\max(\bar{k},0)} \left\{ -pk' + \beta\sum_{j=1}^{N_\varepsilon} \pi^\varepsilon_{ij} W^0(k',0,\psi',\varepsilon_j;s',\mu') \right\},
\end{aligned}$$

where $\pi(k,\varepsilon)$ is defined by (30).

To search for the target capitals that solve the above two problems, it is necessary to find the conditional expected start-of-period value function, $W^0(k',0,\psi',\varepsilon_j;s,\mu)$. As the future deductible expenses ψ' is a function of current deductible stock ψ and current capital stock k, all target capital stocks are functions of k, ψ, and ε. To be specific, let $k^*_H(k,\psi,\varepsilon)$ denotes the target capital for firms invest higher than threshold, $k^*_L(k,\psi,\varepsilon)$ be that for firms invest lower than threshold, and $k^*_N(k,\psi,\varepsilon)$ be that for firms not paying corporate tax,

$$
\begin{aligned}
k_H^*(k,\psi,\varepsilon) &= \arg\max_{k' \in [(1-\delta)k+\bar{I},\tilde{k})} \left\{ -p(1-\tau^c\omega\xi)k' + \beta\sum_{j=1}^{N_\varepsilon} \pi_{ij}^{\varepsilon} W^0(k',0,\psi',\varepsilon_j;s',\mu') \right\}, \\
k_L^*(k,\psi,\varepsilon) &= \arg\max_{k' \leq (1-\delta)k+\bar{I}} \left\{ -p(1-\tau^c\omega)k' + \beta\sum_{j=1}^{N_\varepsilon} \pi_{ij}^{\varepsilon} W^0(k',0,\psi',\varepsilon_j;s',\mu') \right\}. \\
k_N^*(k,\psi,\varepsilon) &= \arg\max_{k' \geq \max(\bar{k},0)} \left\{ -pk' + \beta\sum_{j=1}^{N_\varepsilon} \pi_{ij}^{\varepsilon} W^0(k',0,\psi',\varepsilon_j;s',\mu') \right\}.
\end{aligned} \tag{31}
$$

Thus, the capital decision rule for unconstrained firms, $K^w(k,\psi,\varepsilon)$, follows the *(S, s)* policy described below,

$$
K^w(k,\psi,\varepsilon) = \begin{cases}
k_L^*(k,\psi,\varepsilon) & \text{if } k \geq \frac{k_L^*(k,\psi,\varepsilon)-\bar{I}}{1-\delta} \text{ and } W^L(\cdot) = \max\left\{W^H(\cdot),W^L(\cdot),W^N(\cdot)\right\} \\
(1-\delta)k+\bar{I} & \text{if } k < \frac{k_L^*(k,\psi,\varepsilon)-\bar{I}}{1-\delta} \text{ and } W^L(\cdot) = \max\left\{W^H(\cdot),W^L(\cdot),W^N(\cdot)\right\} \\
k_H^*(k,\psi,\varepsilon) & \text{if } k \in \left(\tilde{k}, \frac{k_H^*(k,\psi,\varepsilon)-\bar{I}}{1-\delta}\right] \text{ and } W^H(\cdot) = \max\left\{W^H(\cdot),W^L(\cdot),W^N(\cdot)\right\} \\
\bar{k} & \text{if } k \in \left(\frac{k_N^*(k,\psi,\varepsilon)-\bar{I}}{1-\delta}, \tilde{k}\right] \text{ and } W^N(\cdot) = \max\left\{W^H(\cdot),W^L(\cdot),W^N(\cdot)\right\} \\
k_N^*(k,\psi,\varepsilon) & \text{if } k < k_N^*(k,\psi,\varepsilon) \text{ and } W^N(\cdot) = \max\left\{W^H(\cdot),W^L(\cdot),W^N(\cdot)\right\}
\end{cases}.
$$

For unconstrained firms, I now describe how tax policies affect firms' the *cost* and *benefit* of investment: the user cost of capital approach from Hall and Jorgenson (1967), and q-theory approach from Summers, Bosworth, Tobin and White (1981). The user cost of capital in Hall and Jorgenson (1967) is defined as the rental rate of capital. This rental rate is observably equivalent to the price difference between purchasing capital at date t and resale it at date $t+1$ after discounting. Assume that a firm stay at type N across date t and $t+1$. This firm buys one unit of capital for 1, produces one unit of output, and can resale the remaining $1-\delta$ fraction at the same price with discounting, i.e.,

$$
c^N = 1 - \beta(1-\delta).
$$

If this firm is L-type, then the cost and benefit of one unit of capital purchase is distorted by the corporate tax. It purchases one unit of capital costs $1-\tau^c\omega$, produces $1-\tau^c$ unit of output, and after-tax resale price of the capital is $(1-\tau^c\omega)\beta(1-\delta)$,

$$
c^L = \frac{1-\tau^c\omega}{1-\tau^c}(1-\beta(1-\delta)).
$$

For an H-type firm, the purchase of one unit of capital brings more taxable income deduction to date $t+1$ through the deductible stock ψ. It acquires one unit of capital at cost $1-\tau^c\omega\xi$, produces $1-\tau^c$ unit of output, and the after-tax resale price is the same as L-type firms. However, as only ξ fraction of the tax benefit has been deducted, $1-\xi$ fraction of the remaining benefit is accumulated in the deductible stock ψ as in (8). As a result, the firm gains additional $\beta\delta^{\psi}(1-\xi)\tau^c\omega$ amount of deduction on its taxable income at date $t+1$, and the corresponding user cost of capital is

$$c^H = \frac{1-\tau^c\omega\xi}{1-\tau^c} - \beta\delta^{\psi}(1-\xi)\frac{\tau^c\omega}{1-\tau^c} - \beta(1-\delta)\frac{1-\tau^c\omega}{1-\tau^c}.$$

When the bonus rate ξ increases, the current cost ("down payment") of capital $1-\tau^c\omega\xi$ is lower, while the benefit from future taxable income deduction is smaller. The fall in current cost dominates, and c^H will be lower when the bonus rate ξ increases. As a result, raising the bonus rate will lead to a boost in investment for all firms. A similar mechanism exists when the Section 179 threshold $\bar{I}$ is increased. This policy only applies to medium-sized firms experiencing a transition from H-type to L-type.

The effect of tax policies on the return on investment can be described by the marginal value of capital (marginal q). Let's ignore the discontinuity in the value function and focus on the case in which a firm remains H-type at the end of the period. One can derive the first-order derivative with respect to capital by the Benveniste-Scheinkman condition,

$$\beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^{\varepsilon} \left[\frac{\partial W^H(k', b', \psi', \varepsilon_j; s, \mu)}{\partial k'} + \frac{\partial W^H(k', b', \psi', \varepsilon_j; s, \mu)}{\partial \psi'} \frac{\partial \psi'}{\partial k'} \right]$$

The first partial derivative, $\frac{\partial W^H(k',b',\psi',\varepsilon_j;s,\mu)}{\partial k'}$, represents the positive *direct* effect of investment. The second partial derivative, the product of $\frac{\partial W^H(k',b',\psi',\varepsilon_j;s,\mu)}{\partial \psi'}$ and $\frac{\partial \psi'}{\partial k'}$, indicates the *indirect* effect of investment through deductible stocks.

As mentioned before, a higher ξ leads to a lower user cost of capital, and thus the k' choice will be larger. On the other hand, the rise in ξ results in an ambiguous indirect effect. Following the law of motion of deductible stock in (8), the increase in k' would raise ψ'. On the other hand, higher ξ leads to lower ψ', which may hurt the marginal value on deductible stock, $\frac{\partial W^H(k',b',\psi',\varepsilon_j;s,\mu)}{\partial \psi'}$. In my model, the direct effect dominates the indirect effect, and thus raising the bonus rate will raise the firm value, conditional on dividend payment. Yet, in the next subsection, I will show that raising the bonus rate induces dividend payment, and the firms' value is lower under a higher bonus rate.

3.2 Minimum saving policy

The *minimum saving policy*, $B^w(k,\psi,\varepsilon)$, can be recursively calculated by the following two equations with both policy functions for labor, $N(k,\varepsilon)$, and capital, $K^w(k,\psi,\varepsilon)$,

$$
\begin{aligned}
B^w(k,\psi,\varepsilon) &= \min_{\varepsilon_j}\left(\tilde{B}(K^w(k,\psi,\varepsilon_i),\psi',\varepsilon_j)\right) \\
\tilde{B}(k,\psi,\varepsilon_i) &= (1-\tau^c)\pi(k,\varepsilon_i) + \tau^c\delta^\psi\psi \\
&\quad - \left(1-\tau^c\mathcal{J}\left(K^w(\cdot),k\right)\right)\left(K^w(k,\psi,\varepsilon_i)-(1-\delta)k\right) \\
&\quad + q\min\left\{B^w(k,\psi,\varepsilon_i),\theta K^w(k,\psi,\varepsilon_i)\right\} \text{ if } \mathcal{I}(k',k,\psi,\varepsilon) > 0 \\
\tilde{B}(k,\psi,\varepsilon_i) &= \pi(k,\varepsilon_i) - \left(K^w(k,\psi,\varepsilon_i)-(1-\delta)k\right) \\
&\quad + q\min\left\{B^w(k,\psi,\varepsilon_i),\theta K^w(k,\psi,\varepsilon_i)\right\} \text{ if } \mathcal{I}(k',k,\psi,\varepsilon) \le 0
\end{aligned}
$$

Above, $\tilde{B}(k,\psi,\varepsilon)$ represents the minimum level of saving (negative debt) that an unconstrained firm needs to put aside to remain unconstrained given the realization of ε_j next period. $B^w(k,\psi,\varepsilon)$, therefore, is the minimum of $\tilde{B}(K^w(\cdot),\psi',\varepsilon_j)$ over all possible ε_j to guarantee the unconstrained status of the firm for all possible future states. Notice that the accumulation of deductible stock, ψ', enters this recursive definition, and thus firm's discrete investment choice will affect the threshold that distinguishes constrained and unconstrained firms. The current dividend D^w that unconstrained firms pay is

$$
\begin{aligned}
D^w(k,b,\psi,\varepsilon) &= (1-\tau^c)\pi(k,\varepsilon) + \tau^c\delta^\psi\psi \\
&\quad - (1-\tau^c\mathcal{J}(K^w(k,\psi,\varepsilon)-(1-\delta)k))(K^w(k,\psi,\varepsilon)-(1-\delta)k) \\
&\quad - b + q\min\left\{B^w(k,\psi,\varepsilon),\theta K^w(k,\psi,\varepsilon)\right\} \text{ if } \mathcal{I}(k',k,\psi,\varepsilon) > 0 \\
D^w(k,b,\psi,\varepsilon) &= \pi(k,\varepsilon) - (K^w(k,\psi,\varepsilon)-(1-\delta)k) \\
&\quad - b + q\min\left\{B^w(k,\psi,\varepsilon),\theta K^w(k,\psi,\varepsilon)\right\} \text{ if } \mathcal{I}(k',k,\psi,\varepsilon) \le 0
\end{aligned}
$$

Both policy tools, ξ and $\bar{I}$, directly enter D^w through the indicator function $\mathcal{J}(k',k)$. As a result, raising investment subsidies will increase the dividend payment and lead to a fall in the unconstrained firms' value function. In my calculation, the bonus rate ξ creates a larger boost in the dividend issuance.

3.3 Decisions among constrained firms

I next consider the decisions of continuing firms identified by (k,b,ψ,ε) that have a nonzero probability of facing a binding collateral constraint in the future states. They cannot adopt the unconstrained capital decision rules, and therefore bond policy functions implied by the minimum saving policy. Therefore, they do not issue dividend payments and accumulate financial savings, $b < 0$, to fund their capital investment. As a result, we can characterize their bond choices by zero dividend condition, $D = 0$ given a choice in capital. In particular, let's denote the capital decision rules as $K^c(k, b, \psi, \varepsilon)$, and bond decision rules as $B^c(k, b, \psi, \varepsilon)$. Let $J(k, b, \psi, \varepsilon; s, \mu)$ be the value function for constrained firms. They undertake the same binary choice between investing higher or lower than the Section 179 threshold:

$$J(k, b, \psi, \varepsilon; s, \mu) = \max \left\{ J^H(k, b, \psi, \varepsilon; s, \mu), J^L(k, b, \psi, \varepsilon; s, \mu), J^N(k, b, \psi, \varepsilon; s, \mu) \right\},$$

where J^H, J^L and J^N are the value function for H-type, L-type, and N-type firms.

For firms that invest higher than the threshold, their value function conditional on survival is

$$\begin{aligned} J^H(k, b, \psi, \varepsilon; s, \mu) &= \max_{k' \in \Omega_H(k,b,\psi,\varepsilon)} \beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon V^0(k', b_H(k'), \psi', \varepsilon_j; s', \mu'), \\ &\text{subject to} \\ b_H(k') &= \frac{1}{q}\Big(-(1-\tau^c)\pi(k,\varepsilon) + b - \tau^c \delta^\psi \psi + (1 - \tau^c \omega \xi)(k' - (1-\delta)k) \Big), \\ \psi' &= (1-\delta^\psi)\psi + (1-\xi)(k' - (1-\delta)k), \end{aligned} \tag{32}$$

The bond choice for H-type firms, $b_H(k')$, is formulated by The choice sets for H-type firms' problem are defined by

$$\Omega_H(k, b, \psi, \varepsilon) = \left[(1-\delta)k + \bar{I}, \min\left\{ \bar{k}_H(k, b, \psi, \varepsilon), \bar{k}(k, \psi, \varepsilon), K^w(k, \psi, \varepsilon) \right\} \right],$$

where $\bar{k}_H$ is the maximum affordable capital with binding collateral constraints for H-type firms,

$$\bar{k}_H = \frac{(1-\tau^c)\pi(k,\varepsilon) - b + (1-\tau^c\omega)(1-\delta)k + \tau^c\delta^\psi\psi}{1 - \tau^c\omega\xi - q\theta}$$

Let the bonus depreciation rate $\xi = 1$, we get the Bellman equation for L-type firms

$$\begin{aligned} J^L(k,b,\psi,\varepsilon;s,\mu) &= \max_{k' \in \Omega_L(k,b,\psi,\varepsilon)} \beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^{\varepsilon} V^0(k', b_L(k'), \psi', \varepsilon_j; s', \mu'), \\ &\text{subject to} \\ b_L(k') &= \frac{1}{q}\Big(-(1-\tau^c)\pi(k,\varepsilon) + b - \tau^c \delta^\psi \psi + (1-\tau^c\omega)(k' - (1-\delta)k)\Big), \\ \psi' &= (1-\delta^\psi)\psi. \end{aligned} \tag{33}$$

The choice set $\Omega_L(k,b,\psi,\varepsilon)$ used above is defined as

$$\Omega_L(k,b,\psi,\varepsilon) = \left[0, \max\left\{0, \min\left\{(1-\delta)k + \bar{I}, \bar{k}_L(k,b,\psi,\varepsilon), K^w(k,\psi,\varepsilon)\right\}\right\}\right],$$

while the maximum affordable capital is

$$\bar{k}_L = \frac{(1-\tau^c)\pi(k,\varepsilon) - b + (1-\tau^c\omega)(1-\delta)k + \tau^c\delta^\psi\psi}{1-\tau^c\omega - q\theta}.$$

Lastly, the value function iteration for N-type firms is equivalent to setting $\tau^c = 0$ in H-type firms' problem,

$$\begin{aligned} J^N(k,b,\psi,\varepsilon;s,\mu) &= \max_{k' \in \Omega_N(k,b,\psi,\varepsilon)} \beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^{\varepsilon} V^0(k', b_N(k'), \psi', \varepsilon_j; s', \mu'), \\ &\text{subject to} \\ b_N(k') &= \frac{1}{q}\Big(-\pi(k,\varepsilon) + b + (k' - (1-\delta)k)\Big), \\ \psi' &= (1-\delta^\psi)\psi + (1-\mathcal{J}(k',k))(k' - (1-\delta)k), \end{aligned} \tag{34}$$

The above choice set $\Omega_N(k,b,\psi,\varepsilon)$ is defined as

$$\Omega_N(k,b,\psi,\varepsilon) = \left[0, \min\left\{\bar{k}_N, \max\left\{\bar{k}, 0\right\}, K^w(k,\psi,\varepsilon)\right\}\right]$$

while the maximum affordable capital is

$$\bar{k}_N = \frac{\pi(k,\varepsilon) - b + (1-\delta)k}{1-q\theta}.$$

Let the capital stock solving (32), (33), and (34) be $\hat{k}_H(k,b,\psi,\varepsilon)$, $\hat{k}_L(k,b,\psi,\varepsilon)$, and $\hat{k}_N(k,b,\psi,\varepsilon)$, respectively. The constrained firms' decision rules on capital are

$$K^c(k,b,\psi,\varepsilon) = \begin{cases} \hat{k}_H(k,b,\psi,\varepsilon) & \text{if } J(\cdot) = J^H(\cdot) \text{ and } k > \tilde{k} \\ \hat{k}_L(k,b,\psi,\varepsilon) & \text{if } J(\cdot) = J^L(\cdot) \text{ and } k > \hat{k} \\ \hat{k}_N(k,b,\psi,\varepsilon) & \text{if } J(\cdot) = J^N(\cdot) \end{cases} \tag{35}$$

Similarly, the bond decision rules are

$$B^c(k,b,\psi,\varepsilon) = \begin{cases} b^H(\hat{k}_H(k,b,\psi,\varepsilon)) & \text{if } J(\cdot) = J^H(\cdot) \text{ and } k > \tilde{k} \\ b^L(\hat{k}_L(k,b,\psi,\varepsilon)) & \text{if } J(\cdot) = J^L(\cdot) \text{ and } k > \hat{k} \\ b^N(\hat{k}_N(k,b,\psi,\varepsilon)) & \text{if } J(\cdot) = J^N(\cdot) \end{cases} \tag{36}$$

4 Calibration

Table 1 lists the parameter set obtained from calibration after some parameters are set outside the model. Table 2 summarizes the calibrated moments. Total factor productivity z is set to 1 in the steady state. I set the length of a period to one year to match the establishment-level investment data. The functional form of the representative household's utility is assumed to be $u(c,l) = \log c + \varphi l$, following Rogerson (1988). I assume Cobb-Douglas production function, $z\varepsilon F(k,n) = z\varepsilon k^{\alpha} n^{\nu}$. The initial capital k_0 is defined as a fraction of steady-state aggregate capital stock,

$$k_0 = \chi \int k\tilde{\mu}(d[k \times b \times \psi \times \varepsilon]), \tag{37}$$

where $\tilde{\mu}$ is the steady-state distribution. Both initial bond level b_0 and initial deductible stock ψ_0 are set to zero. The household's discount rate β is set to imply 4 percent of the annual interest rate. The disutility from working, φ, is determined to reproduce hours of work equal to one-third. The rate of capital depreciation, δ, corresponds to an investment-capital ratio of approximately 6.9 percent. Labor share ν is 60 percent, as seen in US postwar data.

To accurately assess the impact of partial irreversibility from corporate taxation on investment, my model must reproduce firm-level evidence on investment dynamics. I begin by assuming the idiosyncratic productivity shock ε follows log AR(1) process with persistence ρ_ε and standard deviation $\sigma_{\eta_\varepsilon}$. The evolution of ε is $\log \varepsilon' = \rho_\varepsilon \log \varepsilon + \eta'_\varepsilon$, with $\eta'_\varepsilon \sim N(0, \sigma^2_{\eta_\varepsilon})$. I choose three parameters, ρ_ε, $\sigma_{\eta_\varepsilon}$, and average eligible investment ratio ω to match the moments of the investment rate distribution in Cooper and Haltiwanger (2006). In particular, I choose $\rho_\varepsilon = 0.6$ to match the correlation of the investment rates, $\sigma_\varepsilon = 0.1$ to match the standard deviation of the investment rates, and $\omega = 0.6$ to match the firm mass that has investment rates larger than 20 percents. Given the value specified in table 1, I use Tauchen (1986) method to discretize the firm's log-normal idiosyncratic productivity process with 7 values ($N_\varepsilon = 7$) to obtain $\{\varepsilon_j\}_{j=1}^{N_\varepsilon}$ and $(\pi_{ij}^{\varepsilon})_{i,j=1}^{N_\varepsilon}$.

I calibrate the value of two policy tools, ξ and $\bar{I}$, to the 2015 level of bonus rate and Section 179 threshold. In 2015, the bonus rate is 0.5, i.e., $\xi = 0.5$. In the same year, the Section 179 threshold is \$500,000. To find the model counterpart of the Section 179 threshold, I calculate the average investment in 2015 using data from the Bureau of Economic Analysis and Statistics of U.S. Businesses. The investment in 2015 from BEA Table 3.7 is 2459.8 billion. Meanwhile, there are 5,900,731 firms in the US. This gives me an average investment of \$416,853. I calibrate the value of $\bar{I}$ using the same proportionality between aggregate investment generated by the model and average investment in the data. The aggregate equals to the average in the model because of the unit measure of firm distribution. With this observation, the calibrated value of $\bar{I}$ is 0.092.

To demonstrate the importance of investment deductions in replicating realistic investment dynamics within this framework, figure 2 compares investment rate distributions across two versions of the model. Cooper and Haltiwanger (2006) utilizes a balanced panel consisting of large, manufacturing plants. To generate a comparable panel to Cooper and Haltiwanger (2006), I simulate 50,000 unconstrained firms for 100 periods. The solid blue line shows the model with investment deductions under the parameters $\xi = 0.5$ and $\bar{I} = 0.092$, while the dashed yellow line represents the model without investment deductions, essentially setting ξ and $\bar{I}$ equals to zero. Only the model with investment deductions closely matches the empirical investment rate distribution in Cooper and Haltiwanger (2006).

In the model without investment deductions, most firms will fall into the inaction region implied by the (S, s) decision rules, reflected in the outsized mass of firms in the investment rate distribution. When investment deductions are implemented, firms previously in the inaction region invest up to the $\bar{I}$ threshold. This leads to a shift in distribution, with most firms now having positive investment rates.

Furthermore, the model with investment deductions generates a smoother distribution of investment rates as firms are facing different level of irreversibility. L-type firms that are investing are not subject to any irreversibility. H-type firms, on the other hand, do face irreversibility as the purchasing price of capital is $1 - \tau^c\omega\xi$, while the after-tax selling price is $1 - \tau^c\omega$. Thus, the implied irreversibility is $1 - \frac{1-\tau^c\omega}{1-\tau^c\omega\xi} = 0.067$. Firms that face the highest irreversibility are N-type firms. The degree of irreversibility is $1 - \frac{1-\tau^c\omega}{1} = 0.126$, much higher than H-type firms[12]. Since firms facing high irreversibility are less likely to reduce their capital, this variation

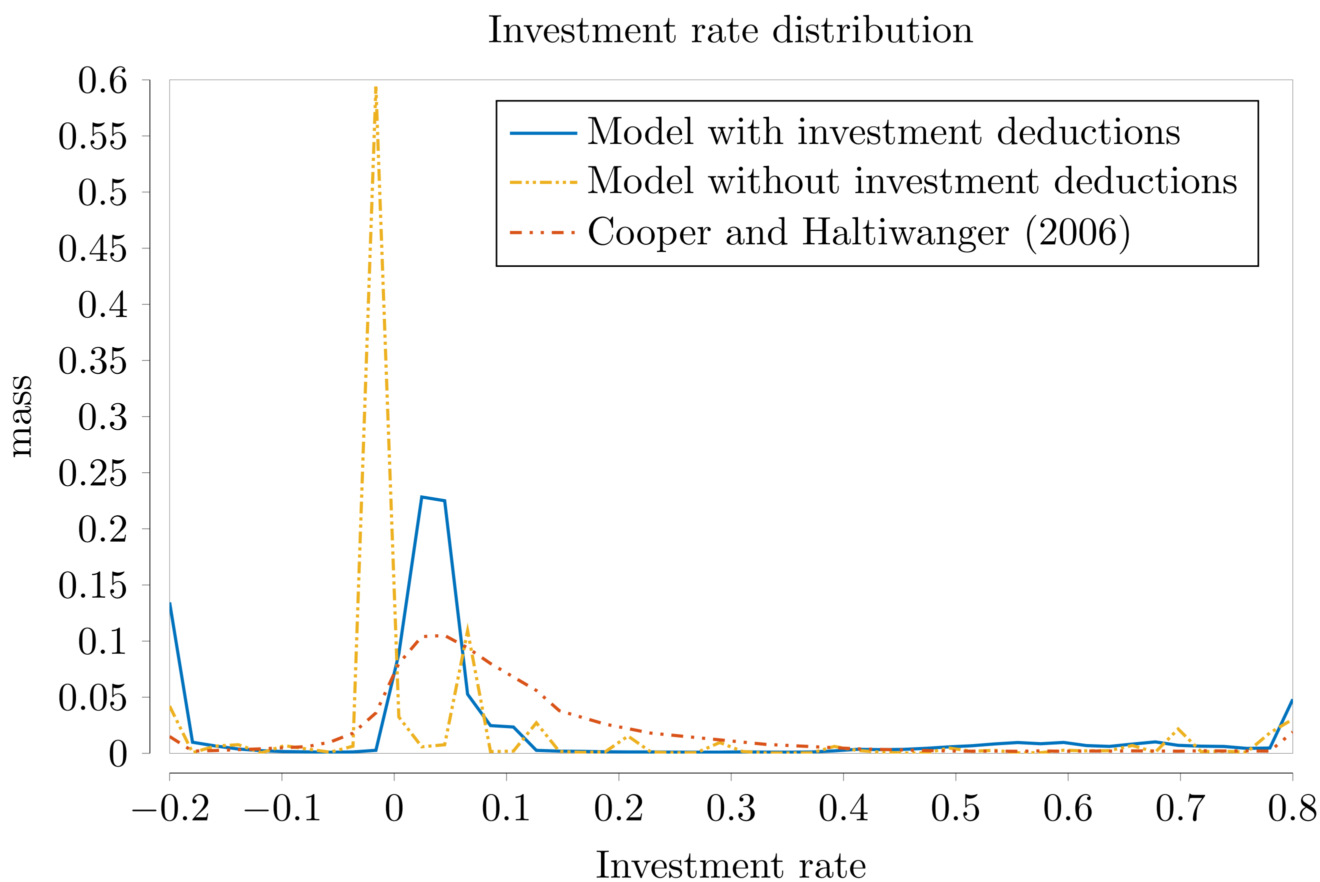
[12] Khan and Thomas (2013) has calibrated the degree of partial irreversibility as 0.046.

in irreversibility causes a more dispersed investment rate distribution compared to the model variant without deductions.

I further validate my model by replicating the empirical investment-weight tax term elasticity documented in Zwick and Mahon (2017). Since the sample in Zwick and Mahon (2017) includes the most of the US firms, regardless of their size, I include full sample of firms in my simulation. Their estimate comes from difference-in-difference around the incidences of raising bonus rate at 2010 after financial crisis, I do not include general equilibrium effects regarding increase in bonus rate ξ. I simulate $50,000$ firms for 100 periods to guarantee firms are in their steady state at date 78. I shock the economy with the credit parameter θ drop by 27% at date 79, and boost bonus rate from 0.5 to 1.0 at date 80. I calculate the tax term elasticity by the percentage change in investment between date 79 to date 80 over the percentage change in tax term, $\frac{1-\tau^c\omega\xi}{1-\tau^c}$. This exercise captures the background and policy implementation in 2010.

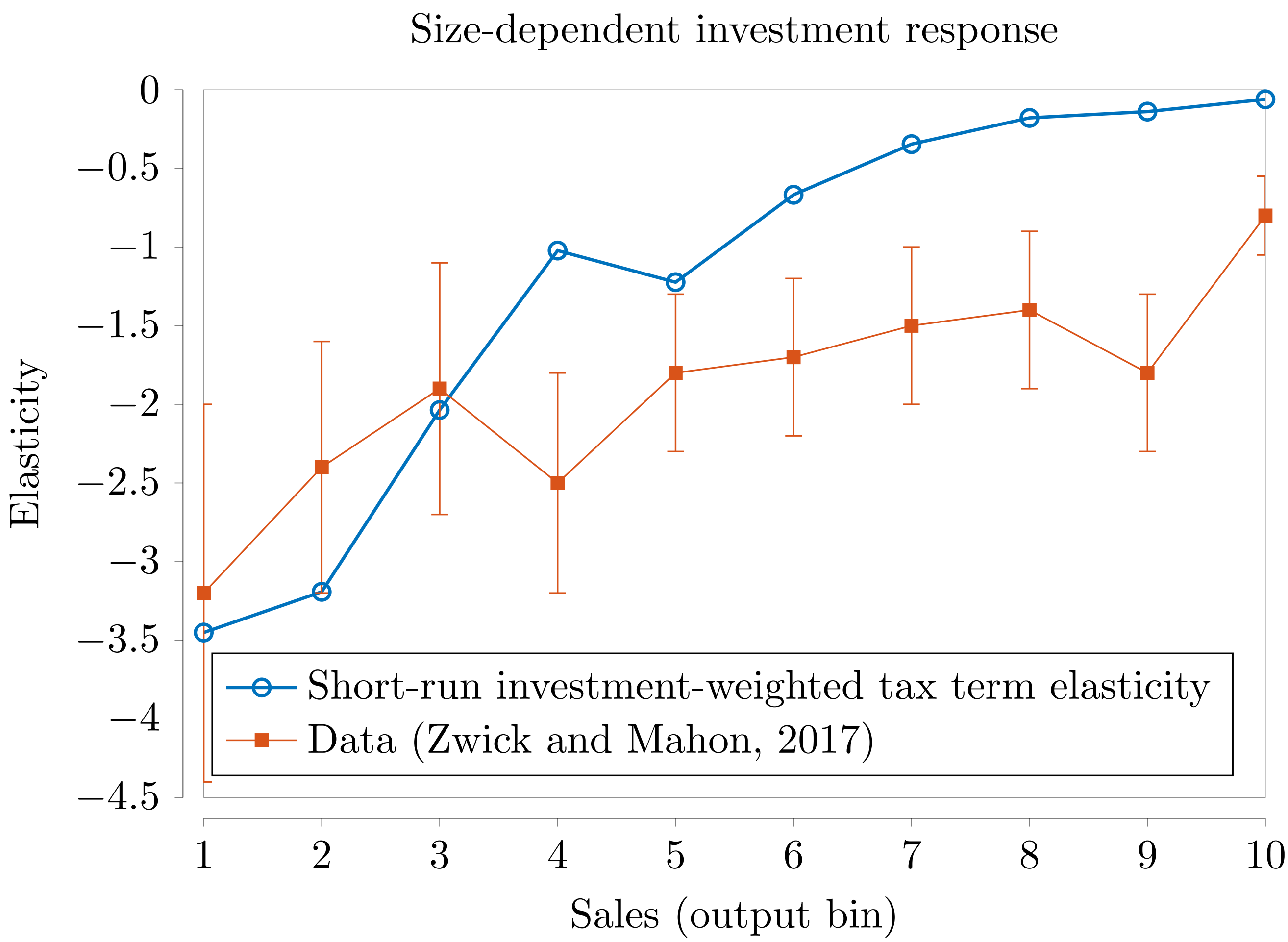
The aggregate tax elasticity produced by my model is -1.23, which captures approximately 80 percent of the empirical estimate of -1.6 from Zwick and Mahon (2017). Figure 3 shows the elasticity across firm size measured in sales. My model captures the negative relationship between firm size and responsiveness toward policy, and tightly matches the scale of responses for firms in the smallest three deciles. The largest firms in my model are free from financial frictions and have already reached their target capital. Therefore, in the absence of general equilibrium effects, their investment are not affected by the credit shocks or expansion of bonus rate, resulting in responses smaller than empirical estimates.

Figure 2: Investment rate distribution



Note: This figure shows the investment rate distribution of models with and without investment deductions, and the empirical dataset from Cooper and Haltiwanger (2006). Both models are solved to generate by simulating 50,000 unconstrained firms over 100 periods to create a comparable dataset to that in Cooper and Haltiwanger (2006).

Figure 3: Short-run size dependent tax term elasticity to investment



Note: This figure shows the short-run investment-weighted tax term elasticity to investment as defined in Zwick and Mahon (2017). I simulate 50,000 firms over 300 periods, and allow unexpected raise of bonus rate from 50% to 100% at period 240 using the partial equilibrium decision rules. I then compute the how much does the change in tax term, i.e., $\frac{1-\tau^c\omega\xi}{1-\tau^c}$, affects the aggregate investment at each bin.

Table 1: Parameters for quantitative model

	Parameter	Value	Reason
Calibrated parameters			
Discount rate	β	0.96	4% real interest rate
Capital share	α	0.3	private capital-output ratio
Labor share	ν	0.6	labor share
Labor tax rate	τ^n	0.25	government spending-output ratio
Preference for leisure	φ	2.05	one-third of time endowment
Capital depreciation rate	δ	0.069	average investment-equipment ratio
Collateralizability	θ	0.54	debt-to-capital ratio
Credit crunch	θ_l	0.3942	26% decrease in debt
Persistence of ε	ρ_ε	0.6	investment distribution moments
Standard deviation of ε	$\sigma_{\eta_\varepsilon}$	0.113	investment distribution moments
Average ratio of eligible investment	ω	0.6	investment distribution moments
Exogenous parameters			
fraction of entrants capital endowment	χ	0.1	10% of aggregate capital
exogenous exit rate	π_d	0.1	10% entry and exit
Corporate tax rate	τ^c	0.21	US Tax schedule after TCJA
Tax benefit depreciation rate	δ^ψ	0.138	$\delta^\psi = 2\delta$ (Double-declining balance)
Bonus depreciation rate in baseline	ξ	0.5	2015 bonus rate
Section 179 threshold	$\bar{I}$	0.092	2015 threshold model counterpart

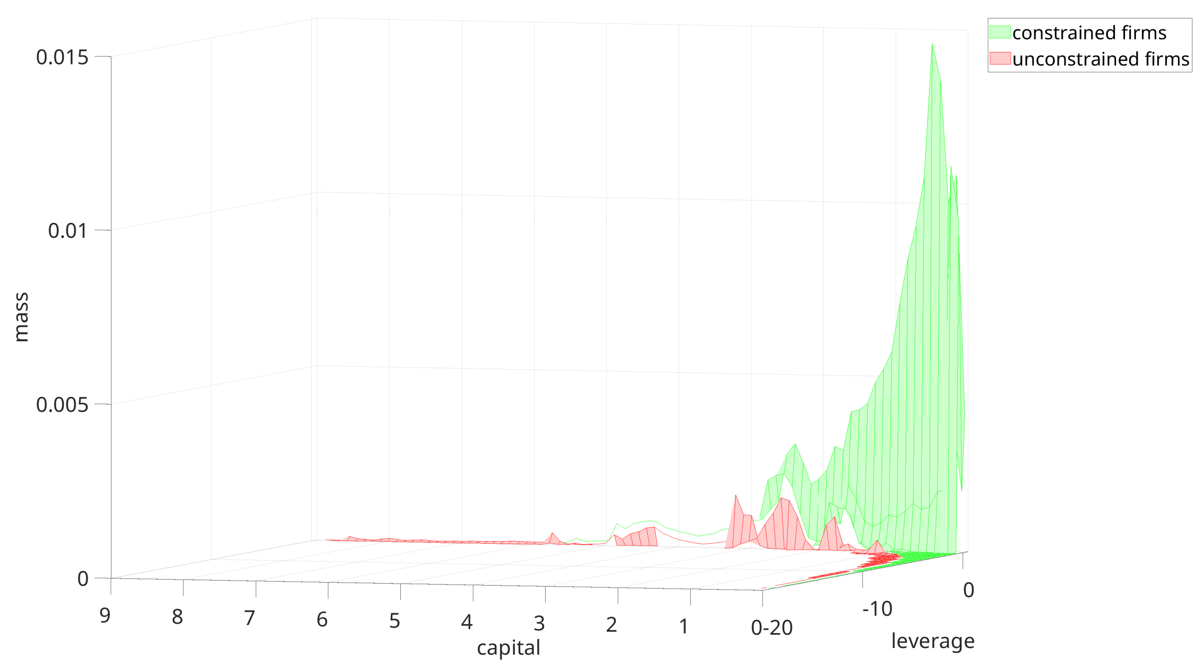
Table 2: Calibrated moments

Parameter	Target		Model
$\beta = 0.96$	real interest rate	$= 0.04$	0.04
$\alpha = 0.3$	private capital-output ratio	$= 2.3$	2.03
$\nu = 0.6$	labor share	$= 0.6$	0.6
$\tau^n = 0.25$	government spending-output ratio	$= 0.21$	0.201
$\delta = 0.069$	average investment-capital ratio	$= 0.069$	0.069
$\varphi = 2.05$	hours worked	$= 0.33$	0.33
$\theta = 0.54$	debt-to-assets ratio	$= 0.37$	0.371
$\theta_l = 0.3942$	decreases in debt	$= 0.26$	0.257
$\rho_\varepsilon = 0.6$	std. investment rate distribution	$= 0.337$	0.300
$\sigma_\varepsilon = 0.1$	corr. investment rate distribution	$= 0.058$	0.050
$\omega = 0.6$	lumpy investment $> 20\%$	$= 0.186$	0.185

5 Steady State

Figure 4 presents the stationary distribution in my model over capital and leverage levels at the median productivity. I collapse this distribution by summing over the deductible stock state variable. This figure effectively displays two distributions, the constrained firms' distribution in green, and the unconstrained firms' distribution in red. The largest spike in the constrained firms' distribution reflect new entrants, with zero debt and initial capital at k0. The spike gradually disperses as firms incrementally increasetheir capital stocks, reflecting how the forward-looking collateral constraints limit firms' ability to accumulate capital. Once a firm becomes unconstrained, it follows the minimum saving policy implied by the unconstrained level of capital. One aspect that distinguishes this model is that there is a small mass of firms that are holding high levels of leverage and capital simultaneously.

Figure 4: Distribution: medium productivity



To explain why some firms in my model hold high levels of capital and leverage, figure 5a shows the policy functions for capital k', deductible stock ψ', and bond b' across capital levels for the highest level of idiosyncratic productivity ε. Three investment types—L, H, and N—are distinguished by two key thresholds: the Section 179 deduction threshold $\bar{I}$ and the zero-taxable-income threshold $\bar{k}$. The green vertical line denotes the division between constrained firms (left) and unconstrained firms (right).

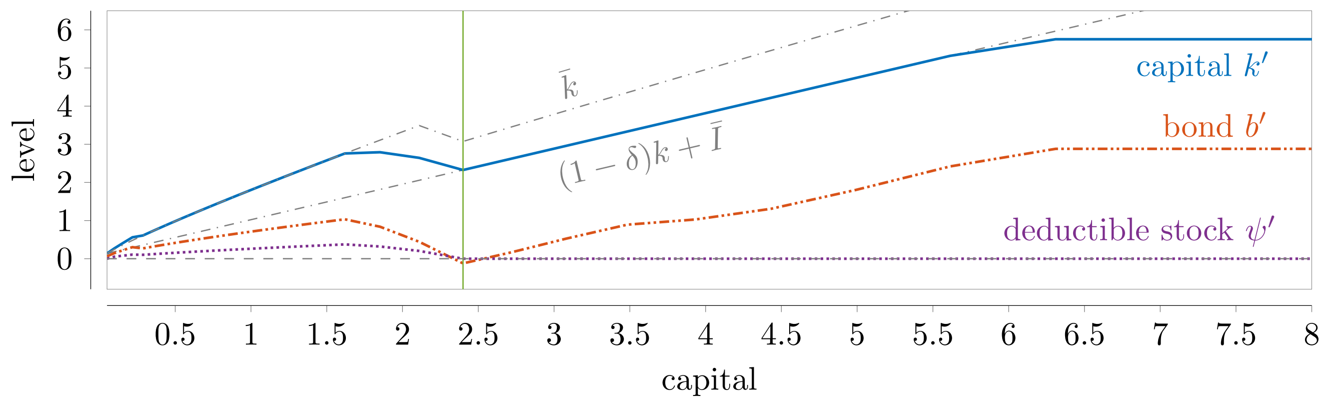
While constrained firms' behavior is consistent with models without corporate taxes (Khan and Thomas, 2013; Jo and Senga, 2019), high-productivity unconstrained firms exhibit positive size-leverage relationship as seen in corporate data (Chatterjee and Eyigungor, 2023). Constrained firms borrow to accumulate both capital and deductible stock in order to reach a more efficient scale Once they reach the plateau at k^*_N, they invest up to $\bar{k}$ to avoid paying corporate taxes. When they become H-type firms, they slow down their capital accumulation and in turn accumulate financial savings because the return on investment are taxed. As their investment is equal to $\bar{I}$, they are eligible to Section 179 expensing, and can deduct all of their investment expenditure immediately. This tax incentive induces them to invest up to $\bar{I}$ and accumulate debt to finance such investment, generating the positive size-leverage relationship.

On the other hand, low productivity firms' behavior is less materially affected by tax deduction policy, as shown in figure 5b. They maintain the same level of debt and utilize the Section 179 expensing to invest up to $\bar{I}$. Once they reach the target capital, they start to deleverage and eventually accumulate financial savings when they are unconstrained. Theism variation acrossi different levels of productivity elucidates corporate taxation's distortionary role.

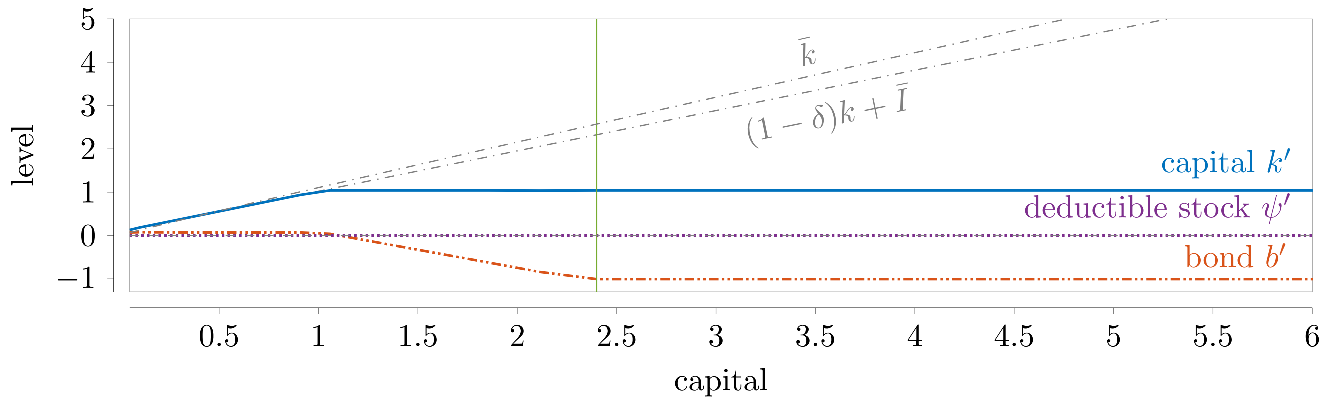
Figure 6a displays the average capital, deductible stock, and leverage choices for a cohort of $50,000$ new entrants over 100 periods with exogenous entry and exit. On average, firms raise capital, deductible stock, and debt for their first 10 periods. After this period, they begin reducing debt and start accumulating financial savings around period 20. By period 25, both the average capital and average deductible stock have reached their unconstrained levels, and average bond levels stabilize by period 30.

To illustrate how deductions affect the firms' life cycle, figure 6 compares average capital and bond levels in economies with and without deductions. The solid blue lines show the model with deductions, and the dashed orange lines represent the model without deductions. The deductions induce firms to initially bear more debt to accelerate capital accumulation. Once their capital reaches the unconstrained level, the deductions lead firms to save compared with the no-deduction model. The lower user cost of capital from deductions reduces the need to accumulate large financial savings to buffer against idiosyncratic productivity shocks.

Figure 5: Choice of capital, bonds, and deductible stock are plotted for each level of current capital stock



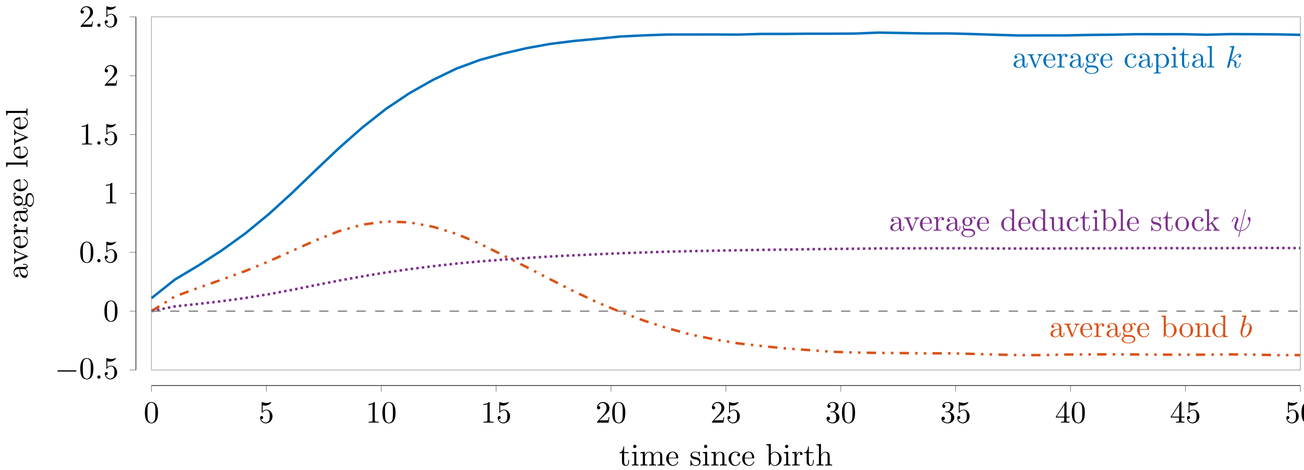
(a) Firm decision rules with high productivity ($\varepsilon = 1.1289$)



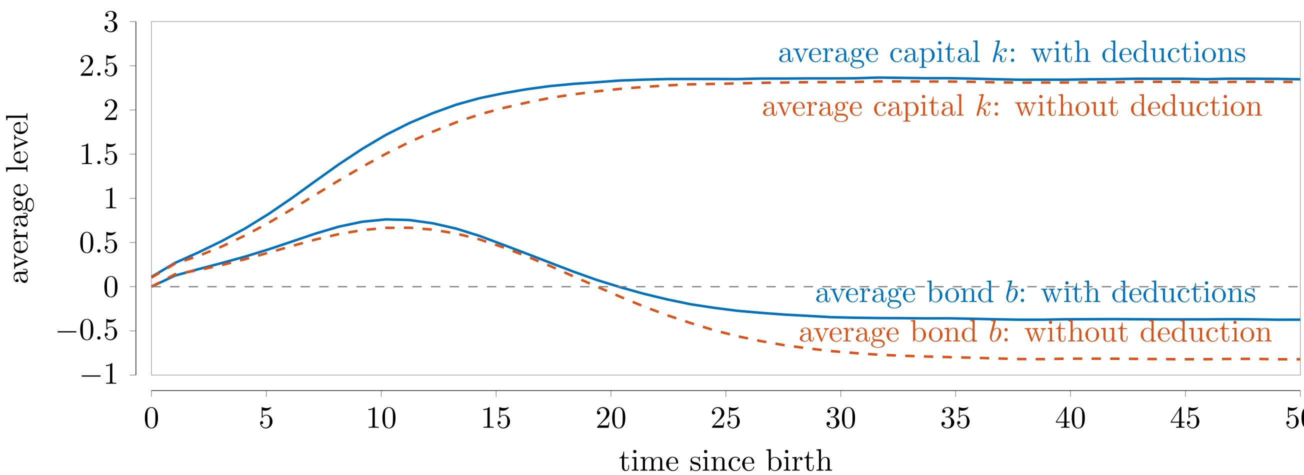
(b) Firm decision rules with low productivity ($\varepsilon = 0.7847$)

Note: Decision rules are plotted given zero current bond and zero current deductible stock.

Figure 6: Cohort average capital, bond, and deductible stock are constructed from a simulation of a balanced panel of firms.



(a) Cohort in steady state



(b) Comparing economy with and without deductions

Note: Model with deductions are calculated with $\xi = 0.5$ and $\bar{I} = 0.092$, and model without deduction are calculated with both ξ and $\bar{I}$ equals to zero.

6 Long-run effects of corporate tax deduction

I next examine the long-run effects of corporate tax deductions. First, I provide an overview of the policy experiments in my model. Next, I assess how the different implementations of of investment deductions affect steady state outcomes in general equilibrium.

6.1 Overview of policy experiments

In my policy experiments, I compare the equilibrium outcomes of the baseline model from previous sections with the new steady states under each policy intervention. Specifically, I measure changes in equilibrium steady states under each policy relative to the baseline. The policy experiments are based on provisions in the Tax Cuts and Jobs Act (TCJA) of 2017, focusing on three key provisions: the bonus depreciation rate ξ, Section 179 expensing limit $\bar{I}$, and the corporate tax rate τ^c[13].

I conduct four policy experiments: (1) expanding Section 179 expensing limit $\bar{I}$ (S179), (2) expanding bonus depreciation rate ξ (Bonus), (3) expanding both $\bar{I}$ and ξ (S179 + Bonus), and (4) reducing the corporate tax rate τ^c (Tax Cut). To fairly assess the effects of each policy, I set the policy experiments so that each costs 0.3 percent of steady-state output. This results in $\bar{I} = 0.292$, $\xi = 0.69$, and $\tau^c = 0.195$ for experiments 1, 2, and 4, respectively. For experiment 3, which combines $\bar{I}$ and ξ, I set $\bar{I} = 0.239$ and $\xi = 0.566$ to ensure a policy cost the same with other experiments.

6.2 Aggregate results from policy experiments

Table 3 summarizes the results from the policy experiments. Relative to the baseline model, all experiments increase aggregate output, consumption, capital, and investment, and raising the Section 179 threshold yields the largest increases across each of these aggregates. Output and consumption increase by 1.78 and 1.55 percent with the threshold is increased. On the other hand, raising the bonus rate only delivers 1.23 and 0.93 percent boosts in output and consumption, respectively. Cutting the corporate tax rate yields the smallest increases among all policy considered, with only a 0.81 percent boost in GDP and a 0.56 percent increase in consumption. When both Section 179 expensing and bonus depreciation are implemented, the

[13] Table 1 in Chodorow-Reich, Smith, Zidar and Zwick (2024) summarizes all domestic provisions in the TCJA, including the corporate tax rate reduction, accelerated depreciation, Domestic Production Activities Deduction (DPAD), alternative minimum tax, deductions for foreign-derived intangible income, and carryforward of net operating losses.

boost in output and consumption is 1.48 and 1.27 percent, smaller than the effect of raising only the Section 179 threshold. This finding aligns with empirical evidence (Ohrn, 2019).

Bonus depreciation is generally less effective as part of the taxpayer-funded deductions are distributed as dividends rather than reinvested. Table 3 shows that while aggregate dividends increase across all three policy experiments on deductions[14], the increase is highest when the bonus rate is raised. Specifically, bonus depreciation leads to an 8.13 percent increase in dividend payments relative to the baseline, compared to only a 0.21 percent increase when the Section 179 threshold is raised.

This outcome stems from the untargeted nature of increasing the bonus rate. Unconstrained firms, which already free from financial frictions, benefit from the reduced user cost of capital, allowing them to more easily reach their target capital levels and distribute remaining cash as dividends. This endogenous interaction between firms' financial positions and investment decisions counteracts the policy goal of stimulating economic growth, as funds intended to encourage investment are diverted to dividends instead.

A direct tax cut, on the contrary, reduces dividend payments. This outcome arises from the wedge in the cost of capital, $1 - \tau^c \mathcal{J}(k', k)$. When the government implements a tax cut, i.e., lowers τ^c, the subsidy on the cost of capital decreases. As a result, unconstrained firms optimally allocate more resources into investment, resulting in lower dividend payment.

Figure 7 illustrates the increased effectiveness of Section 179 expensing by showing the cumulative distribution of excess returns on investment across each policy experiment. The excess return on investment, defined as the marginal value of capital minus the cost of capital after accounting for investment deductions, represents the wedge in the investment Euler equation. Efficient investment results in zero excess returns, indicating capital is optimally allocated across firms.

In the baseline model, only 16 % of firms invest efficiently. Under Section 179 expensing, this proportion increases to 27%, while bonus depreciation raises it to 24%. Tax cuts are the least effective policy among all experiments, with only 16.7% of firms reaching efficient investment. The same trend appears in the average excess return on investment, confirming that Section 179 expensing is the most effective of these policies alleviating capital misallocation.

Next, I investigate how firm heterogeneity interacts with each policy. I calculate the percentage deviation in the average excess return on investment across different productivity levels, comparing each policy scenario to the baseline model in figure 8. Section 179 expensing encourages high-productivity firms to invest more, leading to a more efficient allocation of

[14] Cutting corporate tax rate lead to less dividend payment as the mass of unconstrained firms decreases. As τ^c decreases, the effect on investment subsidy, $1 - \tau^c \mathcal{J}(k', k)$, is smaller, leading to relatively higher user cost of capital.

capital. Low-productivity firms, however, move even farther from efficient investment, resulting in greater capital misallocation among them. In contrast, bonus depreciation distributes tax benefits broadly across firms, resulting in a more diffuse effect that does not contribute to production as effectively.

Table 3: Aggregate results from policy experiments

	Description	Baseline	S179	Bonus	S179 + Bonus	Tax cut
Aggregates						
Y	aggregate output	(0.54)	1.78%	1.23%	1.48%	0.81%
C	aggregate consumption	(0.36)	1.55%	0.93%	1.27%	0.56%
K	aggregate capital	(1.10)	4.43%	3.42%	3.60%	2.16%
I	aggregate investment	(0.08)	4.43%	3.42%	3.60%	2.16%
N	aggregate labor	(0.33)	0.22%	0.30%	0.21%	0.25%
$B > 0$	aggregate debt	(0.41)	7.02%	13.72%	5.97%	3.04%
R	corporate tax revenue	(0.03)	-3.70%	-3.87%	-3.85%	-4.46%
$\hat{z}$	measured TFP	(1.02)	0.33%	0.03%	0.28%	0.01%
Prices						
p	marginal utility of consumption	(2.80)	-1.53%	-0.92%	-1.25%	-0.55%
w	wage	(0.97)	1.55%	0.93%	1.27%	0.56%
Distribution						
μ_{unc}	unconstrained firm mass	(0.08)	14.84%	21.78%	1.77%	-13.17%
μ_{con}	constrained firm mass	(0.92)	-1.31%	-1.92%	-0.16%	1.16%
$\mu_{\text{unc}}K$	capital: unconstrained	(2.69)	-5.47%	0.01%	-6.85%	3.55%
$\mu_{\text{con}}K$	capital: constrained	(0.96)	4.78%	0.80%	5.95%	3.99%
Financial Variables						
D	dividend	(0.03)	0.21%	8.13%	1.10%	-3.88%
$\mu V(\cdot)$	average firm value	(3.43)	-2.56%	-6.43%	-2.64%	1.88%
μc	user cost of capital	(0.11)	-10.83%	-1.30%	-8.63%	67.55%

Notes: values in policy experiments are expressed as a percentage of the baseline value. Baseline model: $(\bar{I}, \xi) = (0.092, 0.5)$. S179 model: $(\bar{I}, \xi) = (0.292, 0.5)$. Bonus model: $(\bar{I}, \xi) = (0.092, 0.69)$. S179 + Bonus model: $(\bar{I}, \xi) = (0.239, 0.566)$.

Figure 7: Cumulative distribution of excess return

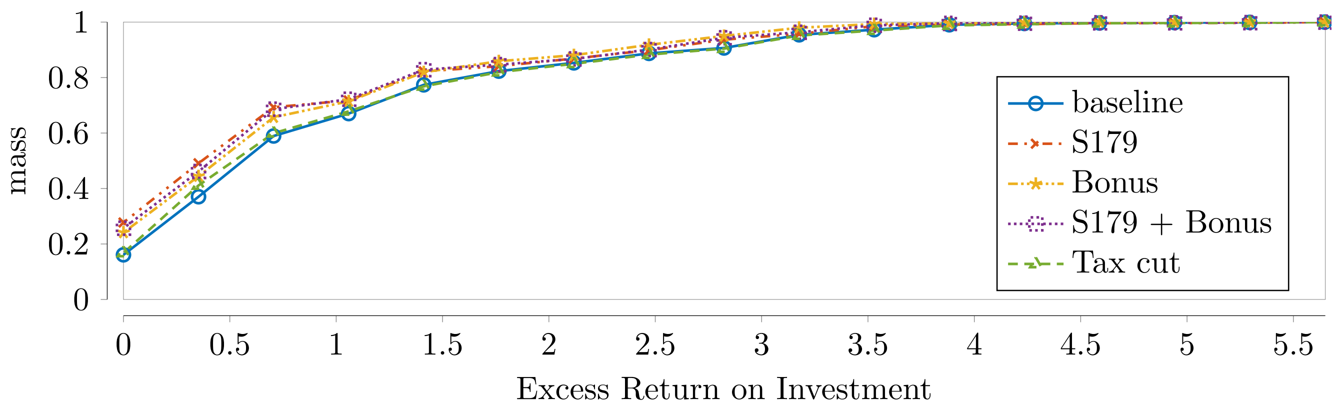
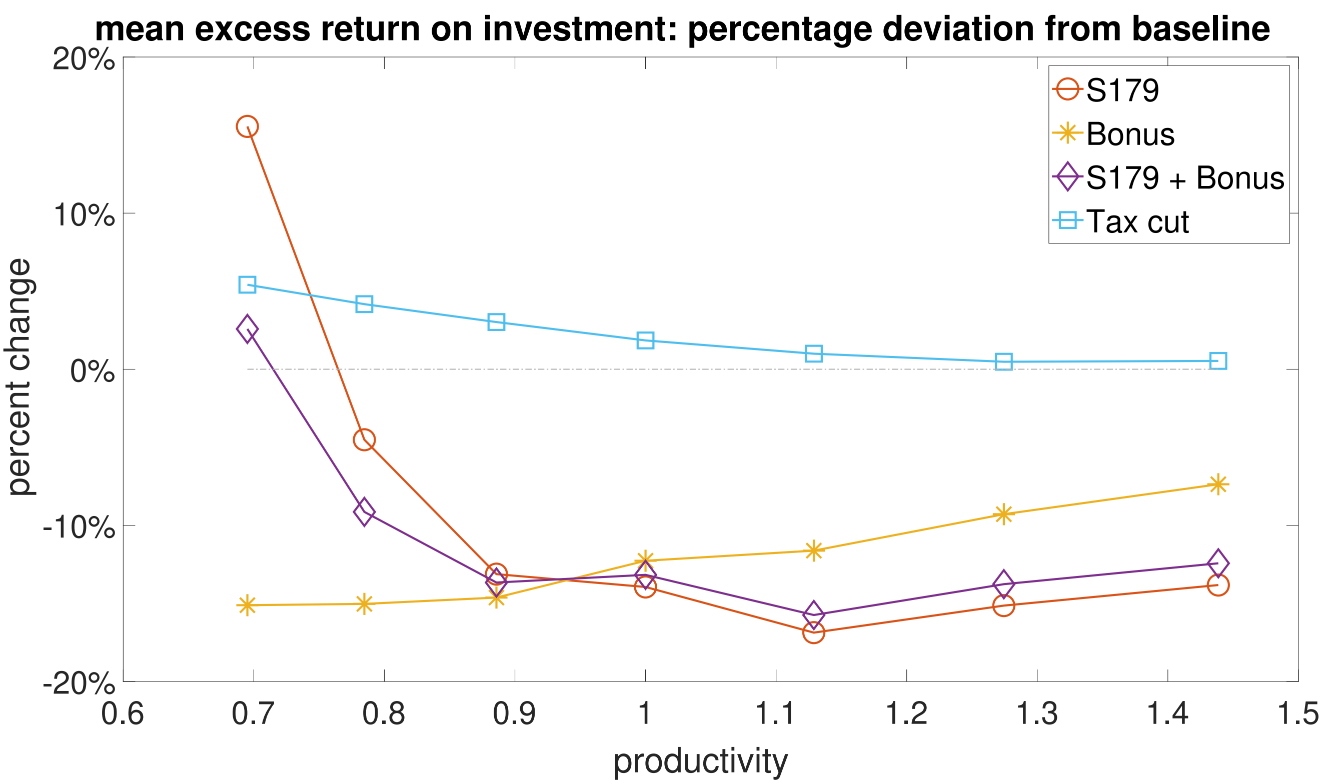


Figure 8: Policy comparison: average excess return across productivity



7 Business cycles

Next, I consider business cycles by examining aggregate TFP shocks and credit shocks. I analyze both the extensive and intensive margins of investment deductions in dynamics. For the extensive margin, I compare responses between two economies: one with investment deductions and one without. For the intensive margin, I quantify the extent to which a temporary increase in investment deductions can mitigate the recessions.

I analyze these shocks under perfect foresight, abstracting from aggregate uncertainty. Impulse responses are computed over a horizon of $\bar{T}$ periods following TFP and credit shocks. In the baseline model, I compute the sequence of government spending, $\{\bar{G}_t\}_{t=1}^{\bar{T}}$, and keep it fixed across all experiments. When the government expands investment deductions, corporate tax revenue $\{R\}_{t=1}^{\bar{T}}$ declines. To maintain a fixed $\{\bar{G}_t\}_{t=1}^{\bar{T}}$, the government imposes a lump-sum tax on households.

7.1 Extensive margin

Figure 9 illustrates the responses of two economies to a 2.18% drop in TFP z at date 1 with persistence 0.909. I chose the size of the shock to match the observed decline in measured TFP in the US from 2007 to 2009. The response from the baseline model is similar to the canonical business cycle model[15].

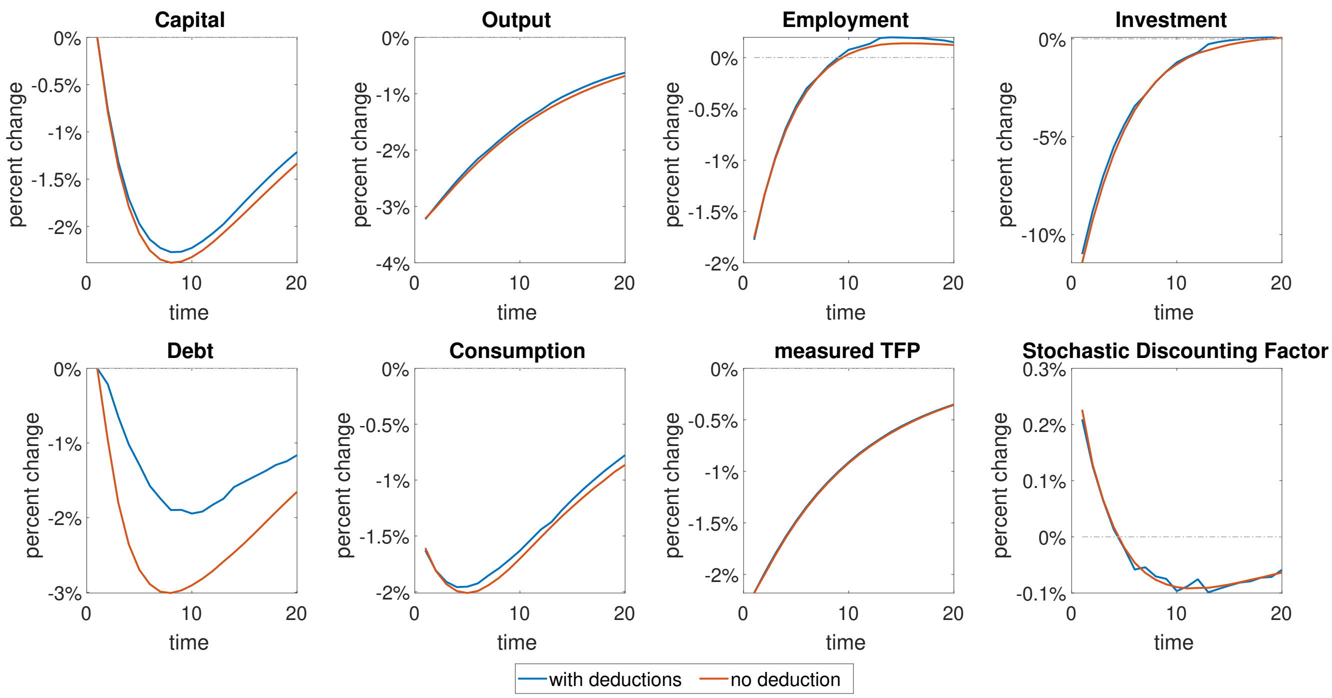
The responses from both economies are nearly identical, with debt as the only exception. TFP shocks affect the return on investment but not the cost. Since investment deductions lower the user cost of capital without increasing firms' flow profit, raising investment tax incentives cannot resolve the capital misallocation arise from TFP shocks.

On the contrary, investment deductions accelerate recoveries from recessions caused by credit shocks. I define the credit shock as the drop of the credit parameter θ in the collateral constraint. Figure 10 shows the responses of two economies to a 27% drop in credit θ at date 1 with the same persistence as the aggregate TFP shock. The scale is set to 27 percent to replicate a 26 percent decrease in debt during the Great Recession. The half life of output decreased by 12.5%, from date 16 to 14. Additionally, investment deductions also mitigate the capital misallocation through the endogenous TFP channel, reducing the half life of endogenous TFP by 25%, from date 16 to 12. These results demonstrate the effectiveness of investment deductions in facilitating economic recoveries from credit shocks.

Why do investment deductions mitigate recessions under credit shocks but not TFP shocks? Credit shocks increase the cost of investment by directly impacting the funding available to

[15] See Hansen (1985), Khan and Thomas (2013)

Figure 9: Comparing the responses to TFP shocks between model with deductions with model without deductions



credit-rationed firms. Investment deductions reduce the need of external financing, easing the financial constraints. Another key difference is the distributional impact of these shocks: TFP shocks affect all firms equally, whereas credit shocks primarily impact financially constrained firms. As a result, government have limited leverage to reallocate resources across firms during TFP shocks, while investment deductions provide the largest benefit to firms most affected by the credit shock.

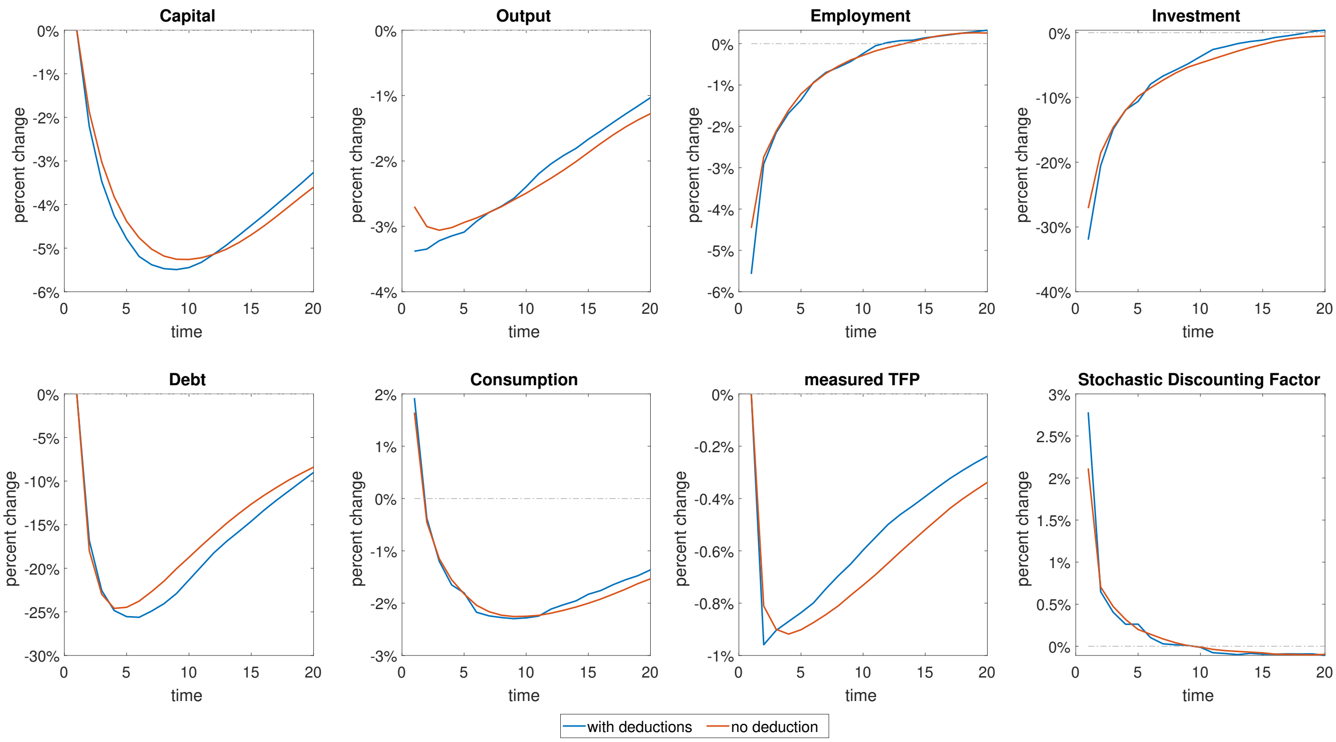
7.2 Intensive margin

7.2.1 TFP shocks

Figure 11 plots dynamics of aggregate variables following a 2.18 percent drop in TFP with persistence 0.909. Table 4 presents the values of aggregates under different policy scenarios. I implement all policy experiments at period 1 with the same value in Section 6. I calculate the policy cost as the present discounted value of the lifetime cost of the policy over the steady state baseline GDP.

The empirical literature shows firms' investments responds to the immediate realization of

Figure 10: Comparing the responses to credit shocks between model with deductions with model without deductions



tax benefits rather than potential future tax deductions[16]. In my model, a temporary boost in either Section 179 deduction or bonus depreciation only generates a spike in investment response at the year of policy implementation. However, as capital is a slow-moving object, even a temporary incentive mitigates the initial drop in capital, leading to a persistently different trajectory compared with the baseline model.

Table 4 demonstrates that raising the Section 179 threshold is more effective than bonus depreciation in mitigating recessionary troughs. Increasing the Section 179 threshold raises GDP by 0.66%, and results in a policy cost of 0.24% of steady-state GDP. In comparison, raising the bonus rate boosts GDP by 0.54%, and leads to higher policy cost of 0.28%. Furthermore, raising the Section 179 threshold increases investment by 6.02%, whereas expanding the bonus rate results in only a 5.33% increase.

Figure 11 illustrates how the boosting effects of different policies results in varying trajectories of aggregate variables. Subsidy policies encourage firms to raise their debt at the first few periods to undertake investment, rather than pay out as dividends As a result, the trajectory of capital is much higher when the S179 subsidy is increased (*orange line*) than I when the Bonus subsidy is increased (*yellow line*), leading to a larger boost in output, employment, and

[16] House and Shapiro (2008) and Zwick and Mahon (2017)

Table 4: Trough Declines: Model Comparison under TFP shocks

	Y	I	N	C	TFP	Debt	Policy cost / Y^{SS}
Baseline	-3.07%	-10.82%	-1.62%	-1.63%	-2.18%	0.63%	0.00%
S179	-2.40%	-4.80%	-0.48%	-1.89%	-2.18%	0.63%	0.24%
Bonus	-2.53%	-5.49%	-0.71%	-1.95%	-2.18%	0.63%	0.28%
S179 + Bonus	-2.49%	-5.49%	-0.64%	-1.68%	-2.18%	0.63%	0.29%

Notes: This table displays the deviation from steady state at period 1, which is trough and the policy implementation date. Policy cost is the present discounted percentage of the lifetime cost of policy over the steady state baseline GDP. The trough is at period 1, and policies are implemented at the same period. Baseline model: $(\bar{I}, \xi) = (0.092, 0.5)$. S179 model: $(\bar{I}, \xi) = (0.292, 0.5)$. Bonus model: $(\bar{I}, \xi) = (0.092, 0.69)$. S179 + Bonus model: $(\bar{I}, \xi) = (0.239, 0.566)$.

consumption. This larger boost in output also allows the government to repay the lump-sum tax more quickly. Implementation of both policies (*purple line*) results in an initial surge exceeding the S179 increase, but this gain rapidly diminishes, converging with the S179 trajectory in capital, output, and consumption.

One important aspect is how the government intertemporally finances these temporary policies. At period 1, the government has to raise lump-sum tax T from households to fund either of these policies, which can be as high as 0.8% of steady-state GDP. However, the cost of policy becomes negative after period 2 as the economy is in less severe recession compared to the baseline model. This means that the tax base has expanded, allowing the government to repay the households via lump-sum transfer. As a result, the present discounted lifetime cost of each policy is less than the period 1 policy cost.

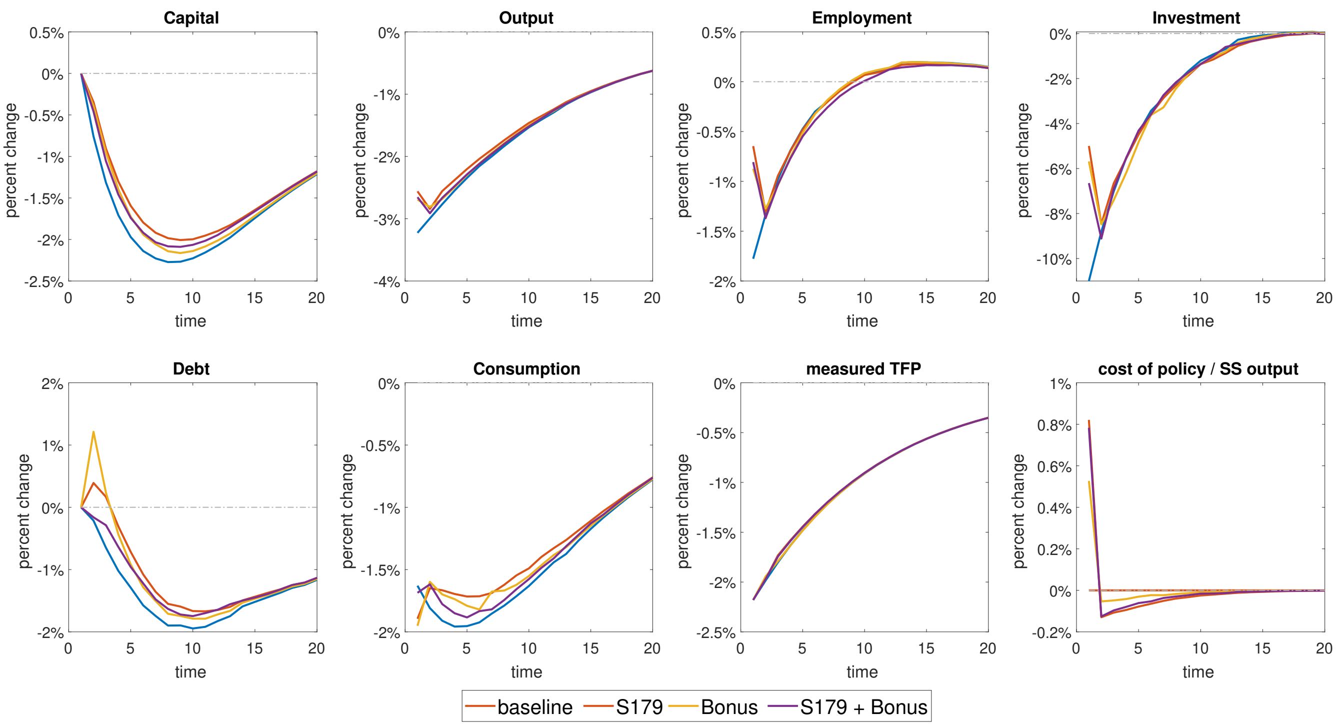
7.2.2 Credit shocks

The timing of the policy is set at period 4 to mimic the timing of both raising bonus depreciation and Section 179 threshold in 2010 while is recession started in late 2007. Figure 12 demonstrates the capability of Section 179 policy to mitigate capital misallocation, as reflected by measured TFP. Table 5 shows the percentage deviation of aggregate variables under baseline model and policy experiments.

To avoid the anticipation effect, firms in figure 12 are not aware in advance that the policies will be implemented at period 4. Among all three experiments, the S179 experiment has the lowest cost of the policy and the highest mitigating effect against the recession. We can see a hump in measured TFP around period 6, indicating the disparity between exogenous TFP and endogenous TFP has been alleviated by the S179 policy.

Table 5 presents the model comparison at period 4, along with the present discounted lifetime policy cost. Expanding the Section 179 (S179) threshold results in a 5.32% increase

Figure 11: Impulse Response to 2.18 percent drop in total factor productivity with persistent 0.909



Notes: Three policy experiments are implemented at period 1. Starting from period 2, the policy tools fall back to baseline value. Baseline model: $(\bar{I}, \xi) = (0.092, 0.5)$. S179 model: $(\bar{I}, \xi) = (0.292, 0.5)$ Bonus model: $(\bar{I}, \xi) = (0.092, 0.69)$. S179 + Bonus model: $(\bar{I}, \xi) = (0239., 0.566)$.

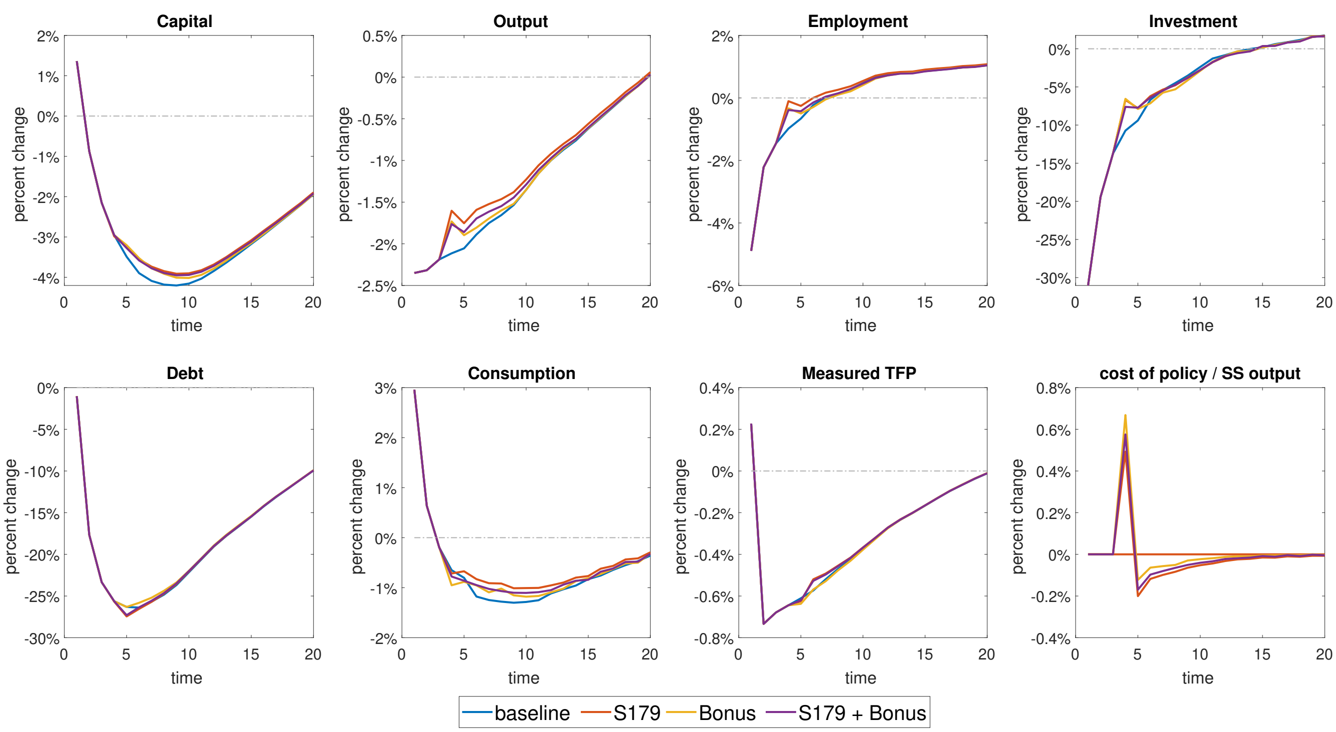
Table 5: Trough Declines: Model Comparison under Credit shocks

	Y	I	N	C	TFP	Debt	Policy cost / Y^{SS}
Baseline	-2.99%	-11.75%	-1.52%	-1.65%	-0.83%	-24.38%	0.00%
S179	-2.40%	-6.43%	-0.38%	-1.91%	-0.67%	-24.46%	0.67%
Bonus	-2.57%	-6.84%	-0.59%	-2.09%	-0.70%	-23.96%	1.12%
S179 + Bonus	-2.49%	-6.84%	-0.51%	-2.02%	-0.68%	-24.33%	0.86%

Notes: This table displays the deviation from steady state at period 4, which is the policy implementation date. Policy cost is the present discounted percentage of the lifetime cost of policy over the steady state baseline GDP. The trough is at period 1, and policies are implemented at the same period. Baseline model: $(\bar{I}, \xi) = (0.092, 0.5)$. S179 model: $(\bar{I}, \xi) = (0.292, 0.5)$. Bonus model: $(\bar{I}, \xi) = (0.092, 0.69)$. S179 + Bonus model: $(\bar{I}, \xi) = (0.239, 0.566)$.

in investment and a 0.59% rise in GDP, whereas raising the bonus depreciation rate leads to a smaller 4.91% increase in investment and a 0.42% boost in GDP. The S179 policy also significantly enhances aggregate productivity, with a 0.15% increase in measured total factor productivity. Figure 12 illustrates this improvement in aggregate productivity. Under the S179 policy (*orange line*), measured TFP rises substantially above the baseline (*blue line*). In contrast, the trajectory of measured TFP under the bonus depreciation policy (*yellow line*) closely follows that of the baseline.

Figure 12: Impulse Response to 27 percent drop in credit parameter with persistent 0.909



Notes: Three policy experiments are implemented at period 4. Starting from period 5, the policy tools fall back to the baseline value. Baseline model: $(\bar{I}, \xi) = (0.092, 0.5)$. S179 model: $(\bar{I}, \xi) = (0.292, 0.5)$ Bonus model: $(\bar{I}, \xi) = (0.092, 0.69)$. S179 + Bonus model: $(\bar{I}, \xi) = (0239., 0.566)$.

8 Concluding Remarks

I developed a general equilibrium model with heterogeneous firms and collateral constraints to evaluate the efficacy of investment subsidy policies. The model is calibrated to match aggregate economic and firm-level moments, replicating the distribution of investment rates and investment elasticity to tax incentives across firms of different sizes. Its micro-foundations and calibration ensure this model provides a realistic assessment of the aggregate effects of investment subsidies by capturing time-varying changes in firms' decisions over physical capital, debt, and deductible stock.

The effectiveness of investment subsidies in boosting aggregate output and productivity depends on their interaction with firms' saving motives and the partial irreversibility generated by corporate taxation. Partial irreversibility adds risk to investment by distorting the purchasing and selling value of capital. Investment deductions lower the user cost of capital, reducing the need for debt financing and the negative impact from partial irreversibility, and leading to more efficient capital allocation across the economy. As a result, the economy with investment deductions recovers faster than the economy without them, following credit shocks consistent with the Great Recession.

Unlike typical policies, U.S. investment subsidies are implemented through both targeted and untargeted corporate tax deductions. I find that targeted policies are more effective at boosting aggregate GDP and productivity, while the current approach of combining both policies diminishes their overall stimulative effect. The increased effectiveness of the targeted policy stems from its improvements in capital allocation across the economy, as demonstrated by the distribution of excess returns on investment. Compared to untargeted subsidies, the targeted policy results in less dispersion of firm investments around the efficient zero excess return level. Additionally, high-productivity firms respond more strongly to targeted policies, while untargeted policies have a more diffuse impact. Combining both types of policies, however, reduces the effectiveness of each.

A natural extension of this framework would introduce endogenous default risk. In the model, financially unconstrained and high productivity firms would incur debt to invest up to the Section 179 threshold. This results in a positive relationship between firm size and leverage. Hence, in contrast with other quantitative frameworks, an extended version of this one could lead to instances of large-firm defaults, amplifying the economy's response to aggregate shocks. Additionally, reducing the incidence of endogenous default would be another transmission channel through which corporate tax deductions could support recovery. An extended model incorporating default that could quantify these effects is left for future work.

References

Barro, Robert J. and Jason Furman (2018) "Macroeconomic Effects of the 2017 Tax Reform," *Brookings Papers on Economic Activity*, 2018 (1), 257–345, 10.1353/eca.2018.0003.

Chatterjee, Satyajit and Burcu Eyigungor (2023) "The firm size-leverage relationship and its implications for entry and business concentration," *Review of Economic Dynamics*, 48, 132–157, 10.1016/j.red.2022.04.002.

Chodorow-Reich, Gabriel, Matthew Smith, Owen Zidar, and Eric Zwick (2024) "Tax Policy and Investment in a Global Economy," *SSRN Electronic Journal*, 10.2139/ssrn.4746790.

Committee on Ways and Means (2003) "Report 109–94: Jobs and Growth Reconciliation Tax Act of 2003,"Technical report.

Cooper, Russell W. and John C. Haltiwanger (2006) "On the Nature of Capital Adjustment Costs," *Review of Economic Studies*, 73 (3), 611–633, 10.1111/j.1467-937x.2006.00389.x.

Cummins, Jason G., Kevin A. Hassett, and R.Glenn Hubbard (1996) "Tax reforms and investment: A cross-country comparison," *Journal of Public Economics*, 62 (1), 237–273, https://doi.org/10.1016/0047-2727(96)01580-0, Proceedings of the Trans-Atlantic Public Economic Seminar on Market Failures and Public Policy.

Fernández-Villaverde, Jesús (2010) "Fiscal Policy in a Model With Financial Frictions," *American Economic Review*, 100 (2), 35–40, 10.1257/aer.100.2.35.

Goolsbee, A. (1998) "Investment Tax Incentives, Prices, and the Supply of Capital Goods," *The Quarterly Journal of Economics*, 113 (1), 121–148, 10.1162/003355398555540.

Habermann, Christian and Fabian Kindermann (2007) "Multidimensional Spline Interpolation: Theory and Applications," *Computational Economics*, 30 (2), 153–169, 10.1007/s10614-007-9092-4.

Hall, Robert E. and Dale W. Jorgenson (1967) "Tax Policy and Investment Behavior," *The American Economic Review*, 57 (3), 391–414, `http://www.jstor.org/stable/1812110`.

Hanlon, Michelle, Edward L. Maydew, and Terry Shevlin (2008) "An unintended consequence of book-tax conformity: A loss of earnings informativeness," *Journal of Accounting and Economics*, 46 (2–3), 294–311, 10.1016/j.jacceco.2008.09.003.

Hansen, Gary D. (1985) "Indivisible labor and the business cycle," *Journal of Monetary Economics*, 16 (3), 309–327, https://doi.org/10.1016/0304-3932(85)90039-X.

House, Christopher L and Matthew D Shapiro (2008) "Temporary Investment Tax Incentives: Theory with Evidence from Bonus Depreciation," *American Economic Review*, 98 (3), 737–768, 10.1257/aer.98.3.737.

Jo, In Hwan and Tatsuro Senga (2019) "Aggregate consequences of credit subsidy policies: Firm dynamics and misallocation," *Review of Economic Dynamics*, 32, 68–93, 10.1016/j.red.2019.01.002.

Joint Committee on Taxation (2017) "Macroeconomic Analysis Of The Conference Agreement For H.R. 1, "The Tax Cuts And Jobs Act"."

Khan, Aubhik and Julia K. Thomas (2013) "Credit Shocks and Aggregate Fluctuations in an Economy with Production Heterogeneity," *Journal of Political Economy*, 121 (6), 1055–1107, 10.1086/674142.

Kiyotaki, Nobuhiro and John Moore (1997) "Credit Cycles," *Journal of Political Economy*, 105 (2), 211–248, 10.1086/262072.

Koby, Yann and Christian Wolf (2020) "Aggregation in heterogeneous-firm models: Theory and measurement," *Working Paper*.

Lamont, Owen (1997) "Cash Flow and Investment: Evidence from Internal Capital Markets," *The Journal of Finance*, 52 (1), 83–109, 10.1111/j.1540-6261.1997.tb03809.x.

Mills, Lillian F. and Kaye J. Newberry (2005) "Firms' Off-Balance Sheet and Hybrid Debt Financing: Evidence from Their Book-Tax Reporting Differences," *Journal of Accounting Research*, 43 (2), 251–282, 10.1111/j.1475-679x.2005.00170.x.

Mills, Lillian F., Kaye J. Newberry, and William B. Trautman (2002) "Trends in Book-Tax Income and Balance Sheet Differences," *SSRN Electronic Journal*, 10.2139/ssrn.313040.

Occhino, Filippo (2022) "The macroeconomic effects of the tax cuts and jobs act," *Macroeconomic Dynamics*, 27 (6), 1495–1527, 10.1017/s1365100522000311.

——— (2023) "The macroeconomic effects of business tax cuts with debt financing and accelerated depreciation," *Economic Modelling*, 125, 106308, 10.1016/j.econmod.2023.106308.

Ohrn, Eric (2018) "The Effect of Corporate Taxation on Investment and Financial Policy: Evidence from the DPAD," *American Economic Journal: Economic Policy*, 10 (2), 272–301, 10.1257/pol.20150378.

——— (2019) "The effect of tax incentives on U.S. manufacturing: Evidence from state accelerated depreciation policies," *Journal of Public Economics*, 180, 104084, 10.1016/j.jpubeco.2019.104084.

Rogerson, Richard (1988) "Indivisible labor, lotteries and equilibrium," *Journal of Monetary Economics*, 21 (1), 3–16, https://doi.org/10.1016/0304-3932(88)90042-6.

Steinmüller, Elias, Georg U. Thunecke, and Georg Wamser (2018) "Corporate income taxes around the world: a survey on forward-looking tax measures and two applications," *International Tax and Public Finance*, 26 (2), 418–456, 10.1007/s10797-018-9511-6.

Summers, Lawrence H., Barry P. Bosworth, James Tobin, and Philip M. White (1981) "Taxation and Corporate Investment: A q-Theory Approach," *Brookings Papers on Economic Activity*, 1981 (1), 67, 10.2307/2534397.

Tauchen, George (1986) "Finite state markov-chain approximations to univariate and vector autoregressions," *Economics Letters*, 20 (2), 177–181, https://doi.org/10.1016/0165-1765(86)90168-0.

Zwick, Eric and James Mahon (2017) "Tax Policy and Heterogeneous Investment Behavior," *American Economic Review*, 107 (1), 217–248, 10.1257/aer.20140855.

A Additional figures

Figure 13: Section 179 Deduction Limits and Bonus Depreciation Rates (2000-2024)

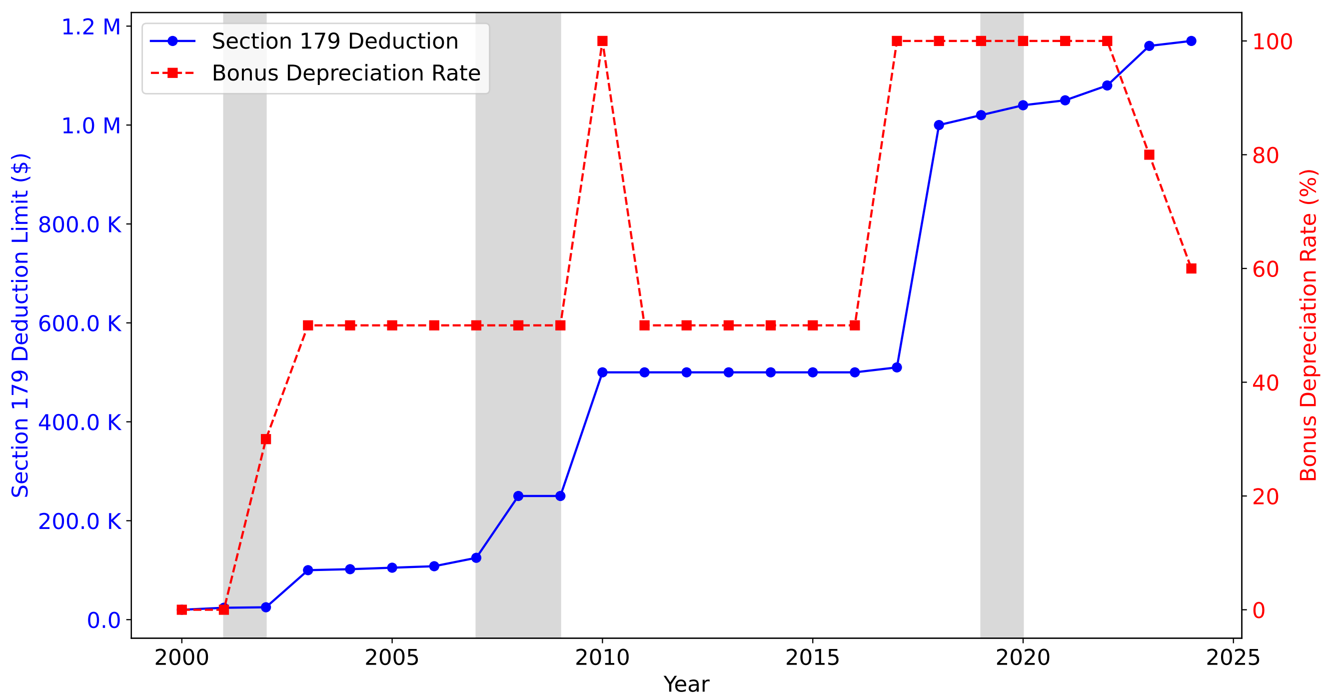


Figure 14: Distribution: minimum productivity