Aggregate Implications of Corporate Taxation over the Business Cycle

Hui-Jun Chen

The Ohio State University

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DKT Workshop

Outline

What are the macro effects of corporate tax deductions?

Policies   Investment deductions follow depreciation schedule and two policies accelerate it

Fact   large deductions (86B), investment responses are large and heterogeneous

(The Joint Committee on Taxation (2017), Chodorow-Reich, Zidar and Zwick (2024b), Zwick and Mahon (2017), Ohrn (2018, 2019))

Model $\underbrace{\text{hetero. firms}}_{\text{size-dependent response}}$ + $\underbrace{\text{financial frictions}}_{\text{limit investment loan}}$ + $\underbrace{\text{corporate taxes}}_{\text{partial irreversibility}}$ + $\underbrace{\text{investment deduction}}_{\text{winner/loser}}$

Calibrate   match key moments in US economy and establishment-level investment data

Validation   (i) $\underbrace{\text{investment rate distribution}}_{\text{Cooper and Haltiwanger (2006)}}$, (ii) $\underbrace{\text{heterogeneous investment response to policy}}_{\text{Zwick and Mahon (2017)}}$

Application   equilibrium effects on investment deductions as counter-cyclical policies

■ against different shocks (TFP v.s. credit); v.s. other stimulus policies (TCJA)

Two policies that accelerates investment deductions

Section 179 expensing allow some firms to deduct all investment expenses (targeted)

Bonus depreciation   allow all firms to deduct a fraction of investment expenses, and the
                        remaining fraction follows depreciation schedule (untargeted)
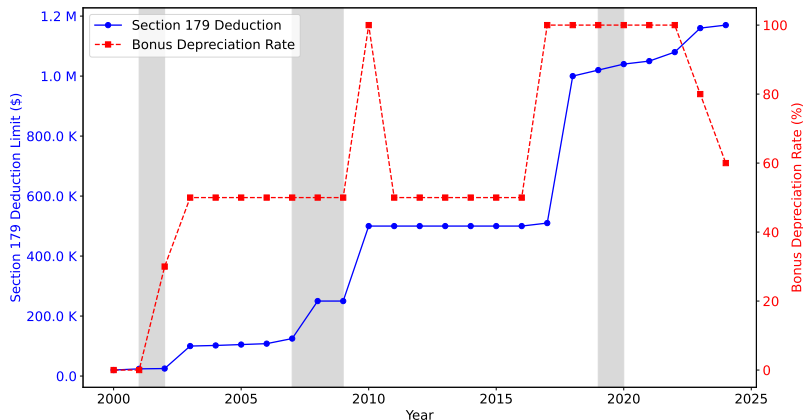
Preview of findings

Extensive margin Comparing two economy, with and without investment tax deductions,

- Deductions reduce half life of agg. TFP by 25% after credit shocks (date $16 \to 12$)

- Deductions have almost no effect after TFP shocks

Intensive margin in LR Comparing steady states with policy expansion; cost: 0.3% of GDP

- Targeted policy boosts GDP by 1.6%, yet untargeted one boosts by 1.06%

- Convex combination of both deductions only boosts GDP by 1.3% (Ohrn (2019))

Intensive margin in SR Comparing temporarily raise deductions during Great Recessions,

- Targeted policy reduces GDP trough by 0.51%, while untargeted on reduces by 0.38%

Literature

Key mechanisms

Two inefficiencies: financial frictions and partial irreversibility created by tax wedges

- Partial irreversibility leads to *(S, s)* decision rules and inaction firms

- Financial frictions hinder capital accumulation of small firms by limit investment loan

Why targeted policy is better? Both policies alter the cost and benefit of investment:

Cost   Targeted policy allow some firms to deduct more, resulting in lower relative prices

Untargeted policy induces large dividend payment as large firms also get subsidized

Benefit Targeting motivates self-selection $\Rightarrow$ capital misallocation $\downarrow$ for high productivity firms

Untargeted policy spread the tax incentives across firms $\Rightarrow$ effects are more diffused

Literature

- Large empirical literature on responsiveness of investment to tax credit
  - Public firm data: Goolsbee (1998), Cummins, Hassett and Hubbard (1996), House and Shapiro (2008), Lamont (1997); Firm/State-level data: Zwick and Mahon (2017), Ohrn (2018), Ohrn (2019)

  New - evaluates aggregate effects of both investment subsidy policies

- Representative firm model on the response of fiscal policies with simplistic tax structure
  - Hall and Jorgenson (1967), Summers, Bosworth, Tobin and White (1981), Fernández-Villaverde (2010), Occhino (2022), Occhino (2023), Chodorow-Reich, Smith, Zidar and Zwick (2024a)

  New - accounts for distributional effects and a realistic tax deduction structure

- Heterogeneous firm model that accounts for distribution effects of shocks
  - Khan and Thomas (2013), House (2014), Koby and Wolf (2020), Winberry (2021)

  New - utilize the technique and expands the analysis to counter-cyclical fiscal policies

Back

Outline

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- Model

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Environment

Household: supplies labor, pays labor tax, lends risk-free loans, and owns the firms

Government: collect taxes to fund exogenous government spending

Firms: states $(k, b, \psi, \varepsilon)$

- DRS production; persistent idiosyncratic productivity ε; i.i.d. exit shock π_d

- Deductible stock ψ stores unrealized investment tax deductions

- Capital k accumulation is hindered by financial frictions and tax wedges:
  1. collateral constraint $b' \leq \theta k'$

  2. selling capital generate taxable income $\Rightarrow$ after-tax selling prices $<$ purchasing prices

Investment deductions and taxable income
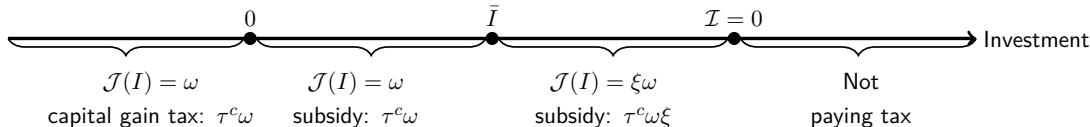
$$\mathcal{I}(k',k,\psi,\varepsilon) = \max\left\{ z\varepsilon f(k,n) - wn - \mathcal{J}(k',k)(k' - (1-\delta)k) - \delta^\psi\psi, 0 \right\},$$

$\mathcal{J}(k',k)$: indicator function for investment deduction policies

$$\mathcal{J}(k',k) = \begin{cases} \omega & \text{if } k' - (1-\delta)k \le \bar{I} \\ \xi\omega & \text{if } k' - (1-\delta)k > \bar{I} \end{cases}$$

$\bar{I}$: Section 179 threshold (targeted policy); $\xi \in [0,1]$: bonus depreciation (untargeted policy)
ω controls scale of subsidies (investing) and degree of irreversibility (dis-investing)

choice state space

How corporate taxes affect budget constraints

Firms' budget constraints

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

If $\mathcal{I}(k', k, \psi, \varepsilon) > 0$,

$$D = \underbrace{(1-\tau^c)}_{\text{taxed}}(z\varepsilon F(k,n) - wn) - b + qb' - \underbrace{(1 - \tau^c \mathcal{J}(k',k)\omega)}_{\text{subsidized/capital gain tax}}(k' - (1-\delta)k) + \tau^c \delta^\psi \psi$$

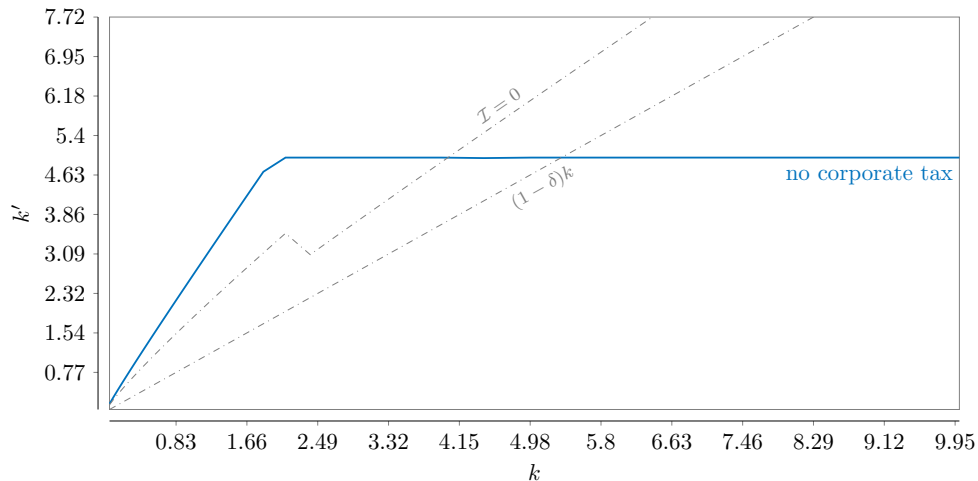ψ: deductible stock; LoM: $\psi' = (1-\delta^\psi)\psi + (1 - \mathcal{J}(k',k))\omega(k' - (1-\delta)k)$

- $\delta^\psi \psi$: deduction from past investment

- $\delta^\psi > \delta$: "accelerated" depreciation $\Rightarrow$ selling price $>$ adjusted basis (Hanlon, Maydew and Shevlin, 2008)

Distortion created by tax wedge

$$D = \qquad (z\varepsilon F(k,n) - wn) - b + qb' - \qquad\qquad - \qquad I$$

capital decision rule at median productivity with zero debt and taxable capital
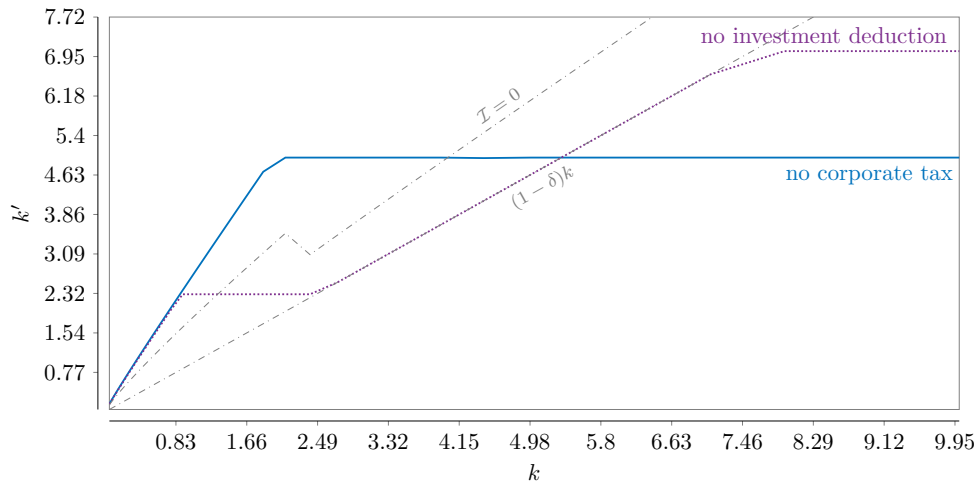
Distortion created by tax wedge

$$D = (1 - \tau^c)(z\varepsilon F(k, n) - wn) - b + qb' - \qquad\qquad I\mid_{I \geq 0} - (1 - \tau^c\omega)I\mid_{I < 0}$$

capital decision rule at median productivity with zero debt and taxable capital

Distortion created by tax wedge

$$D = (1 - \tau^c)(z\varepsilon F(k,n) - wn) - b + qb' - (1 - \tau^c \mathcal{J}(k',k)\omega)I \mid_{I \geq 0} - (1 - \tau^c \omega)I \mid_{I < 0} + \tau^c \delta^\psi \psi$$

capital decision rule at median productivity with zero debt and taxable capital

no investment deduction

bonus depreciation

no corporate tax
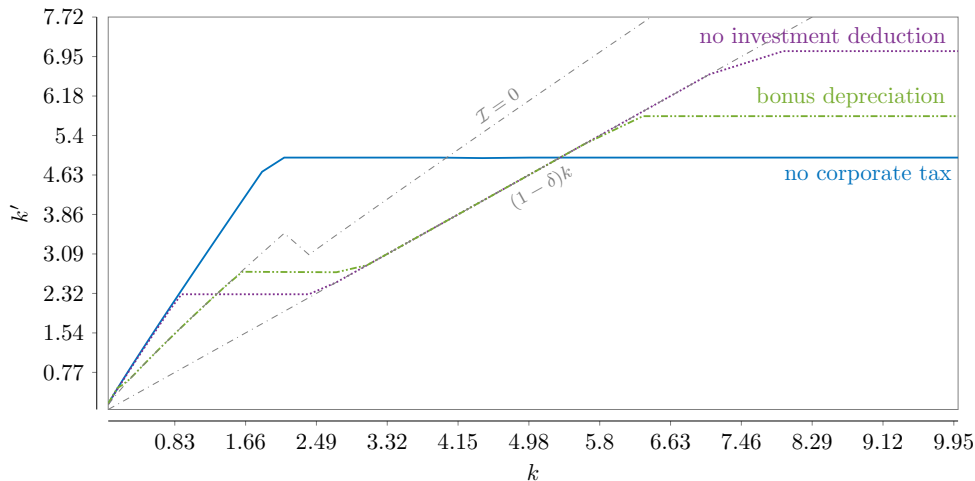
Distortion created by tax wedge

$$D = (1 - \tau^c)(z\varepsilon F(k, n) - wn) - b + qb' - (1 - \tau^c \mathcal{J}(k', k)\omega)I\mid_{I \geq 0} - (1 - \tau^c\omega)I\mid_{I < 0} + \tau^c\delta^\psi\psi$$
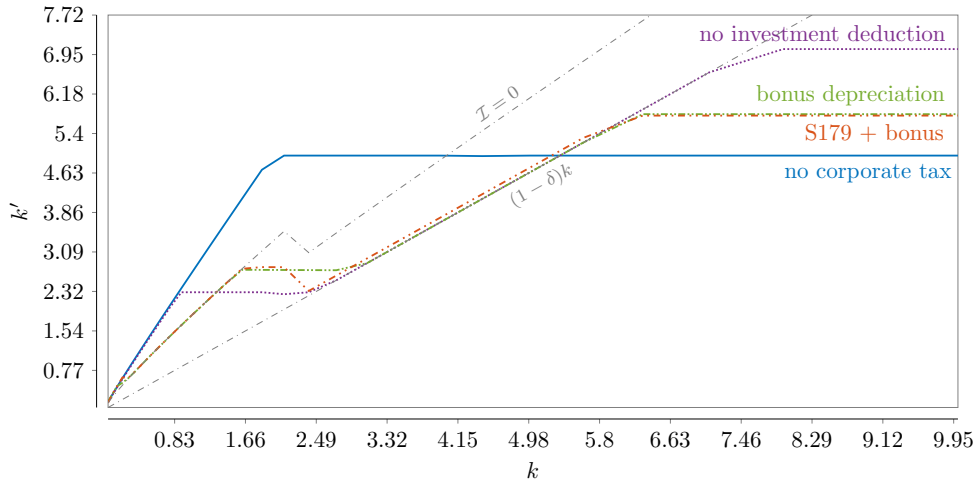
capital decision rule at median productivity with zero debt and taxable capital

Budget constraints and Discrete Choice

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

$$= \underbrace{(1-\tau^c)}_{\text{taxed}}(z\varepsilon F(k,n) - wn) - b + qb' - \underbrace{(1 - \tau^c \mathcal{J}(k',k)\omega)}_{\text{subsidized/capital gain tax}} (k' - (1-\delta)k) + \textcolor{red}{\tau^c \delta^\psi \psi}$$

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

$$+ (1 - \pi_d)v(k,b,\psi,\varepsilon;\mu)$$

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

For each option, firms maximize dividend and continuation value subject to
(1) <u>budget constraints</u>, (2) <u>collateral constraints</u>, and (3) <u>deductible stock LoM</u>

v^H v^L v^N Household   Equilibrium

Outline

- Introduction

- Model

- Calibration

- Long-run effects of corporate tax deductions

- Short-run dynamics of corporate tax deduction

- Application: policy evaluation

Calibrated Moments for Baseline Model

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
$\rho_\varepsilon = 0.6$	corr. in investment rate	$= 0.058$	0.050
$\sigma_\varepsilon = 0.1$	std. in investment rate	$= 0.337$	0.300
$\omega = 0.6$	investment rate $> 20\%$	$= 0.186$	0.185
$\xi = 0.5$	2015 bonus rate		
$\bar{I} = 0.092$	2015 threshold model counterpart Detail		

Functional Form   Exogenous parameters   investment rate distribution

Model validation: investment rate distribution for unconstrained firms

Investment rate distribution
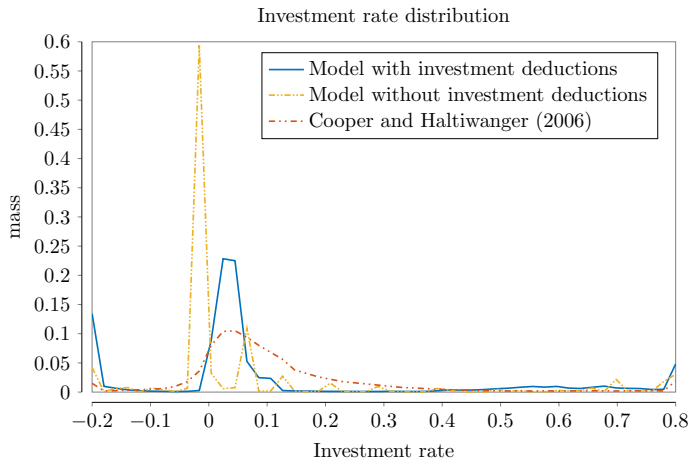
- Simulate $50,000$ unconstrained firms for 100 periods

- Take the last 17 periods and plot investment rate distribution

- Model with investment deduction tightly match the investment rate distribution

Model validation: heterogeneous investment response in the short-run

Size-dependent investment response
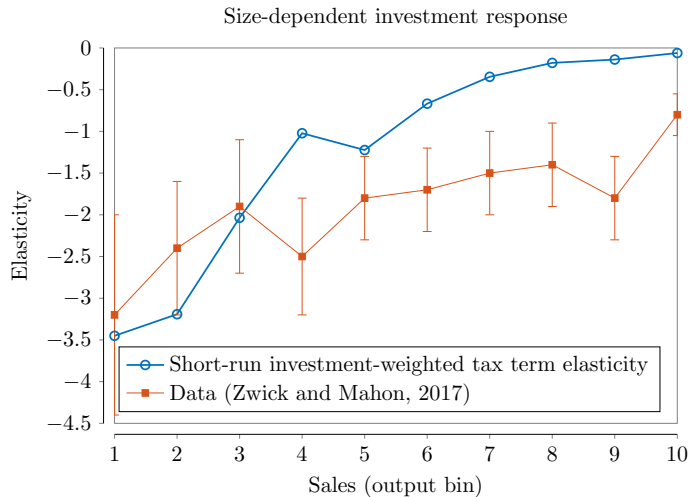
- Simulate $50,000$ firms for 100 periods

- Drop credit at date 79 and boost bonus rate at date 80

- aggregate tax term elasticity from date 79 to date 80: -1.23

- Zwick and Mahon (2017): -1.6

Model prediction: not much heterogeneity in long-run investment response

Size-dependent investment response
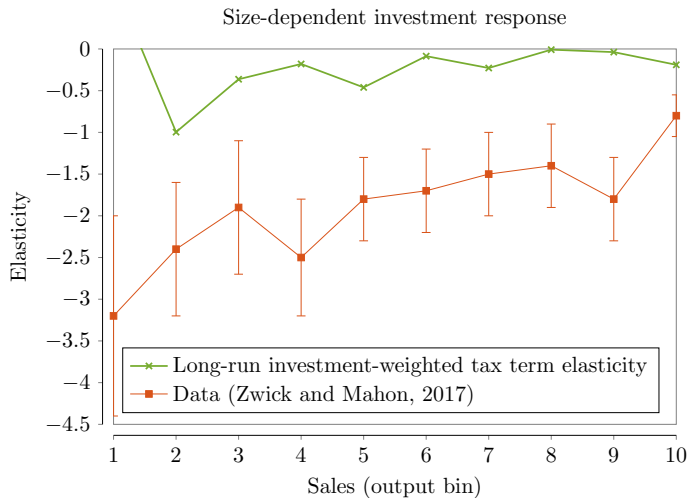
- Include the GE effects

- aggregate elasticity: -0.17

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Aggregate outcomes as percentage deviation of baseline

| Variable	S179	Bonus	S179 + Bonus	Tax cut
Output	1.61%	1.06%	1.31%	0.64%
Consumption	1.55%	0.92%	1.27%	0.56%
Labor	0.06%	0.13%	0.04%	0.08%
Capital	4.22%	3.21%	3.39%	1.95%
Investment	4.22%	3.21%	3.39%	1.95%
Measured TFP	0.32%	0.03%	0.28%	0.01%
Dividend	2.08%	10.14%	2.99%	-2.09%

- Each policy costs 0.3% of baseline GDP and delivers the same government spending $\bar{G}$

- In S179 + Bonus, policy tools are 82% of the level in S179 and Bonus

- Untargeted nature of bonus induces dividend payment: recall $D \propto \mathcal{J}(k', k)$
  - unconstrained firms: user cost of capital drops, easier to achieve target capital

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Distribution of Excess Return on Investment

Cumulative distribution of Excess Return on Investment

	mean	mass at 0
baseline	1.24	20%
S179	1.08	31%
Bonus	1.09	26%

Expanding S179 reduces investment wedge for productive firms

mean excess return on investment: percentage deviation from baseline

Legend: S179, Bonus, S179 + Bonus, Tax cut
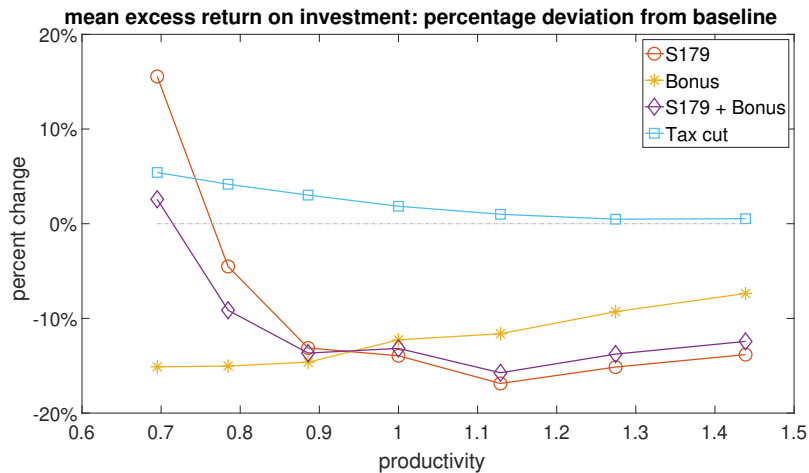
efficiency low excess return

S179   high ε firms: $(+)$
      low ε firms: $(-)$
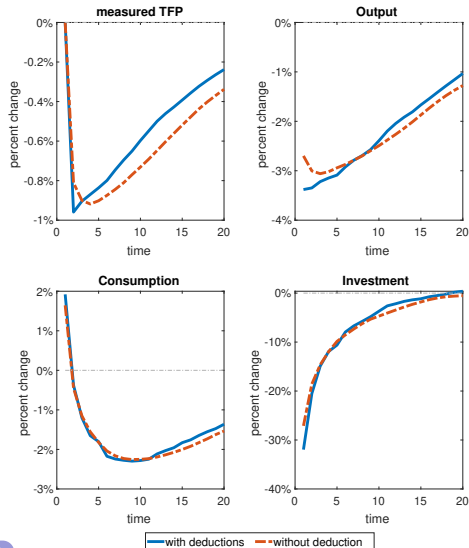
Bonus   all firms $(+)$
      low ε firms: $(++)$

excess return

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Corporate tax deductions leads to faster recoveries after credit shocks

with deductions   without deduction

Exercise Two economy, w/ and w/o deductions

Shock 27% initial drop in credit, $\rho = 0.909$
          lead to 26% drop in debt

Control   Hold $\{G\}_{t=0}^{T}$ fixed

Summary

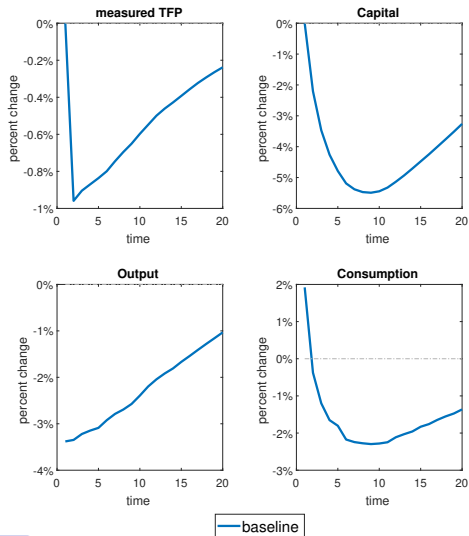|	w/ deduct	w/o deduct
Half life: $\hat{z}$	12 period	16 period
Trough: $\hat{z}$	-0.95%	-0.91%
Half life: y	14 period	16 period
Trough: y	-3.38%	-3.05%

TFP

Almost no role of corporate taxation following a TFP shock
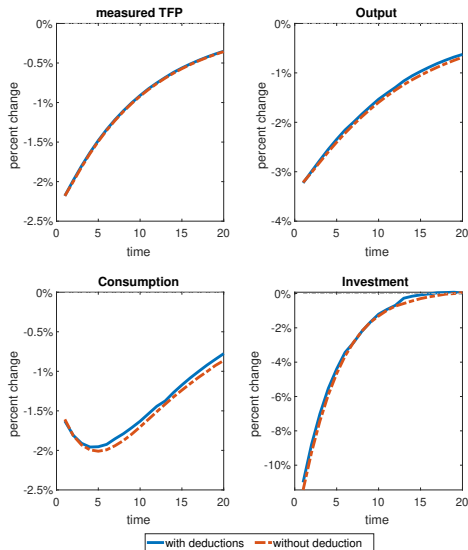
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Comparison of temporary investment tax deductions under credit shocks

Shock 27% initial drop in credit, $\rho = 0.909$
lead to 26% drop in debt

Policy implement in date 4, unexpected by HH

S179 boost $\hat{z}$ by 0.05% at date 6

	Y	C	K
trough ↓	0.51%	0.28%	0.29%

Bonus boost $\hat{z}$ by 0.005% at date 6

	Y	C	K
trough ↓	0.38%	0.14%	0.19%

S179 + Bonus boost $\hat{z}$ by 0.04% at date 6

	Y	C	K
trough ↓	0.35%	0.19%	0.25%

Detail

Comparison of temporary investment tax deductions under credit shocks

Shock 27% initial drop in credit, $\rho = 0.909$
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	Y	C	K
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Detail

Comparison of temporary investment tax deductions under credit shocks

measured TFP, Capital, Output, Consumption

baseline — S179 ‑‑‑ Bonus

Detail

Shock 27% initial drop in credit, $\rho = 0.909$
       lead to 26% drop in debt

Policy implement in date 4, unexpected by HH

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Comparison of temporary investment tax deductions under credit shocks
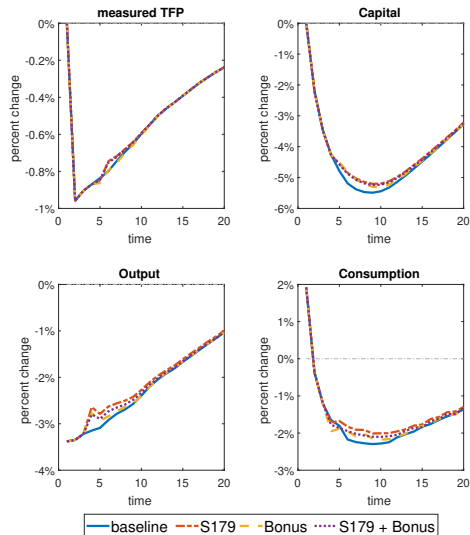
measured TFP / Capital / Output / Consumption plots

—baseline ---S179 --Bonus ····S179 + Bonus

Shock 27% initial drop in credit, $\rho = 0.909$
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	Y	C	K
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Detail

Conclusions

- Equilibrium model of how investment tax credit and subsidy policies boost economy

- Use model to quantify the macroeconomics effects of both subsidy policies:
  - S179 boost GDP by motivating marginal firms to be unconstrained and alleviate misallocation

  - Bonus depreciation is 50% less effective than S179 as it motivates dividend payment

  - Cutting statutory tax rate is the least effective

- What's next:
  - Permanent change in policies

  - Policy effectiveness under aggregate uncertainty

  - Endogenizing financial frictions: does deduction policy reduce the incidence of firm default?

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Outline

- Empirical Literatures

- Model Appendix
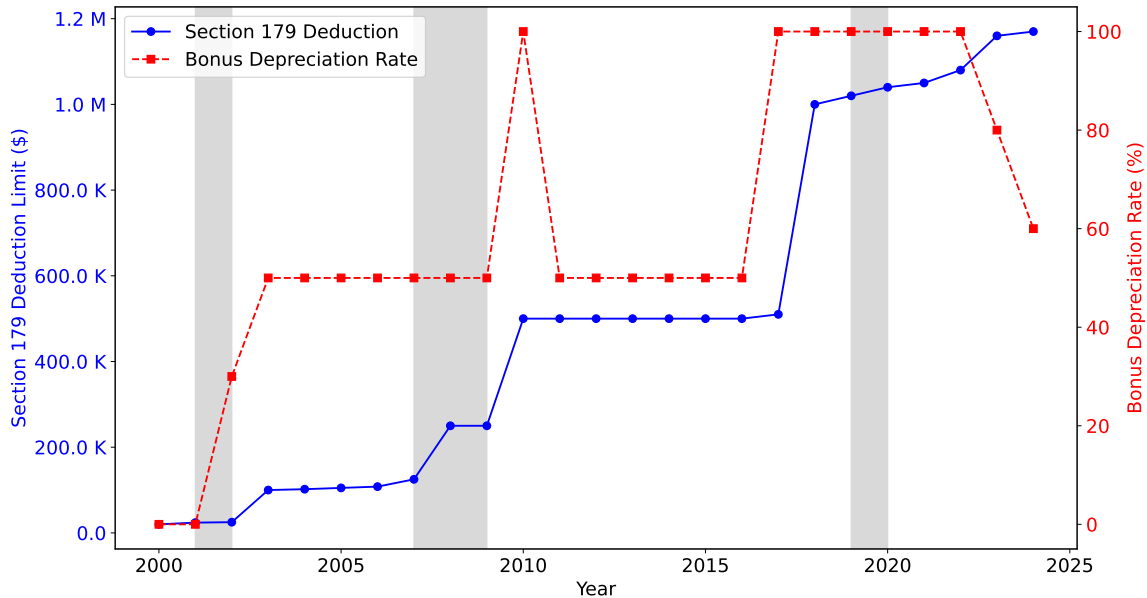
Example: Modified Accelerated Cost Recovery System (MARCS)

Shawn bought and placed in service a used pickup for $15,000 on March 5,1998. The pickup has a 5 year class life. His depreciation deduction for each year is computed in the following table.

Year	Cost × MACRS %	Depreciation
1998	$15,000 × 20.00\%$	$3,000
1999	$15,000 × 32.00\%$	$4,800
2000	$15,000 × 19.20\%$	$2,880
2001	$15,000 × 11.52\%$	$2,880
2002	$15,000 × 11.52\%$	$2,880
2003	$15,000 × 5.76\%$	$864
Total		$15,000

MACRS Percentage Table

Year	3 Year	5 Year	7 Year
1	33.33%	20.00%	14.29%
2	44.45%	32.00%	24.49%
3	14.81%	19.20%	17.49%
4	7.41%	11.52%	12.49%
5		11.52%	8.93%
6		5.76%	8.92%
7			8.93%
8			4.46%

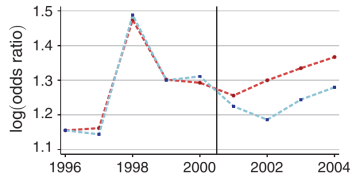# Long-duration industries respond more to bonus depreciation
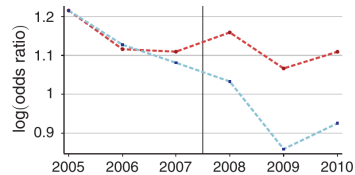

Panel A. Intensive margin: bonus I
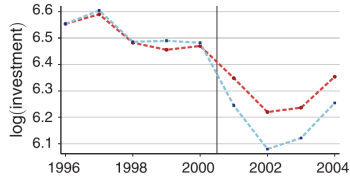
Panel B. Intensive margin: bonus II
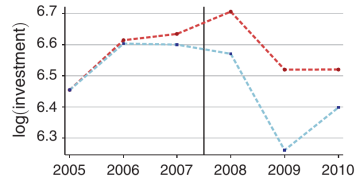
Panel C. Extensive margin: bonus I

Panel D. Extensive margin: bonus II

- - - Treatment group (long duration industries)
- - - Control group (short duration industries)

Conforming states enjoys 18% of investment boosts

Table: Investment Impacts of State Bonus and State 179

Dependent Var:	ln CapEx			
Specification	(1)	(2)	(3)	(4)
State Bonus	0.038		0.031	0.174^{**}
	(0.036)		(0.037)	(0.073)
State 179		0.013	0.012	0.020^{**}
		(0.009)	(0.009)	(0.009)
Bonus 179 Interaction				-0.047^{***}
				(0.016)
Year FE	✓	✓	✓	✓
State Controls, Time Trends	✓	✓	✓	✓
NAICS x Year FE	✓	✓	✓	✓
Adj. R-Square	0.286	0.286	0.286	0.286
State x NAICS Groups	883	883	883	883
Observations	11,987	11,987	11,987	11,987

Notes: Table 5 presents coefficient estimates of the impact of State 179 and State Bonus on Ln CapEx. All specifications include include year fixed effects, State $\times$ NAICS fixed effects, state linear time trends, NAICS $\times$ Year fixed effects, and a robust set if time-varying state level controls to capture the effect of changes in state politics, productivity, population, and finances. Standard errors are at the state level and are reported in parentheses. Statistical significance at the 1 percent level is denoted by $**$, 5 percent by $**$, and 10 percent by $*$.

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Firm distribution in 2008-2009
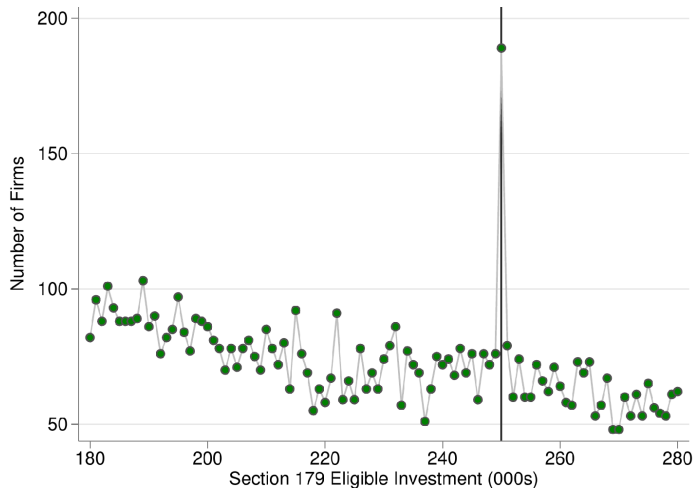
Heterogeneity in investment response

Table: Heterogeneity by Ex Ante Constraints

	Sales		Div payer?		Lagged cash	
	Small	Big	No	Yes	Low	High
$z_{N,t}$	6.29	3.22	5.98	3.67	7.21	2.76
	(1.21)	(0.76)	(0.88)	(0.97)	(1.38)	(0.88)
Equality test	$p = 0.030$		$p = 0.079$		$p = 0.000$	
Observations	177,620	255,266	274,809	127,523	176,893	180,933
Clusters (firms)	29,618	29,637	39,195	12,543	45,824	48,936
R^2	0.44	0.76	0.69	0.80	0.81	0.76

Heterogeneous response to bonus depreciation
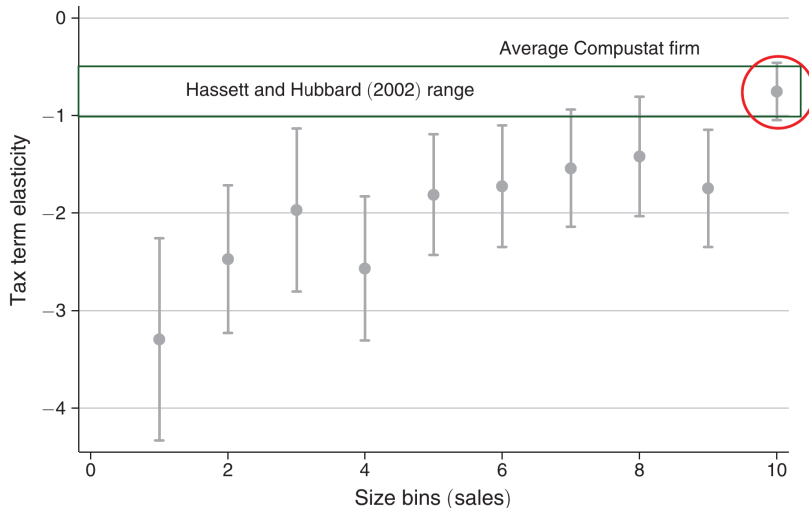
How to determine $\bar{I}$

In 2015,

- Real investment: $2459.8B (Table 3.7 BEA)

- Numbers of firms in US: $5,900,731$ (SUSB)

- Average investment: $416,853$

- Section 179 deduction: $500,000$

- Choose $\bar{I} = \frac{500,000}{416,853} \times$ aggregate investment ~ 0.092

Outline

- Empirical Literatures

- Model Appendix

Unconstrained firms' problem: positive taxable income

Let W function be the value function for unconstrained firms.

The start-of-period value before the realization of exit shock is

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

Upon survival, unconstrained firms undertake binary choice,

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

Firm's current value: $W(k, b, \psi, \varepsilon; \mu) = W(k, 0, \psi, \varepsilon; \mu) - pb$
Start-of-period value: $W^0(k, b, \psi, \varepsilon; \mu) = W^0(k, 0, \psi, \varepsilon; \mu) - pb$.

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Unconstrained firms' problem (Cont.)

Given these transformation, firms' problem can be rewritten as

$$
\begin{aligned}
W^L(k, b, \psi, \varepsilon_i; \mu) = {}& p\left((1-\tau^c)(z\varepsilon f(k,n) - wn) - b + (1-\tau^c\omega)(1-\delta)k + \tau^c\delta^\psi\psi\right) \\
& + \max_{k' \le (1-\delta)k+\bar{I}} \left\{ -p(1-\tau^c\omega)k' + \beta\sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon W^0(k', 0, \psi', \varepsilon_j; \mu') \right\},
\end{aligned}
$$

$$
\begin{aligned}
W^H(k, b, \psi, \varepsilon_i; \mu) = {}& p\left((1-\tau^c)(z\varepsilon f(k,n) - wn) - b + (1-\tau^c\omega\xi)(1-\delta)k + \tau^c\delta^\psi\psi\right) \\
& + \max_{k' \in ((1-\delta)k+\bar{I}, \bar{k})} \left\{ -p(1-\tau^c\omega\xi)k' + \beta\sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon W^0(k', 0, \psi', \varepsilon_j; \mu') \right\},
\end{aligned}
$$

$$
\begin{aligned}
W^N(k, b, \psi, \varepsilon_i; \mu) = {}& p\left(z\varepsilon f(k,n) - wn - b + (1-\delta)k\right) \\
& + \max_{k' \ge \bar{k}} \left\{ -pk' + \beta\sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon W^0(k', 0, \psi', \varepsilon_j; \mu') \right\},
\end{aligned}
$$

Unconstrained firms' problem when taxable income is nonpositive

The following question defines the lower bound for capital when the firms are having zero or negative taxable income:

$$W^N(k, b, \psi, \varepsilon_i; \mu) = p(y - wn - b + (1-\delta)k) + \max_{k'} \left\{ -pk' + \beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon W^0(k', 0, \psi', \varepsilon_j; \mu') \right\},$$

where

$$\psi' = (1 - \delta^\psi)\psi + (1 - \mathcal{J}(I))\omega I \qquad \text{if } (y - wn - \mathcal{J}(I)\omega I - \delta^\psi\psi) \geq 0$$
$$\psi' = \psi + \omega I - y + wn \qquad\qquad \text{if } (y - wn - \mathcal{J}(I)\omega I - \delta^\psi\psi) < 0$$

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, $K^w(k, \psi, \varepsilon)$,

$$B^w(k, \psi, \varepsilon) = \min_{\varepsilon_j} \left(\tilde{B}(K^w(k, \psi, \varepsilon_i), \psi', \varepsilon_j) \right)$$

$$\tilde{B}(k, \psi, \varepsilon_i) = \frac{1}{1 - \tau^c \tau^b} \Big((1 - \tau^c) \pi(k, \varepsilon_i) + \tau^c \delta^\psi \psi$$
$$- (1 - \tau^c \omega \mathcal{J} \left(K^w(k, \psi, \varepsilon_i) - (1 - \delta)k \right)) \left(K^w(k, \psi, \varepsilon_i) - (1 - \delta)k \right)$$
$$+ q \min \left\{ B^w(k, \psi, \varepsilon_i), \theta K^w(k, \psi, \varepsilon_i) \right\} \Big),$$

I set interest deductability $\tau^b = 0$ as minimum saving policy cannot converge with positive τ^b. As $\frac{1}{q}$ is the risk-free rate, firms are paying $\frac{q}{1 - \tau^c \tau^b} > q$, implies the interest rate that firms are paying is less than risk-free rate.

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Constrained firms' problem

Constrained firms' bond decision is implied by binding collateral constraints, i.e.,
$B^c(k, b, \psi, \varepsilon) = \theta K^c(k, b, \psi, \varepsilon)$, and the capital decision $K^c(k, b, \psi, \varepsilon)$ has to be determined recursively.

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

and J^H, J_L and J_N are defined as

Constrained firms' problem: invest higher than threshold

$$J^H(k, b, \psi, \varepsilon; \mu) = \max_{k' \in \Omega_H(k,b,\psi,\varepsilon)} \beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon V^0(k', b_H^2(k'), \psi', \varepsilon_j; \mu'),$$

subject to

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

$$\psi' = (1-\delta^\psi)\psi + (1-\xi)(k'-(1-\delta)k),$$

The choice sets for *H*-type firms' problem are defined by

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

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

Constrained firms' problem: invest lower than threshold

$$J^L(k, b, \psi, \varepsilon; \mu) = \max_{k' \in \Omega_L(k, b, \psi, \varepsilon)} \beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon V^0(k', b_L^2(k'), \psi', \varepsilon_j; \mu'),$$

subject to

$$b_L(k') = \frac{1}{q}\Big(-(1 - \tau^c)\pi(k, \varepsilon) + b - \tau^c \delta^\psi \psi + (1 - \tau^c \omega)(k' - (1 - \delta)k)\Big),$$

$$\psi' = (1 - \delta^\psi)\psi.$$

Choice set: $\Omega_L(k, b, \psi, \varepsilon) = \Big[0, \max\Big\{0, \min\Big\{(1 - \delta)k + \bar{I}, \bar{k}_L(k, b, \psi, \varepsilon)\Big\}\Big\}\Big]$,

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

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When taxable income is negative for constrained firms

$$J^N(k, b, \psi, \varepsilon; \mu) = \max_{k' \in \Omega^N(k,b)} \beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon V^0(k', b_N(k'), \psi', \varepsilon_j; \mu')$$

subject to

$$b_N(k') = -\frac{1}{q} \left(z\varepsilon f(k, n) - wn - b - (k' - (1-\delta)k) \right)$$

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

$$\Omega^N(k, b, \varepsilon) = \left[\min\left\{ \max\left\{ \bar{k}, 0 \right\}, \bar{k}_N(k, b, \varepsilon) \right\}, \bar{k}_N(k, b, \varepsilon) \right]$$

$$\bar{k}_N(k, b, \varepsilon) = \frac{z\varepsilon f(k, n) - wn - b + (1-\delta)k}{1 - q\theta}$$

When taxable income is nonpositive

- In principle, IRS will not give tax subsidy if taxable income is negative.

- User cost of capital for firms with nonpositive taxable income is not affected by deduction.

- Solving for $\mathcal{I} \geq 0$ gives the upper threshold for capital decision that pays corporate tax:

$$k' \leq \bar{k} \equiv \min\left(\frac{z\varepsilon f(k,n) - wn - \delta^{\psi}\psi}{\xi\omega} + (1-\delta)k, \mathbf{K}_{max}\right),$$

Assume $F(k,n) = k^{\alpha}n^{\nu}$, I solve for $\bar{k} = (1-\delta)k + \bar{I}$ and get,

$$\tilde{k} \equiv \left(\frac{\delta^{\psi}\psi + \xi\omega\bar{I}}{A(w)z^{\frac{1}{1-\nu}}\varepsilon^{\frac{1}{1-\nu}}}\right)^{\frac{1-\nu}{\alpha}}$$

Firms that invest higher than threshold

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

subject to

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

$$k' \in ((1-\delta)k + \bar{I}, \bar{k}) \text{ and } k > \tilde{k} \qquad \text{(Choice Sets)}$$

$$b' \le \theta k' \qquad \text{(Collateral)}$$

$$\psi' = (1-\delta^\psi)\psi + (1-\xi)\omega(k'-(1-\delta)k) \qquad \text{(deductible stock LoM)}$$

$$\mu' = \Gamma(\mu) \qquad \text{(Distribution LoM)}$$

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Firms that invest lower than threshold

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

subject to

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

$$k' \le (1 - \delta)k + \bar{I} \text{ and } k > \hat{k} \qquad \text{(Choice Sets)}$$

$$b' \le \theta k' \qquad \text{(Collateral)}$$

$$\psi' = (1 - \delta^\psi)\psi \qquad \text{(Tax Benefit LoM)}$$

$$\mu' = \Gamma(\mu) \qquad \text{(Distribution LoM)}$$

Firms not paying corporate tax

$$v^N(k, b, \psi, \varepsilon_i; \mu) = \max_{D, k', b', n} D + \sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon Q(\mu) v^0(k', b', \psi', \varepsilon_j; \mu'), \qquad (2)$$

subject to

$$0 \leq D = z\varepsilon F(k, n) - wn - b + qb' - (k' - (1-\delta)k) \qquad \text{(Dividend)}$$

$$k' \geq \max(\bar{k}, 0) \qquad \text{(Choice Sets)}$$

$$b' \leq \theta k' \qquad \text{(Collateral)}$$

$$\psi' = (1 - \delta^\psi)\psi + (1 - \mathcal{J}(k', k))\omega(k' - (1-\delta)k) \qquad \text{(Tax Benefit LoM)}$$

$$\mu' = \Gamma(\mu) \qquad \text{(Distribution LoM)}$$

Household

In each period, representative households maximize their lifetime utility by choosing consumption, c, labor supply, n^h, future firm shareholding, λ', and future bond holding, a':

$$V^h(\lambda, a; \mu) = \max_{c, n^h, a', \lambda'} \left\{ u(c, 1 - n^h) + \beta V^h(\lambda', a'; \mu') \right\}$$

$$\text{s.t.} \quad c + q(\mu)a' + \int \rho_1(k', b', \psi', \varepsilon'; \mu) \lambda'(d[k' \times b' \times \psi' \times \varepsilon']) \leq (1 - \tau^n)w(\mu)n^h, \quad (3)$$

$$+ a + \int \rho_0(k, b, \psi, \varepsilon; \mu) \lambda(d[k \times b \times \psi \times \varepsilon]) + R - T$$

where $\rho_0(k, b, \psi, \varepsilon)$ is the dividend-inclusive price of the current share, $\rho_1(k', b', \psi', \varepsilon')$ is the ex-dividend price of the future share, τ^n is payroll tax, R is the steady state government lump-sum rebates to households, and T is lump-sum tax to fund policy changes.

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Equilibrium

$$\text{Market clear}: \quad Y = C + \left[(1 - \pi_d)\left(K' - (1-\delta)K\right) - \pi_d(1-\delta)K \right] + \pi_d k_0 + \bar{G}$$

$$\text{Output}: \quad Y = \int z\varepsilon F(k, n(k, \varepsilon))d\mu$$

$$\text{Capital}: \quad K = \int k\, d\mu$$

$$\text{Labor}: \quad N^h = N, \text{ where } N = \int n(k, \varepsilon)d\mu$$

$$\text{Taxable capital}: \quad \Psi = \int \psi(k, \psi, \varepsilon)d\mu$$

$$\text{Debt}: \quad B = \int b\, d\mu$$

$$\text{Corp. revenue}: \quad R = \tau^c \left(Y - w(\mu)N - \omega \mathcal{J}(I)(K' - (1-\delta)K) - \delta^\psi \Psi \right)$$

$$\text{Gov. Budget}: \quad \bar{G} = \tau^n w N^h + R + T$$

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Household Optimality Conditions

- After-tax wage fully compensate MRS between leisure and consumption:

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

With $u(c, 1-n^h) = \log c + \varphi(1-n^h)$, implied Frisch elasticity is ∞,

$$w(\mu) = \frac{\varphi c}{(1-\tau^n)}$$

- As there's no agg. shock, SDF equals discounting factor equals to bond prices

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

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Exogenous Parameters

	Parameter	Value	Reason
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)

Frequency and Functional Form

- Model frequency: annual

- Household utility function: $u(c, n^h) = \log c + \varphi(1 - n^h)$

- Production function: $F(k, n) = k^\alpha n^\nu$

- Initial capital for entrants: $k_0 = \chi \int k \tilde{\mu}(d[k \times b \times \psi \times \varepsilon])$

- Initial bond and taxable capital: $b_0 = 0$ and $\psi_0 = 0$

- Idiosyncratic productivity shock: $\log \varepsilon' = \rho_\varepsilon \log \varepsilon + \eta'_\varepsilon$, $\eta_\varepsilon \sim N(0, \sigma_\varepsilon^2)$
  - 7-state Markov chain discretized using Tauchen algorithm

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Unproductive firm: similar to standard model ($\varepsilon = 0.7847$)
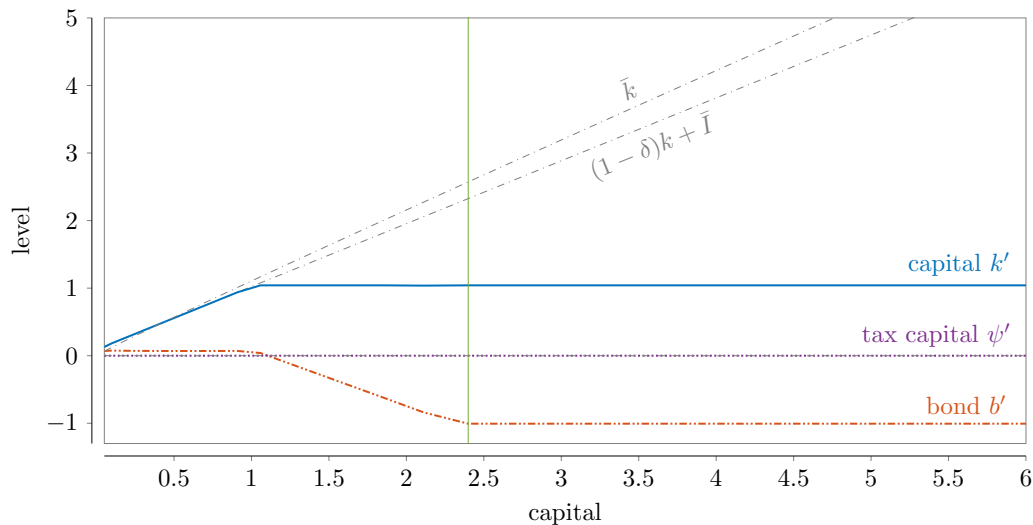
Steady State Comparison

	Description	baseline	S179	bonus	both
$\tilde{T}/Y$	cost of policy / baseline output	-	0.30	0.31	0.42
Y	aggregate output	100 (0.54)	101.61	101.06	102.00
C	aggregate consumption	100 (0.36)	101.55	100.92	101.91
K	aggregate capital	100 (1.10)	104.22	103.21	105.30
I	aggregate investment	100 (0.08)	104.22	103.21	105.30
N	aggregate labor	100 (0.33)	100.06	100.13	100.09
$B > 0$	aggregate debt	100 (0.41)	106.35	113.01	112.48
R	corporate tax revenue	100 (0.03)	94.25	94.08	91.89
$\hat{z}$	measured TFP	100 (1.02)	100.32	100.02	100.38
$dY/\tilde{T}$		-	5.40	3.44	4.74
$dC/\tilde{T}$		-	3.42	1.98	2.98
$dI/\tilde{T}$		-	1.98	1.46	1.76

Notes: output, capital, debt, labor, consumption, government spending, measured TFP are expressed as fractions of baseline value.

Steady State Comparison (Cont.)

	Description	baseline	S179	bonus	both
Prices					
p	marginal utility of consumption	100 (2.80)	98.47	99.08	98.13
w	wage	100 (0.97)	101.55	100.92	101.91
Distribution					
μ_{unc}	unconstrained firm mass	0.080	0.093	0.099	0.129
μ_{con}	constrained firm mass	0.920	0.907	0.901	0.871
$\mu_{\text{unc}}K$	capital: unconstrained	100 (2.70)	94.31	99.78	92.51
$\mu_{\text{con}}K$	capital: constrained	100 (0.96)	104.36	100.39	100.03
$\mu_{\text{unc}}I$	investment: unconstrained	100 (0.01)	170.53	7.04	102.47
$\mu_{\text{con}}I$	investment: constrained	100 (0.18)	102.29	106.01	105.38
Financial Variables					
D	dividend	100 (0.03)	102.08	110.14	115.64
$\mu V(\cdot)$	average firm value	100 (3.41)	98.02	94.13	95.35
μc	user cost of capital	100 (0.14)	86.26	97.44	85.45
τ^*	effective corporate tax rate	100 (0.10)	92.43	94.08	91.68

Capital choice state space
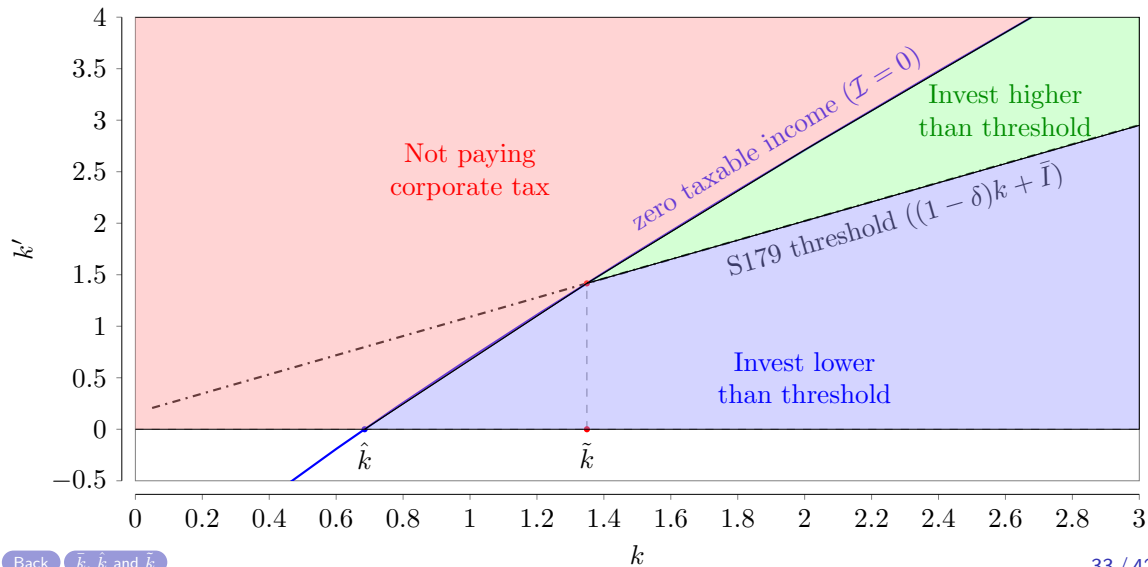
Investment Response to raising bonus depreciation

Tax term: $\frac{1-\tau^c\omega\xi}{1-\tau^c}$; Elasticity: $\frac{\%\Delta\text{Investment at bin}}{\%\Delta\text{tax term}}$

Size-dependent investment response
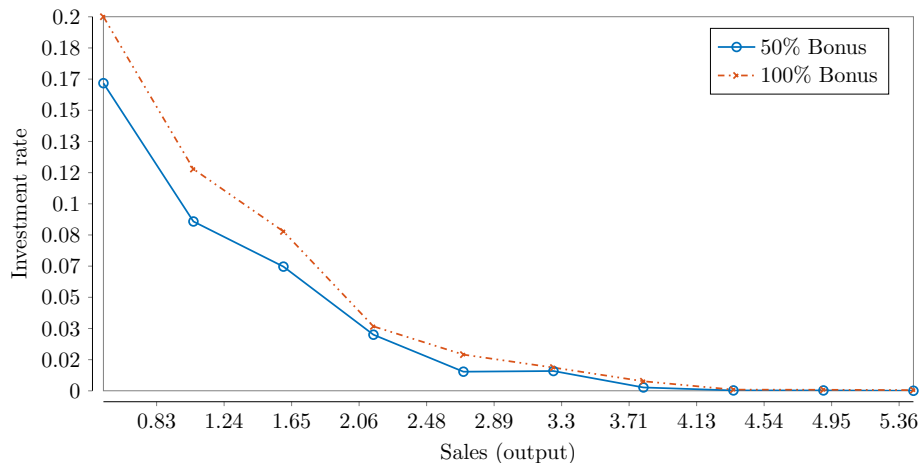
Private excess return on capital

N-type firms:

$$
\beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon \left[\frac{\partial V^0(k', b', \psi', \varepsilon_j; \mu)}{\partial k'} + \frac{\partial V^0(k', b', \psi', \varepsilon_j; \mu)}{\partial \psi'} \frac{\partial \psi'}{\partial k'} \right] - 1
$$

H-type firms:

$$
\beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon \left[\frac{\partial V^0(k', b', \psi', \varepsilon_j; \mu)}{\partial k'} + \frac{\partial V^0(k', b', \psi', \varepsilon_j; \mu)}{\partial \psi'} \frac{\partial \psi'}{\partial k'} \right] - (1 - \tau^c \omega \xi)
$$

L-type firms:

$$
\beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^\varepsilon \left[\frac{\partial V^0(k', b', \psi', \varepsilon_j; \mu)}{\partial k'} + \frac{\partial V^0(k', b', \psi', \varepsilon_j; \mu)}{\partial \psi'} \frac{\partial \psi'}{\partial k'} \right] - (1 - \tau^c \omega)
$$

Approximating the derivatives of the value functions

I use RHS and LHS secant to approximate the derivatives of the value functions.

Let $i_\varepsilon = 1, \ldots, N(\varepsilon)$, $i_b = 1, \ldots, N(b)$, $i_k = 1, \ldots, N(k)$ and $i_\psi = 1, \ldots, N(\psi)$.

RHS secant at $(k_{i_k}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon})$, $i_k = 1, \ldots, N(k) - 1$ is

$$s_r(k_{i_k}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon}) = \frac{V^0(k_{i_k+1}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon}) - V^0(k_{i_k}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon})}{k_{i_k+1} - k_{i_k}}$$

LHS secant at $(k_{i_k}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon})$, $i_k = 2, \ldots, N(k)$ is

$$s_l(k_{i_k}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon}) = \frac{V^0(k_{i_k}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon}) - V^0(k_{i_k-1}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon})}{k_{i_k} - k_{i_k-1}}$$

Approximating the derivatives of the value functions (Cont.)

When $i_k = 2, \ldots, N(k) - 1$,

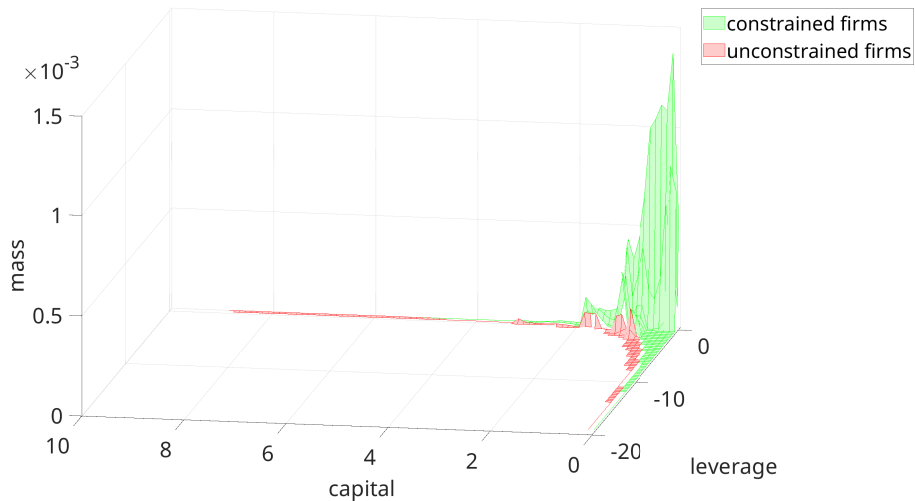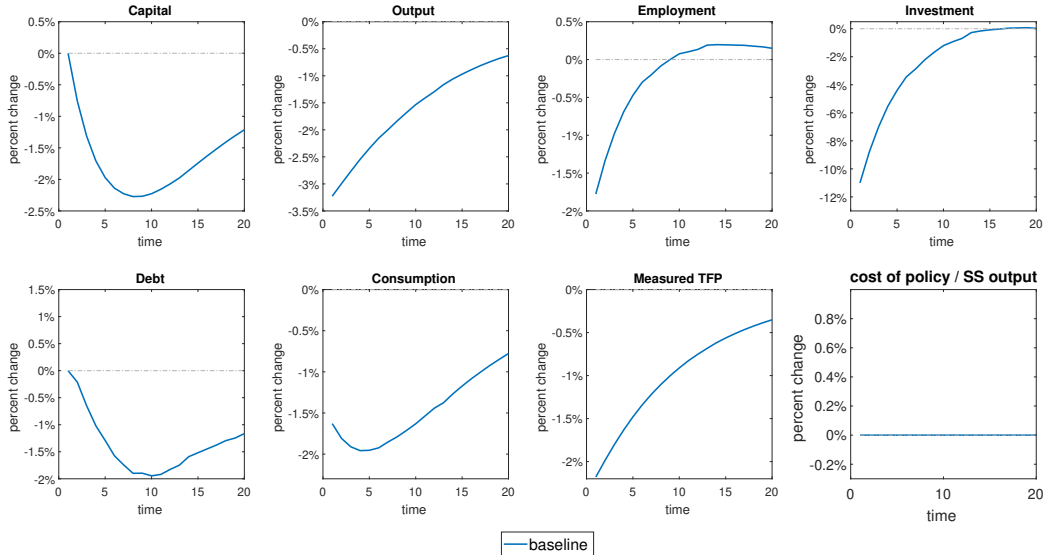$$D_k V^0(k_{i_k}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon}) = 0.5 s_r(k_{i_k}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon}) + 0.5 s_l(k_{i_k}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon})$$

When $i_k = 1$,

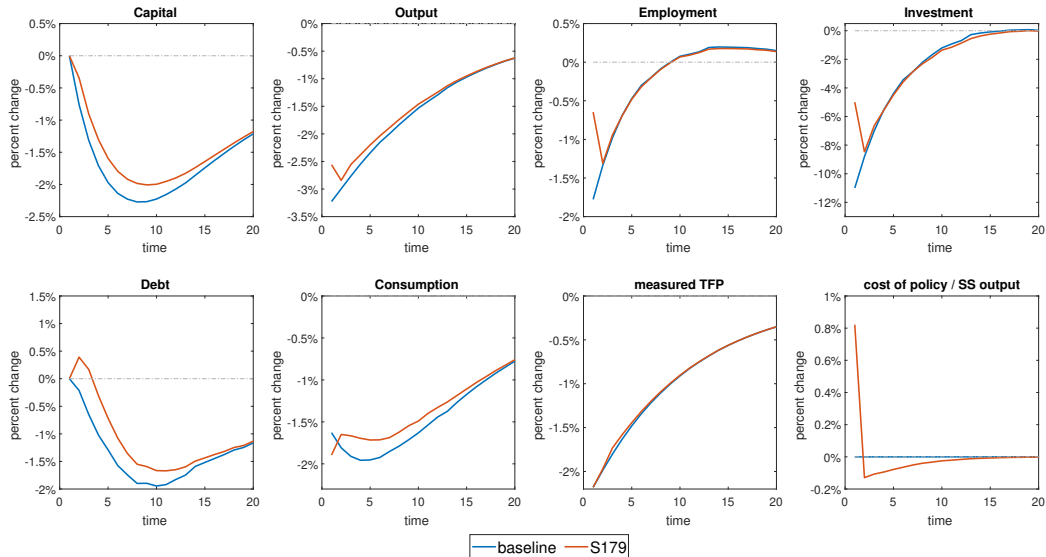$$D_k V^0(k_{i_k}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon}) = s_r(k_{i_k}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon})$$

When $i_k = N(k)$,

$$D_k V^0(k_{i_k}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon}) = s_l(k_{i_k}, b_{i_b}, \psi_{i_\psi}, \varepsilon_{i_\varepsilon})$$

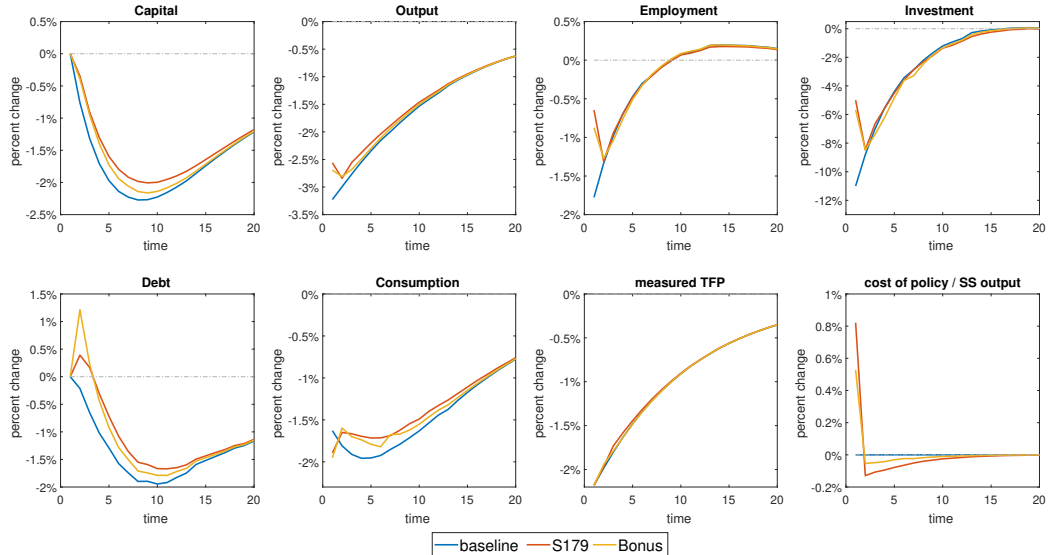# Distribution: median productivity
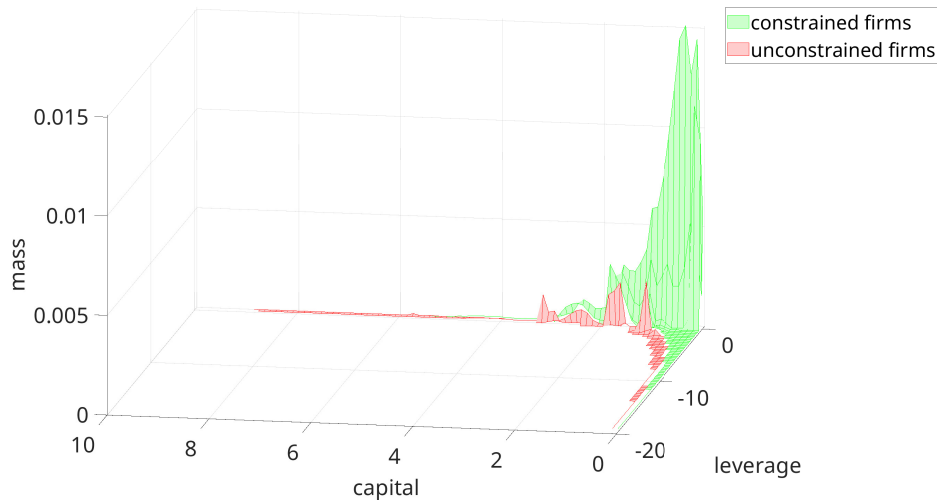
Distribution: minimum productivity

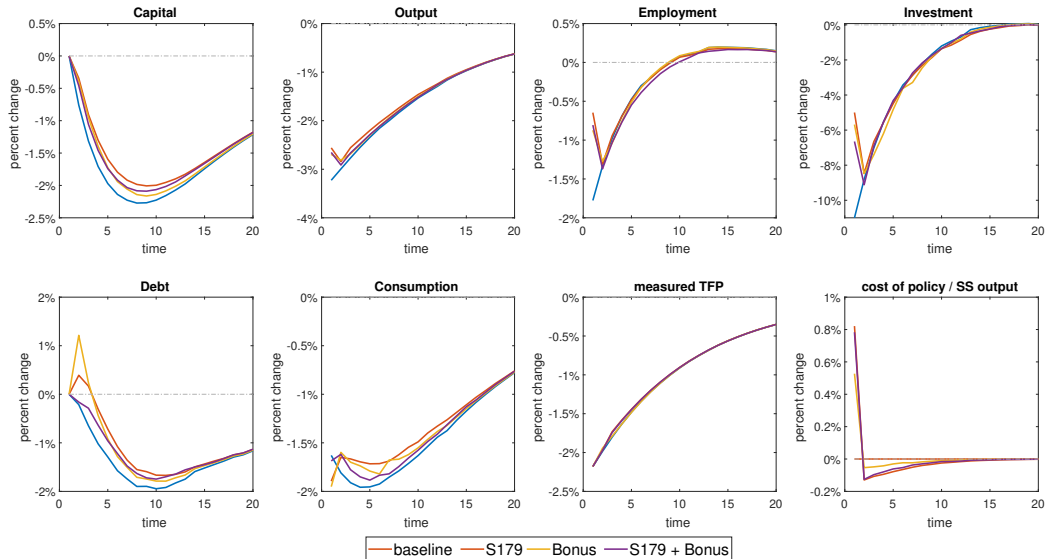# IRF: negative TFP shocks with scale 2.18% and persistence 0.909
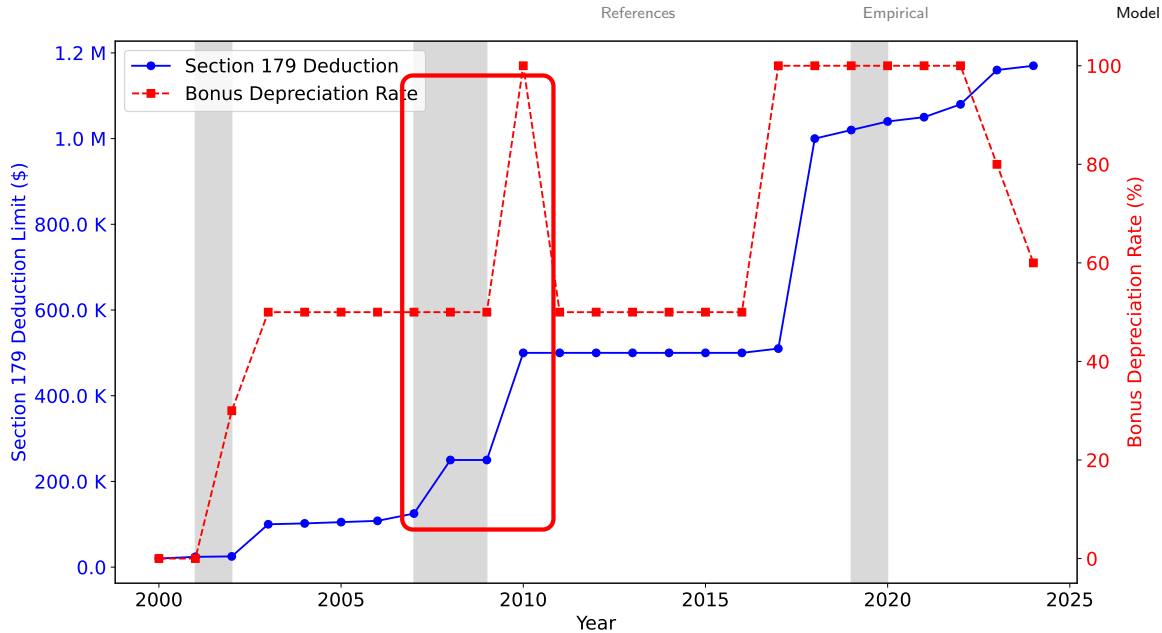

baseline

IRF: negative TFP shocks with scale 2.18% and persistence 0.909

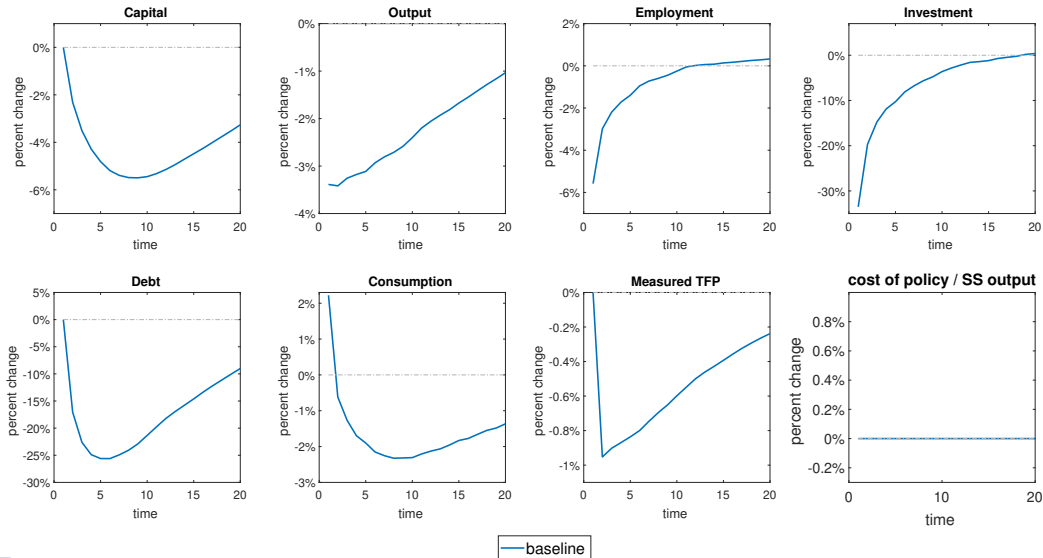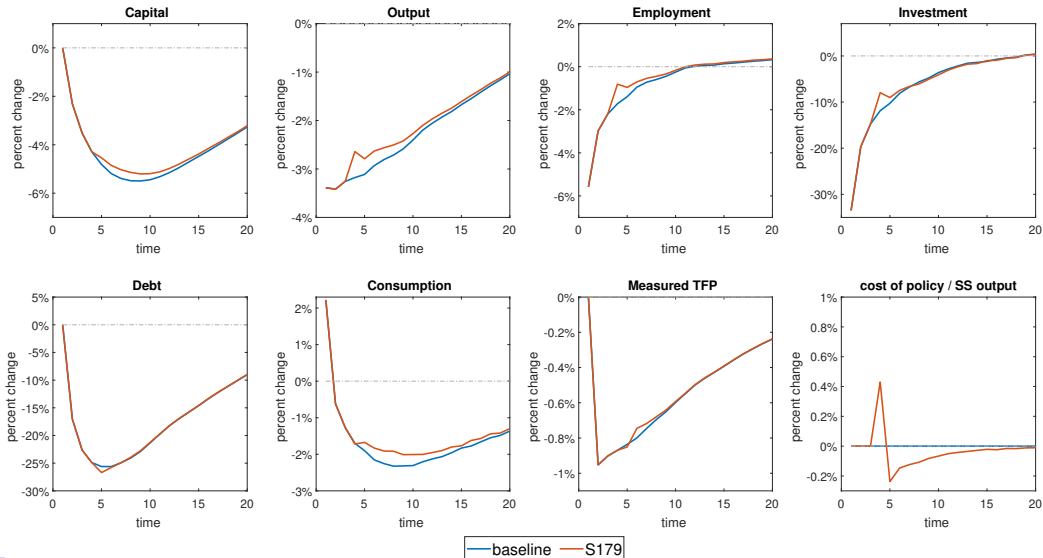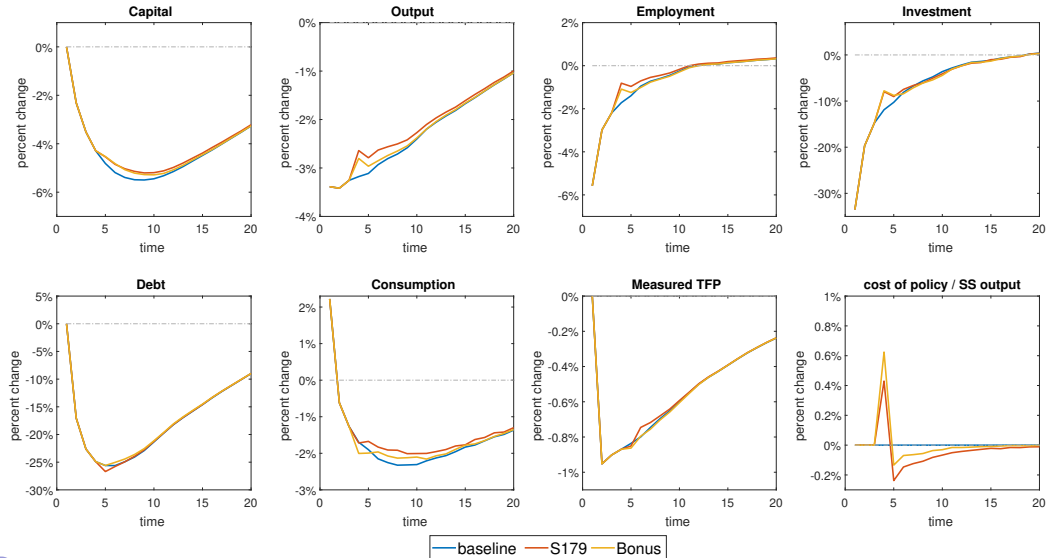# IRF: negative TFP shocks with scale 2.18% and persistence 0.909

baseline — S179 — Bonus

IRF: negative TFP shocks with scale 2.18% and persistence 0.909

baseline ── S179 ── Bonus ── S179 + Bonus

IRF: negative credit shocks with scale 27% and persistence 0.909

baseline

IRF: negative credit shocks with scale 27% and persistence 0.909

baseline   S179

Back

IRF: negative credit shocks with scale 27% and persistence 0.909

baseline ── S179 ── Bonus

IRF: negative credit shocks with scale 27% and persistence 0.909

baseline —— S179 —— Bonus —— S179 + Bonus

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