

Tax Policy and Capital Maintenance

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When Tax Cuts Raise Investment, How Much Does Capital Grow?



The Canonical Hall and Jorgenson (1967) Model

Firms choose investment to maximize the value of after-tax dividends:

$$\max_{\{I_t, K_{t+1}\}} \sum_{t=0}^{\infty} (1+r)^{-t} \left[(1-\tau^c)F(K_t) - p^I(1-\tau^c z - c)I_t \right]$$

subject to

$$K_{t+1} = I_t + (1-\delta)K_t$$

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In steady state:

$$F'(K) = p^I(r+\delta) \frac{1-\tau^c z - c}{1-\tau^c} \equiv \Psi^{\text{HJ}}$$

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$$\varepsilon_{I,\tau} = \varepsilon_{K,\tau}$$

How does maintenance change the effects of tax reform?

Two Ways to Adjust the Capital Stock: Investment and Maintenance

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Maintenance Makes Capital Less Responsive to Tax Cuts

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Proposition

1. For $\delta(m) = \delta$, user cost is higher and the optimal capital stock is lower.
2. Define the maintenance share of user cost as $s_m \equiv p^M m / \Psi$. By the envelope theorem,

$$\varepsilon_{K,\tau} = (1 - s_m) \varepsilon_{K,\tau}^{\text{HJ}}$$

Capital's response to tax reform is attenuated by the maintenance share.

Investment Responds More Than Capital to Tax Cuts

$$-\delta'(m) = \frac{p^M(1 - \tau^c)}{p^I(1 - \tau^c z - c)}$$

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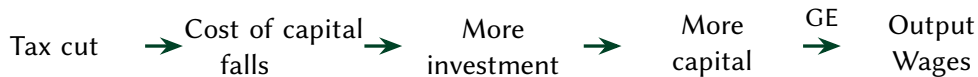
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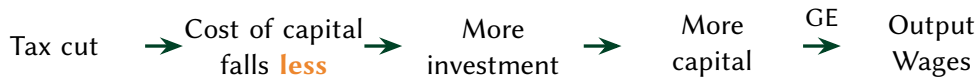
Tax policy affects capital and depreciation through investment and maintenance:

$$|\varepsilon_{I,\tau}| = |\varepsilon_{K,\tau}| + |\varepsilon_{\delta,\tau}| \quad \Rightarrow \quad |\varepsilon_{I,\tau}| > |\varepsilon_{K,\tau}|$$

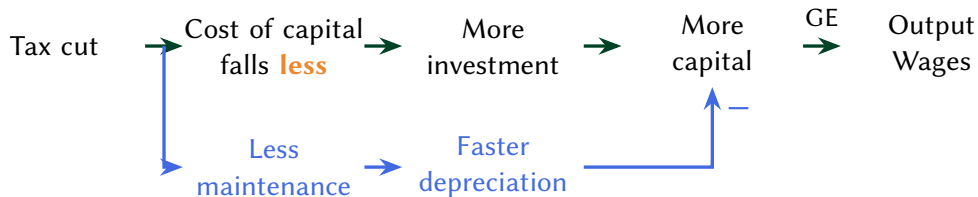
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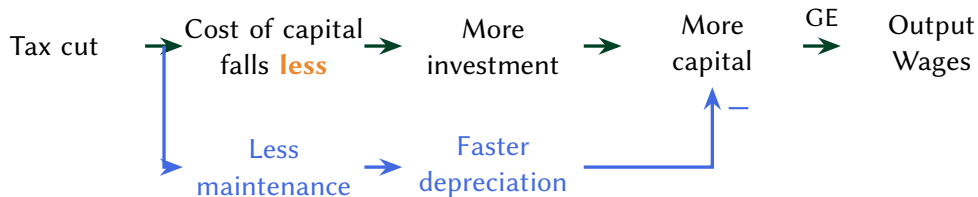
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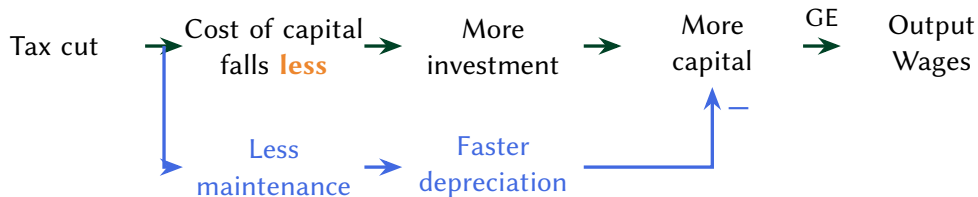
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- **Maintenance share of user cost**, $s_m \Rightarrow$ governs the attenuation of capital's tax elasticity: $\varepsilon_{K,\tau} = (1 - s_m)\varepsilon_{K,\tau}^{HJ}$.

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- **Maintenance share of user cost**, $s_m \Rightarrow$ governs the attenuation of capital's tax elasticity: $\varepsilon_{K,\tau} = (1 - s_m)\varepsilon_{K,\tau}^{HJ}$.
- **Maintenance demand elasticity**, $\omega \Rightarrow$ governs the capital-investment elasticity gap: $|\varepsilon_{I,\tau}| - |\varepsilon_{K,\tau}|$.

Maintenance in the Data

Statistics of Income (SOI)

Form 1120 Department of the Treasury Internal Revenue Service	U.S. Corporation Income Tax Return	OMB No. 1545-0123
	For calendar year 2017 or tax year beginning _____, 2017, ending _____, 20 _____ ▶ Go to www.irs.gov/Form1120 for instructions and the latest information.	2017

13 Salaries and wages (less employment credits)

14 Repairs and maintenance

15 Bad debts

- Repeated cross-section of nationally representative industry-level IRS data
- Frequently used to study *investment* elasticity (Zwick and Mahon 2017)
- Data contain samples of *All Firms*, *Taxable Firms*, and *Untaxable Firms*
- May understate maintenance expenditures: wages may be reported on line 13

Regulatory Filings of R-1 Freight Railroads

Name of railway operating expense account (a)	Salaries & Wages (b)	Material, tools, supplies, fuels, & lubricants (c)	Purchased services (d)
FREIGHT CARS			
Administration	10,852	2,515	3,289
Repair & maintenance	82,145	224,455	84,906

Union Pacific, 2022 R-1, Schedule 410: freight car maintenance (\$ thousands)

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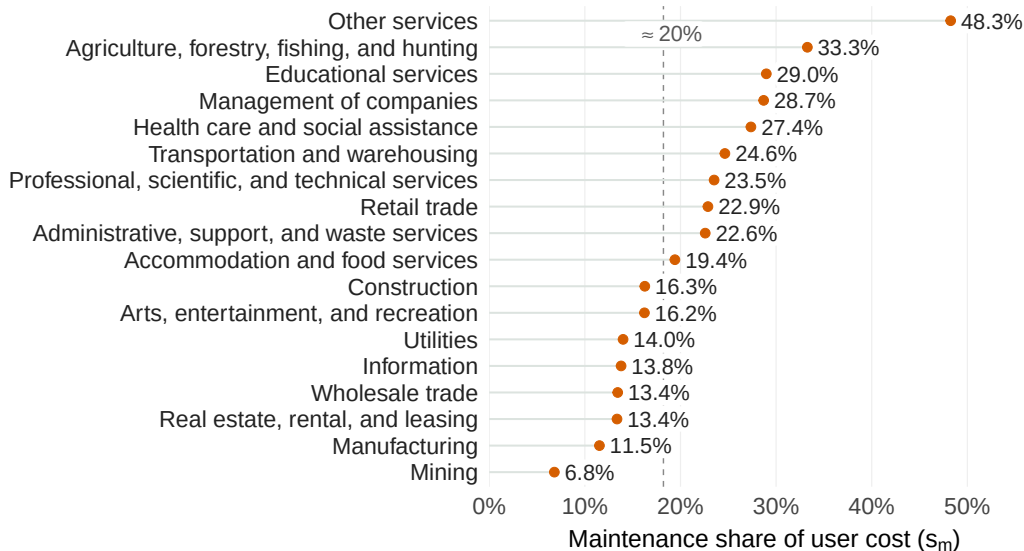
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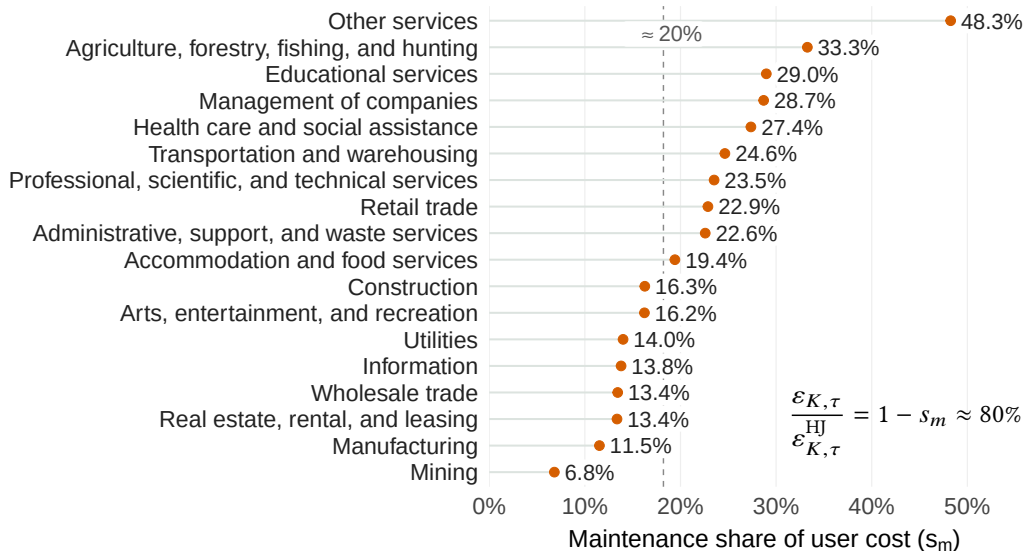
- Large freight railroads are required to file R-1 reports with the Surface Transportation Board
 - I digitize reports for all firms from 1999–2023 $\Rightarrow$ First use since Bitros (1976)
- Focus on locomotives and freight cars, observing maintenance expenditures, investment, and capital stocks for each asset type
- Construct firm-by-asset maintenance rates M/K for total, internal, and external maintenance, with associated relative prices $p_{i,j,t}^M/p_{j,t}^I$

Estimating the *Maintenance* Share of User Cost

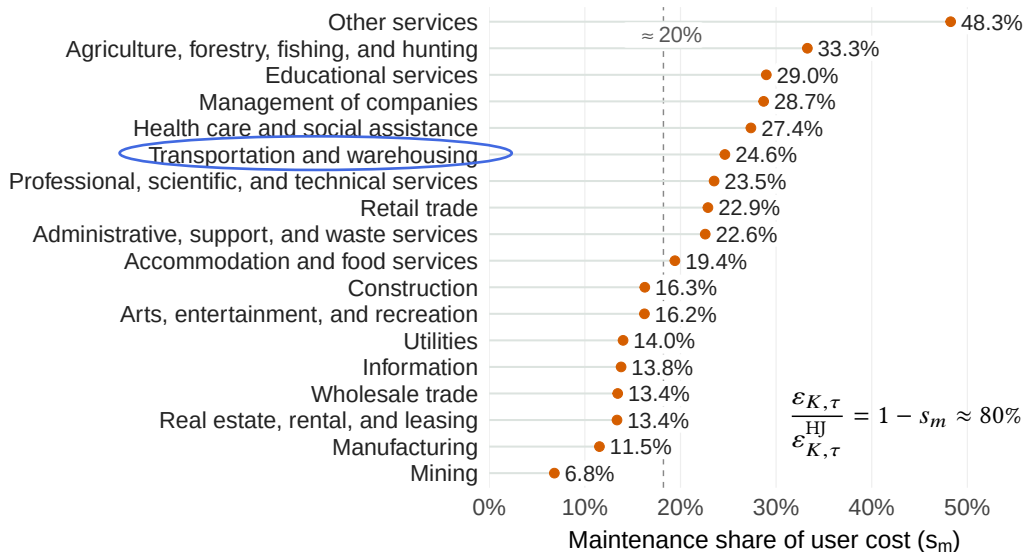
The Maintenance Share of User Cost by Broad Industry



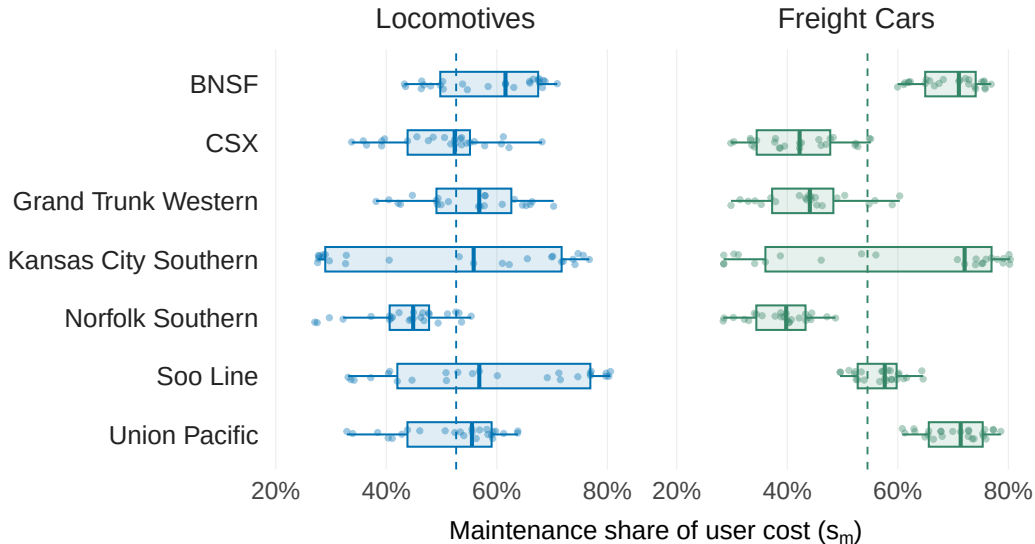
The Maintenance Share of User Cost by Broad Industry



The Maintenance Share of User Cost by Broad Industry



The Maintenance Share of User Cost in Railroad Equipment



Estimating the Maintenance Demand Elasticity

Estimating the Maintenance Demand Elasticity ω

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$$\Rightarrow \log m = \log \gamma - \omega \log \left[\frac{p^M}{p^I} \frac{1 - \tau^c}{1 - \tau^c z - c} \right] + u$$

Estimate ω using relative prices p^M/p^I in R-1 and the tax term $\frac{1-\tau^c}{1-\tau^c z - c}$ in SOL.

Identifying ω in the SOI Data

Identification: DiD with continuous exposure to bonus depreciation

$$\log m_{i,t} = \alpha_i + \lambda_t - \omega \log \left[\frac{1 - \tau_t^c}{1 - \tau_t^c z_{i,t}} \right] + \text{Controls} + \varepsilon_{i,t}$$

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Bonus exposure $z_{i,t}$ varies depending on industry i 's pre-reform asset composition (Zwick and Mahon, 2017).

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Identifying Assumption

Conditional on fixed effects and controls, absent the tax reforms, maintenance would have followed parallel trends across industries with different exposure.

Identifying ω in the R-1 Data

Identification: Shift-share IV

$$\log m_{i,j,t} = \kappa_{ij} + \lambda_t - \omega \log \left[\frac{p_{i,j,t}^M}{p_{j,t}^I} \frac{1 - \tau_{i,t}^c}{1 - \tau_{i,t}^c z_t} \right] + \text{Controls} + u_{i,j,t}$$

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Instrument: Lagged labor intensity $\times$ state wage shocks

$$Z_{i,j,t} = \underbrace{\frac{\text{Labor}_{i,j,t-2}}{\text{Internal Maintenance}_{i,j,t-2}}}_{\text{pre-determined}} \times \underbrace{\sum_s \frac{\text{Rail Miles}_{i,s,t}}{\text{Rail Miles}_{i,t}} W_{s,t}}_{\text{exogenous shifts}}$$

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Identifying Assumption

Conditional on fixed effects and controls, the instrument affects maintenance only through the relative price of maintenance.

Estimates of the Maintenance Demand Elasticity

	SOI		
	All	Taxable	Untaxable
$\hat{\omega}$	2.71** (1.04)	3.16*** (1.13)	-0.09 (1.70)
Fixed effects	Industry and year		
Controls	Capital age, NAICS trends		
Observations	1,113	1,051	1,049

Standard errors in parentheses, clustered by industry (SOI) and firm (R-1).

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

► SOI robustness

► Event study

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AR 95% CI				[3.0, 8.4]	[3.8, 12.1]	[-7.0, 11.0]
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Maintenance and the 2017 Tax Cuts and Jobs Act

2017 Tax Cuts and Jobs Act (TCJA)

- Corporate tax rate declined from 35% to 21% and bonus depreciation for equipment increased from 50% to 100%.
- Chodorow-Reich et al. (2025) estimate a 7% increase in domestic capital in GE.

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- Chodorow-Reich et al. (2025) estimate a 7% increase in domestic capital in GE.
- Revisit this prediction allowing firms to adjust capital through both investment and maintenance.
- Compare aggregate outcomes in the post-reform steady states, starting from the same initial steady state.

Environment

- Representative firms in the corporate and passthrough sectors produce output:

$$F(K_s, L_s) = A_s K_s^{\alpha_K} L_s^{\alpha_L}.$$

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- Calibration: Use SOI estimates for (γ, ω) . Calibrate δ_0 and passthrough productivity A_{nc} jointly to match pre-reform I/Y and K_c/K .

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- **GE + crowding out:** [▶ Details](#) Interest rates rise with government debt.
 - Compute 2027 debt/GDP including each model's revenue feedback, then translate it into an interest rate increase using Plante, Richter, and Zubairy (2026).

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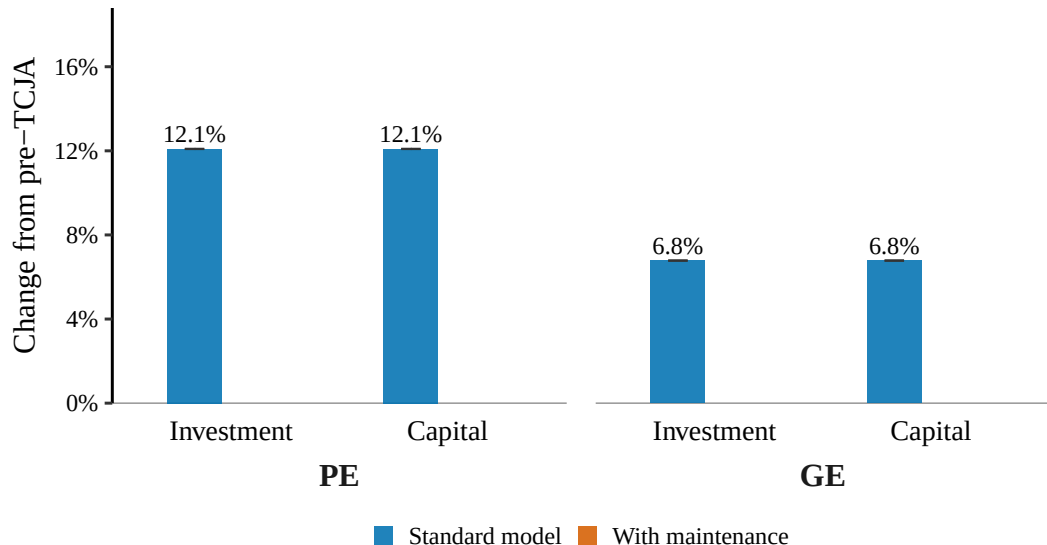
$$L_c + L_{nc} = 1.$$

- **GE + crowding out:** [Details](#) Interest rates rise with government debt.
 - Compute 2027 debt/GDP including each model's revenue feedback, then translate it into an interest rate increase using Plante, Richter, and Zubairy ([2026](#)).

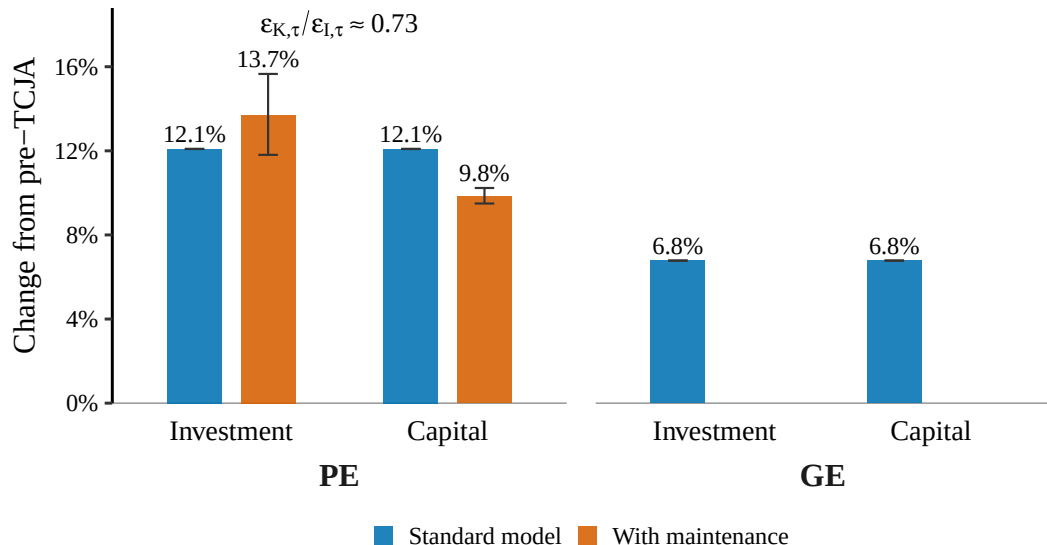
- **GE + maintenance sector:** [Details](#) Maintenance uses labor and materials:

$$L_c + L_{nc} + L_m = 1.$$

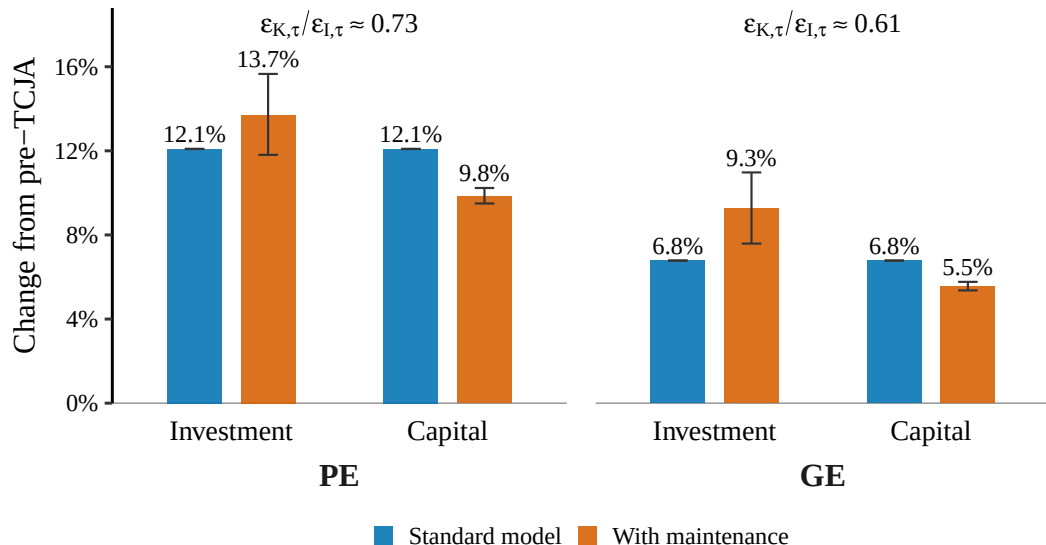
Investment Responds More Than Capital in Steady State



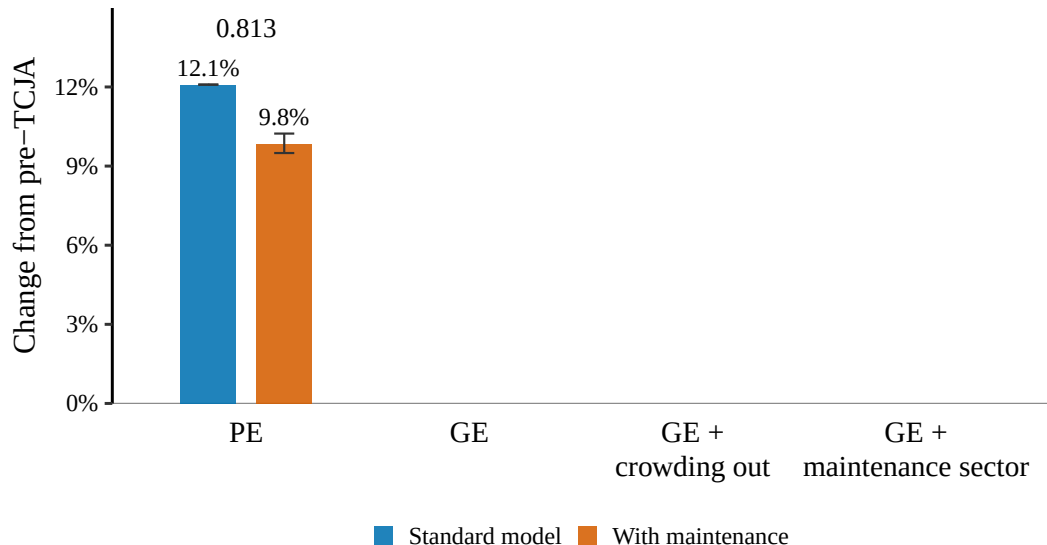
Investment Responds More Than Capital in Steady State



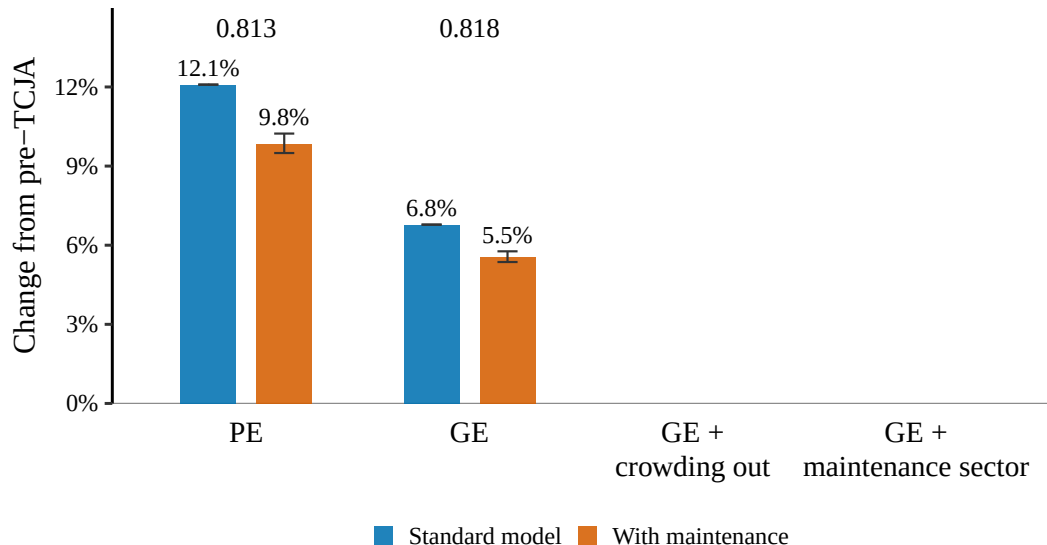
Investment Responds More Than Capital in Steady State



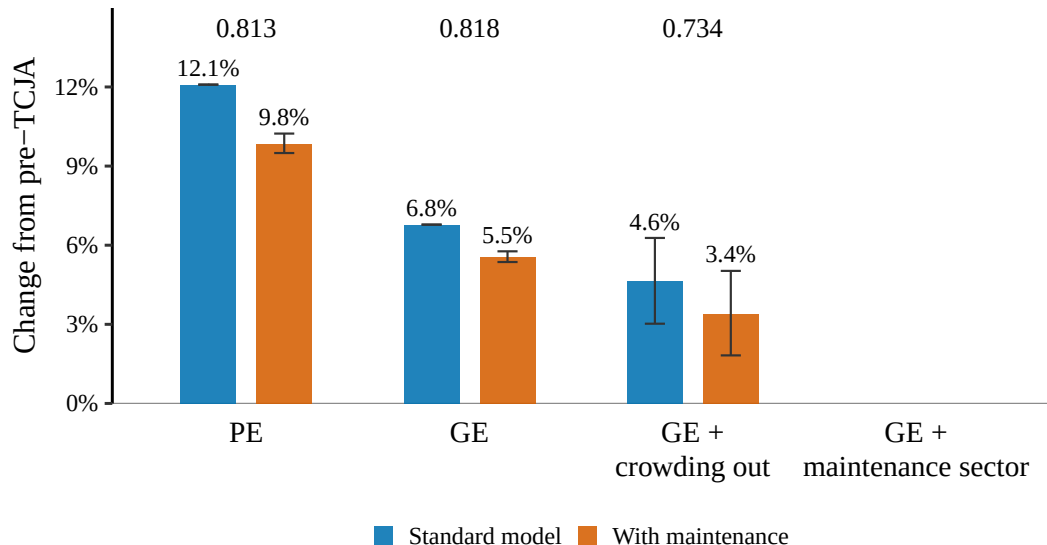
Maintenance Reduces Capital's Response Across Model Closures



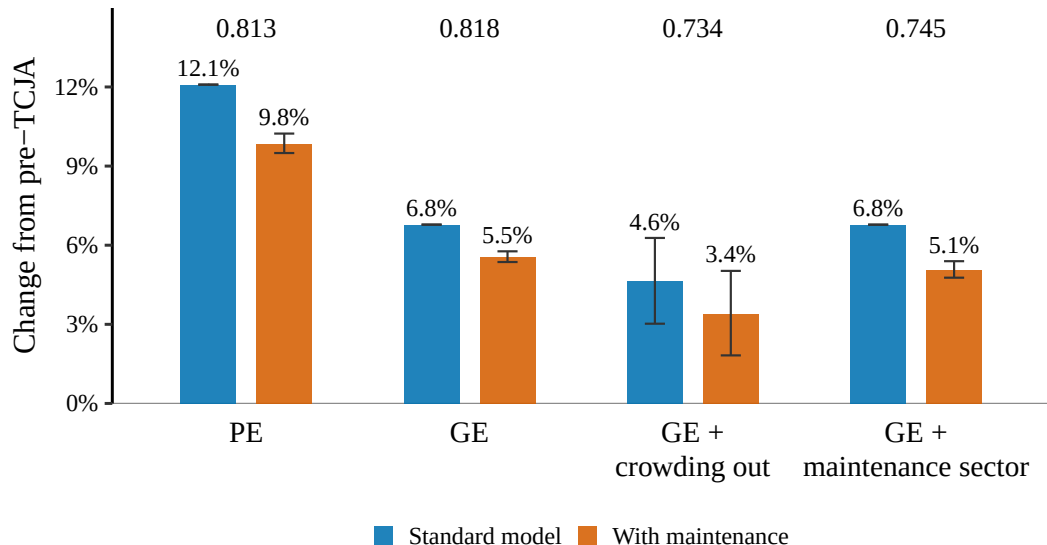
Maintenance Reduces Capital's Response Across Model Closures



Maintenance Reduces Capital's Response Across Model Closures



Maintenance Reduces Capital's Response Across Model Closures



Capital maintenance and repair...still too big to ignore

- In the TCJA exercise, capital's tax elasticity is **27–39% smaller than investment's**.
- Accounting for maintenance reduces the steady-state capital response by **19–27% across model closures**.
- These mechanisms apply across a wide class of investment models.

Capital maintenance and repair...still too big to ignore

- In the TCJA exercise, capital's tax elasticity is **27–39% smaller than investment's**.
- Accounting for maintenance reduces the steady-state capital response by **19–27% across model closures**.
- These mechanisms apply across a wide class of investment models.
- My broader agenda: How do business tax reforms shape the lifecycle of capital?
 - *Taxation and Reallocation in the Secondary Market for Capital Goods* shows, in the same vein as Gordon, Hines, and Summers (1987), that bonus depreciation reduces reallocation of capital.

Backup

R-1 Robustness

- Summary statistics
- Alternative specifications
- First-stage estimates
- Without controls
- Reduced form
- Dynamics
- Weak-IV inference
- Exposure-robust inference
- Prior maintenance
- Labor-share balance

SOI Robustness

- Specifications and samples
- Capital age and full estimates
- Identification diagnostics
- Bonus depreciation exposure
- Dynamics
- Taxable–untaxable contrast
- Investment weighting
- Canada comparison
- Labor expenditures
- Summary statistics

Constructing the Maintenance Share of User Cost

$$s_m = \frac{p^M(M/K)}{p^I(r + \delta) \frac{1 - \tau^c z - c}{1 - \tau^c} + p^M(M/K)}.$$

SOI

- $p^M(M/K)$: Reported repairs / lagged book capital
- p^I : BEA investment deflator
- r : Industry-specific (Gormsen and Huber 2022)
- δ : Capital-weighted BEA rates
- z : Capital-weighted depreciation allowances
- τ^c : Federal corporate tax rate

R-1

- $p^M(M/K)$: Total maintenance / lagged book capital
- p^I : BLS locomotive and freight car prices
- $r = 0.0713$: NAICS 48
- δ : 4% locomotives; 3% freight cars
- z : Seven-year MACRS and bonus depreciation
- τ^c : Firm-specific tax treatment

◀ Industry shares

◀ Railroad shares

▶ R-1 data

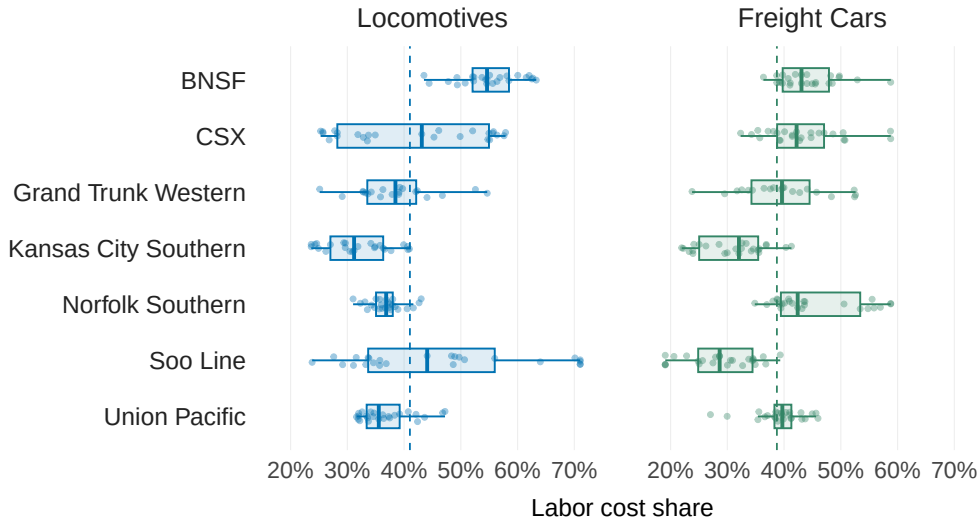
▶ SOI data

▶ Prices

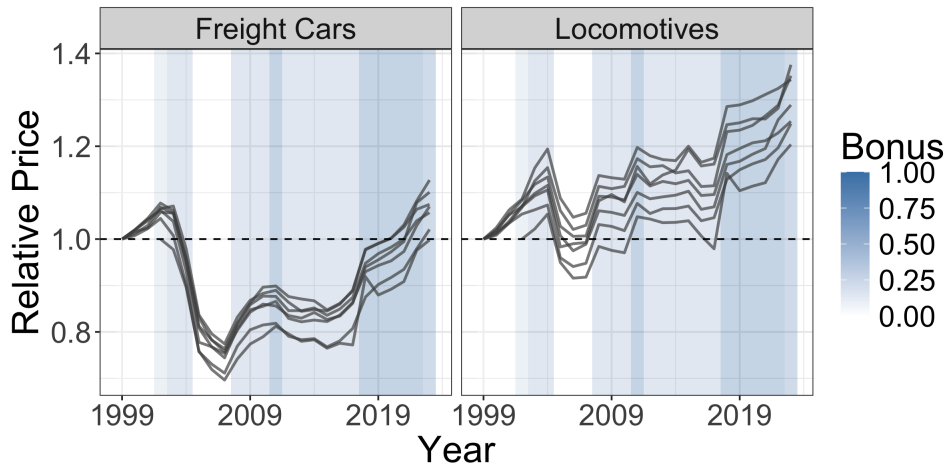
R-1 Maintenance and Investment Prices

- Internal maintenance combines firm-specific maintenance wages from Wage Form A&B with the BLS rolling-stock parts index.
 - Firm-asset labor and materials cost shares weight their price changes in a Törnqvist index.
- External maintenance prices use the expenditure-weighted internal price across railroads.
- Combine internal and external prices using each firm-asset's purchased-services share to construct the total maintenance price $p_{i,j,t}^M$.
- Investment prices $p_{j,t}^I$ come from the BLS locomotive and freight car series.

Maintenance Labor Shares in the R-1 Data



Relative Prices Vary Across Firms and Time



◀ Demand equation

◀ Price construction

◀ Identification

R-1 Summary Statistics: Locomotives

7 railroads, 1999–2023; 172 firm–asset–years per asset.

Variable	Mean	SD	Median	10th–90th	<i>N</i>
Maintenance rate	0.17	0.09	0.14	[0.07, 0.30]	172
Internal maintenance rate	0.11	0.07	0.09	[0.04, 0.19]	172
External maintenance rate	0.06	0.05	0.05	[0.00, 0.11]	172
Investment rate	0.15	0.16	0.10	[0.02, 0.28]	172
After-tax relative price	1.11	0.09	1.10	[1.00, 1.25]	172
Capital age	1.48	0.21	1.51	[1.24, 1.69]	172
Two-year-lagged labor share	0.41	0.11	0.37	[0.29, 0.56]	170
Maintenance share s_m	0.53	0.13	0.53	[0.34, 0.71]	172

Rates use lagged book capital; prices are indexed to the first year. Age: gross / net book capital.

N: nonmissing observations. Regression samples additionally require controls and exposure.

► Locomotives

► Freight cars

► R-1 data

► Robustness

► Rates

R-1 Summary Statistics: Freight Cars

7 railroads, 1999–2023; 172 firm–asset–years per asset.

Variable	Mean	SD	Median	10th–90th	<i>N</i>
Maintenance rate	0.22	0.14	0.16	[0.08, 0.45]	172
Internal maintenance rate	0.15	0.11	0.10	[0.05, 0.34]	172
External maintenance rate	0.07	0.04	0.05	[0.02, 0.12]	172
Investment rate	0.08	0.09	0.05	[0.00, 0.19]	172
After-tax relative price	0.90	0.10	0.88	[0.77, 1.04]	172
Capital age	1.59	0.27	1.62	[1.18, 1.93]	172
Two-year-lagged labor share	0.39	0.09	0.39	[0.26, 0.50]	170
Maintenance share s_m	0.55	0.16	0.55	[0.34, 0.76]	172

Rates use lagged book capital; prices are indexed to the first year. Age: gross / net book capital.

N: nonmissing observations. Regression samples additionally require controls and exposure.

► Locomotives

► Freight cars

► R-1 data

► Robustness

R-1 Maintenance Demand: OLS and IV

	Total		Internal		External	
	OLS	IV	OLS	IV	OLS	IV
$\hat{\omega}$	1.74*** (0.26)	4.76*** (1.07)	2.81*** (0.74)	8.43*** (1.76)	-0.52 (0.59)	0.12 (3.74)
First-stage F		12.63		12.63		12.63
t_F 95% interval	[1.48, 8.04]		[3.02, 13.84]		[-11.35, 11.58]	
AR 95% interval	[3.03, 8.37]		[3.84, 12.13]		[-6.99, 10.96]	
Observations	340	340	340	340	340	340

All specifications include firm-asset and year fixed effects, capital age, and GDP exposure. Firm-clustered standard errors in parentheses. Intervals refer to the IV estimates.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Firm-Clustered and Weak-IV-Robust Inference

Inference	With controls $\hat{\omega} = 4.76$	No controls $\hat{\omega} = 5.41$
Analytic	[2.66, 6.85]	[3.34, 7.48]
Weak-IV robust (t_F)	[1.48, 8.04]	[2.04, 8.78]
Weak-IV robust (AR)	[3.03, 8.37]	[2.50, 7.63]

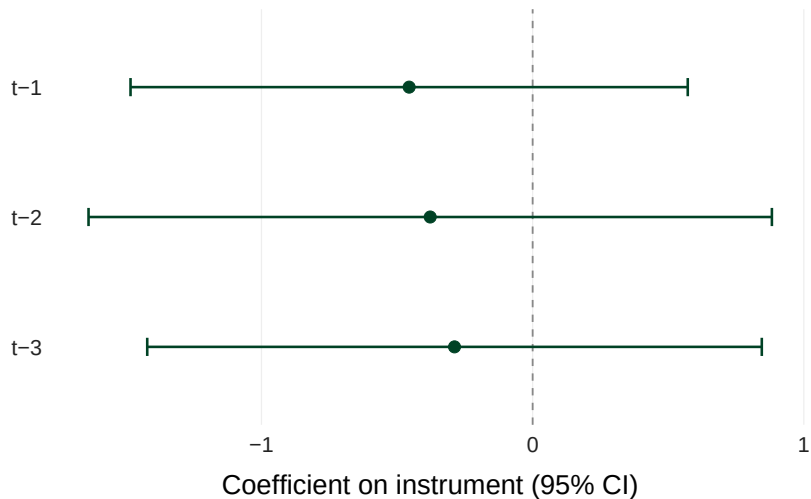
Every bounded interval excludes both zero and a unit elasticity.

Exposure-Robust Inference

Inference	With controls	No controls
Shift level: state clusters	[2.09, 7.43]	[2.24, 8.58]
Shift level: year clusters	[2.52, 7.00]	[2.93, 7.89]
AKM exposure robust	[−384.95, 394.47]	[−204.36, 215.18]
AKM0 weak-IV robust	$(-\infty, \infty)$	$(-\infty, \infty)$
Effective state-cluster shifts	26	

State wage shifts move together. AKM intervals are extremely wide and AKM0 intervals are unbounded.

The Instrument and Prior Maintenance



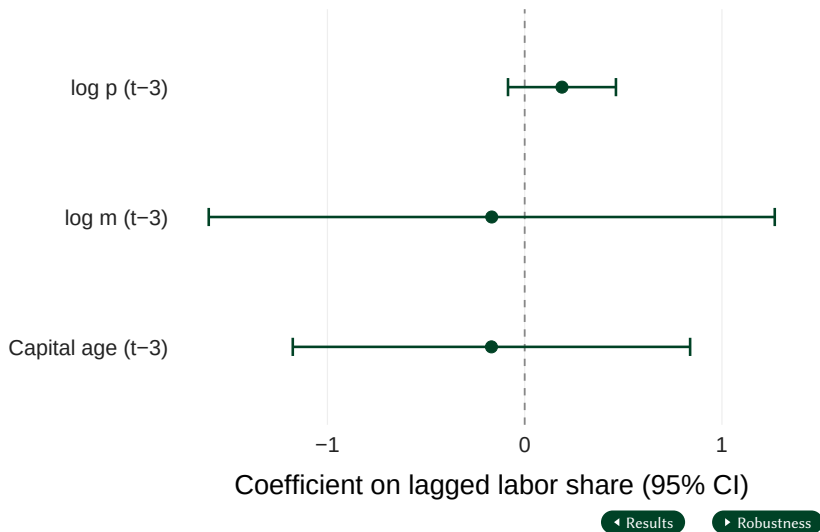
◀ Results

▶ Robustness

R-1 Estimates Across Specifications

Specification	$\hat{\omega}$	Cluster SE	Effective F
Headline (all controls)	4.76***	(1.07)	12.63
No controls	5.41***	(1.05)	11.54
Three-year-lagged shares	6.06***	(1.07)	14.68
National wage	6.77***	(0.91)	10.68
Physical maintenance outcome	3.70**	(1.67)	12.63

Balance Tests for Predetermined Labor Shares



First-Stage Estimates

Instrument	First stage	Cluster SE	Effective F	N
Baseline, no controls	0.165***	(0.049)	11.54	340
Baseline, all controls	0.168***	(0.047)	12.63	340
Three-year-lagged shares	0.156***	(0.041)	14.68	326
National wage	0.00149***	(0.00046)	10.68	314

All rows include firm–asset and year fixed effects. Controlled rows add capital age and GDP exposure.
Standard errors are clustered by firm.

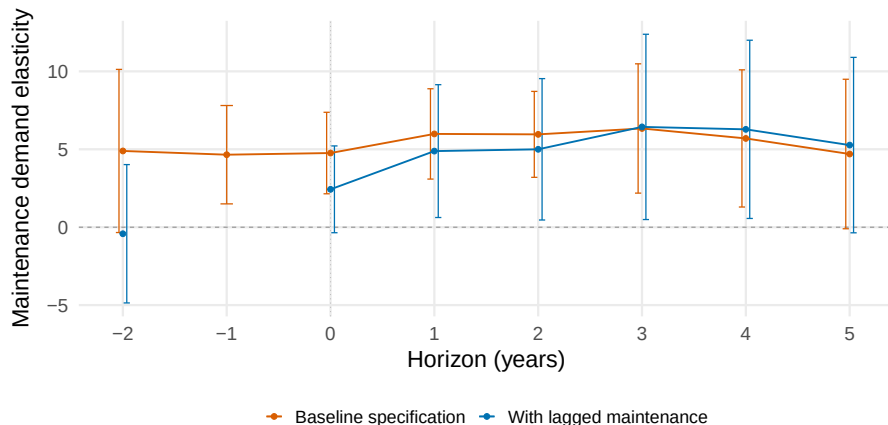
R-1 Maintenance Demand without Controls

	All	Internal	External
OLS	1.84***	2.91**	-0.41
IV	5.41***	9.21***	0.85
AR 95% CI	[2.50, 7.63]	[0.77, 13.60]	[-6.70, 9.69]
Effective F	11.54	11.54	11.54

Reduced-Form Effects by Maintenance Type

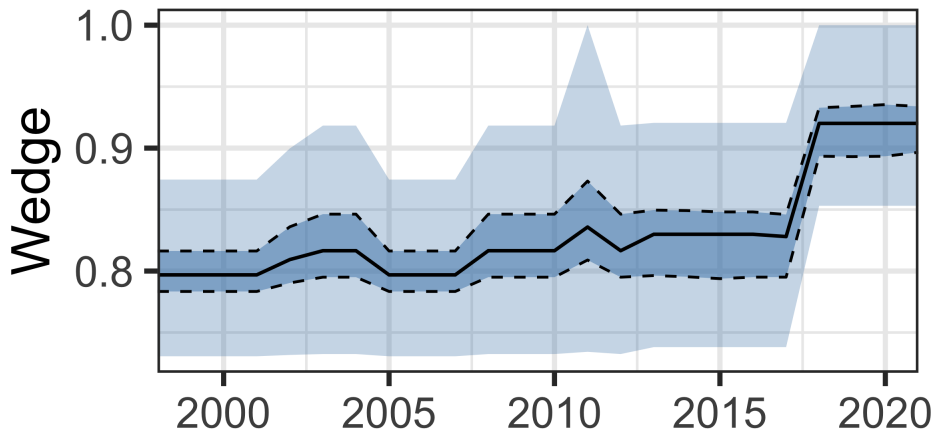
	All	Internal	External
Reduced form	-0.801^{***} (0.194)	-1.418^{***} (0.534)	-0.020 (0.627)
Implied $\hat{\omega}$	4.76	8.43	0.12

R-1 Maintenance Responses over Time

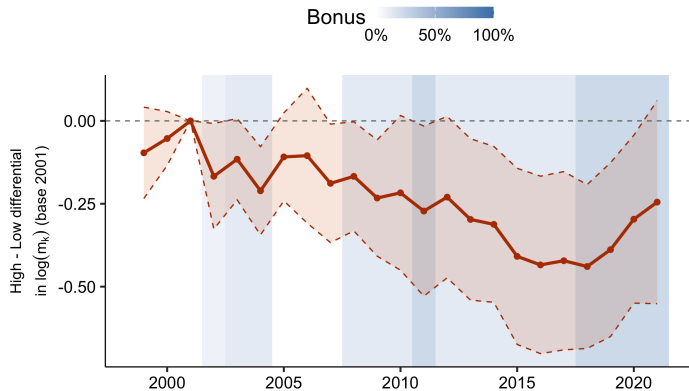


Capital age and GDP exposure; firm-asset and year fixed effects. 95% firm-clustered intervals. The lag-controlled response at $h = -1$ is mechanically zero and omitted.

Cross-Industry Exposure to Tax Reform



Maintenance falls under bonus depreciation



High-minus-low baseline exposure relative to 2001; dashed lines are 95% industry-clustered intervals and shading is the statutory bonus rate.

SOI Summary Statistics: All Firms

49 industries, 1999–2021; industry–year observations.

Variable	Mean	SD	Median	10th–90th	<i>N</i>
Maintenance rate	0.05	0.03	0.04	[0.02, 0.09]	1,116
Investment proxy	0.06	0.21	0.06	[−0.14, 0.23]	1,115
Tax wedge	0.83	0.06	0.82	[0.76, 0.92]	1,116
Maintenance share s_m	0.18	0.10	0.15	[0.08, 0.31]	1,116
Labor-adjusted s_m	0.25	0.12	0.22	[0.12, 0.41]	1,116
Capital age	2.21	0.47	2.15	[1.66, 2.80]	1,113

Investment proxy: change in reported capital / lagged book capital. The labor adjustment divides reported maintenance by 0.65 before constructing s_m .

N: nonmissing observations. Regression samples additionally require controls and exposure.

► All

► Taxable

► Untaxable

► SOI data

► Robustness

► Rates

SOI Summary Statistics: Taxable Firms

49 industries, 1999–2021; industry–year observations.

Variable	Mean	SD	Median	10th–90th	<i>N</i>
Maintenance rate	0.05	0.04	0.04	[0.02, 0.11]	1,051
Investment proxy	0.11	0.52	0.05	[−0.47, 0.61]	1,051
Tax wedge	0.83	0.06	0.82	[0.76, 0.92]	1,114
Maintenance share s_m	0.19	0.10	0.17	[0.07, 0.33]	1,051
Labor-adjusted s_m	0.26	0.13	0.23	[0.11, 0.43]	1,051
Capital age	2.25	0.49	2.19	[1.69, 2.93]	1,114

Investment proxy: change in reported capital / lagged book capital. The labor adjustment divides reported maintenance by 0.65 before constructing s_m .

N: nonmissing observations. Regression samples additionally require controls and exposure.

► All

► Taxable

► Untaxable

► SOI data

► Robustness

SOI Summary Statistics: Untaxable Firms

49 industries, 1999–2021; industry–year observations.

Variable	Mean	SD	Median	10th–90th	<i>N</i>
Maintenance rate	0.05	0.04	0.04	[0.01, 0.12]	1,049
Investment proxy	0.13	0.54	0.02	[−0.40, 0.83]	1,049
Tax wedge	0.83	0.06	0.82	[0.76, 0.92]	1,113
Maintenance share s_m	0.19	0.12	0.16	[0.06, 0.36]	1,049
Labor-adjusted s_m	0.26	0.14	0.23	[0.08, 0.47]	1,049
Capital age	2.12	0.48	2.06	[1.52, 2.75]	1,113

Investment proxy: change in reported capital / lagged book capital. The labor adjustment divides reported maintenance by 0.65 before constructing s_m .

N: nonmissing observations. Regression samples additionally require controls and exposure.

► All

► Taxable

► Untaxable

► SOI data

► Robustness

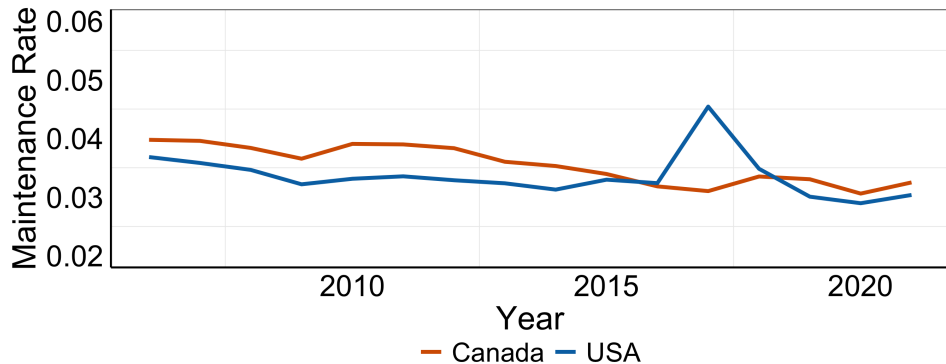
Comparing Taxable and Untaxable Firms

Specification	$\hat{\omega}_{\text{tax}} - \hat{\omega}_{\text{untaxed}}$	Cluster SE	<i>p</i> -value
Without capital age	3.10	2.29	0.18
With capital age	3.25	2.28	0.16

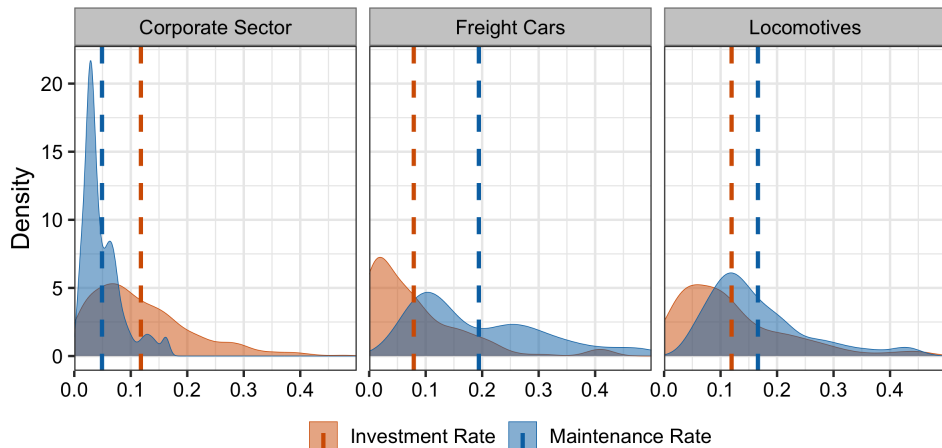
- Stack both samples with sample-specific industry and year fixed effects, trends, and controls.
- Cluster by industry across both samples.
- The difference is imprecisely estimated.

[◀ Results](#)[▶ Full estimates](#)[▶ Robustness](#)

Comparing Canada and SOI Maintenance Rates



Maintenance and Investment Rates



► SOI statistics

► R-1 statistics

► SOI data

SOI Estimates Across Specifications

Specification	$\hat{\omega}$	Cluster SE	N
Main: quadratic NAICS trends	2.71**	(1.04)	1,113
Without capital age (calibration)	2.61**	(1.01)	1,116
FE only	1.97*	(1.00)	1,113
Linear NAICS trends	2.52**	(0.94)	1,113
Industry-specific linear trends	1.44*	(0.75)	1,113
Pre-2014 window	1.47**	(0.65)	733
Alternative capital stock	1.47	(1.09)	1,113
Leave-one-industry-out	[2.24, 3.27]	—	—

All specifications include capital age except the calibration comparison. Standard errors are clustered by industry. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

SOI Identification Diagnostics

Diagnostic	Result	Reading
Mean-independence of effects from exposure	Not rejected, $p = .40-.85$	Consistency condition not rejected
Pre-trends across exposure	$F = .66, p = .62$	No detected differential pre-trend
Selection on exposure	$-0.07, p = .68$	No detected pre-2002 trend difference
Dose-response monotonicity	Increasing, $p < .001$	Response is monotone in the dose

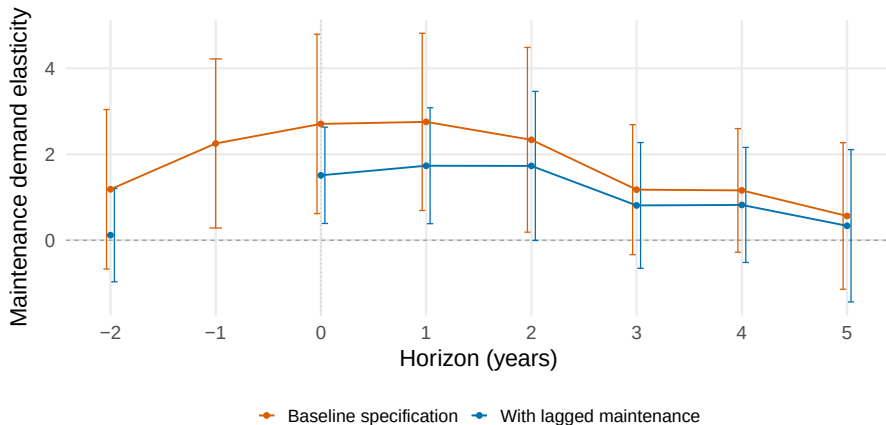
Mean-independence tests use specifications without capital age.

SOI Estimates with Investment Weights

	All		Taxable		Untaxable	
	Baseline	+ age	Baseline	+ age	Baseline	+ age
$\hat{\omega}$	-2.29*	-2.24*	-0.33	-0.15	0.45	0.19
	(1.29)	(1.23)	(1.32)	(1.30)	(1.72)	(1.70)

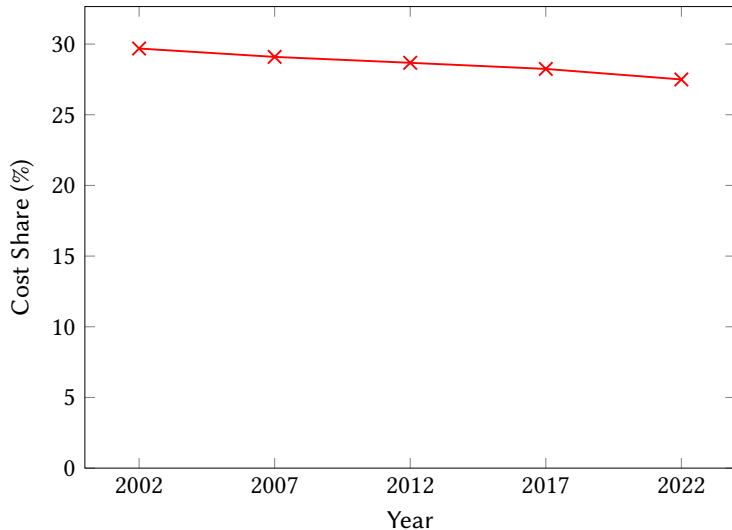
Changing to investment-flow weights changes the estimates substantially. Capital weights correspond to the installed stock on which maintenance is performed.

SOI Maintenance Responses over Time



Log tax wedge, capital age, and NAICS trends; industry and year fixed effects. 95% industry-clustered intervals. The lag-controlled response at $h = -1$ is mechanically zero and omitted.

Maintenance-sector payroll is 27–30% of receipts



SOI Estimates with and without Capital Age

	All		Taxable		Untaxable	
	Baseline	+ age	Baseline	+ age	Baseline	+ age
$\hat{\omega}$	2.61** (1.01)	2.71** (1.04)	3.07** (1.15)	3.16*** (1.13)	-0.03 (1.69)	-0.09 (1.70)
N	1,116	1,113	1,051	1,051	1,049	1,049
Industry and year FE	✓	✓	✓	✓	✓	✓
Capital age		✓		✓		✓
Two-digit NAICS trends	✓	✓	✓	✓	✓	✓

From Estimates to Aggregates

- Use the SOI specification without capital age to calibrate maintenance demand:
 - $\omega = 2.61$, with the level matched to observed maintenance rates.
- Calibrate baseline depreciation δ_0 and passthrough productivity A_{nc} to:
 - Investment–output ratio: $I/Y = 0.109$.
 - Corporate share of capital: $K_c/K = 0.70$.
- Models with and without maintenance start from matched initial steady states.

Partial Equilibrium

- Hold wages and interest rates at their pre-reform values:

$$w = w_0, \quad r = r_0.$$

- Labor supply is perfectly elastic at w_0 ; firm labor choices satisfy:

$$F_{L,c}(K_c, L_c) = F_{L,nc}(K_{nc}, L_{nc}) = w_0.$$

- Investment and maintenance prices are fixed.

General Equilibrium

- Fix total labor supply:

$$L_c + L_{nc} = 1.$$

- A common wage equalizes marginal products of labor:

$$F_{L,c}(K_c, L_c) = F_{L,nc}(K_{nc}, L_{nc}) = w.$$

- Interest rates and investment and maintenance prices are fixed.
- The corporate tax cut draws workers toward the corporate sector and raises wages.

GE with Crowding Out

Labor clears as in GE: $L_c + L_{nc} = 1$.

1. Solve each model under TCJA at the baseline interest rate to compute its output path and revenue feedback.
2. Combine TCJA's fiscal cost and revenue feedback to project the 2027 change in debt/GDP, Δb_{2027} .
3. Use Plante, Richter, and Zubairy (2026) to map debt into interest rates:

$$\Delta r = \beta_b \Delta b_{2027}, \quad \beta_b = 3.20 \quad (\text{SE} = 1.22).$$

Debt/GDP changes are in percentage points; Δr is in basis points. Re-solve the model at the resulting interest rate.

GE with a Maintenance Sector

- A competitive maintenance sector uses labor L_m and materials X_m :

$$Q = A_m L_m^\eta X_m^{1-\eta} = M_c + M_{nc}, \quad \eta = 0.30.$$

- Labor clears across production and maintenance:

$$L_c + L_{nc} + L_m = 1.$$

- With the materials price normalized to one, maintenance unit cost is:

$$p^M = \frac{1}{A_m} \left(\frac{w}{\eta} \right)^\eta \left(\frac{1}{1-\eta} \right)^{1-\eta}.$$

- Competitive factor payments satisfy:

$$wL_m = \eta p^M Q, \quad X_m = (1-\eta)p^M Q.$$

Maintenance Sector: Calibration and Accounting

- Calibrate δ_0 , A_{nc} , A_m , and α_L to the following initial targets:

$$\frac{K_c}{K_c + K_{nc}} = 0.70, \quad \frac{I_c + I_{nc}}{G} = 0.109, \quad \frac{w}{G} = 0.65, \quad p_0^M = 1.$$

- Private GDP nets out materials used by maintenance:

$$G = Y_c + Y_{nc} - X_m.$$

- Match K_c , K_{nc} , private GDP, wages, and labor supply across models.
- $\alpha_L = 0.614$ with maintenance; $\alpha_L^{HJ} = 0.650$ in the standard model.

Maintenance and Convergence to Steady State

Suppose investment approaches its long-run response without overshooting:

$$\varepsilon_{I,\tau}(t) = \varepsilon_{I,\tau}^{LR} \left[1 - (1 - \theta)e^{-\kappa t} \right], \quad 0 < \theta < 1.$$

Here θ is the impact share and κ is the convergence rate.

Proposition: Slower Convergence

When larger impact shares imply faster convergence, matching the same short-run investment response gives:

$$\left| \varepsilon_{I,\tau}^{LR,M} \right| > \left| \varepsilon_{I,\tau}^{LR,HJ} \right| \Rightarrow \kappa^M < \kappa^{HJ}.$$

TCJA transitions allow investment to overshoot and use model-specific short-run targets.

◀ Calibration

◀ Crowding out

▶ Next: Transition setup

Transition Dynamics and Adjustment Costs

Investment faces a tax-deductible adjustment cost:

$$\Phi(I_t, K_t, M_t) = \frac{\phi}{2} \left(\frac{I_t}{K_t} - \delta(m_t) \right)^2 K_t.$$

- Chodorow-Reich et al. (2025): short-run investment response $\hat{\varepsilon}_I \approx 4.3$.
- Calibrate ϕ using this investment response, correcting the maintenance model's target for user cost measurement.
- Maintenance creates an immediate depreciation response, requiring higher adjustment costs to reconcile investment with capital accumulation.
- Use the output path to compute revenue feedback and debt for crowding out.

Adjustment Cost Calibration

- The standard model uses the observed investment elasticity:

$$\phi^{HJ} = \frac{1}{\delta^{HJ} |\widehat{\varepsilon}_I|}.$$

- With maintenance, first correct the investment elasticity for the maintenance share of user cost:

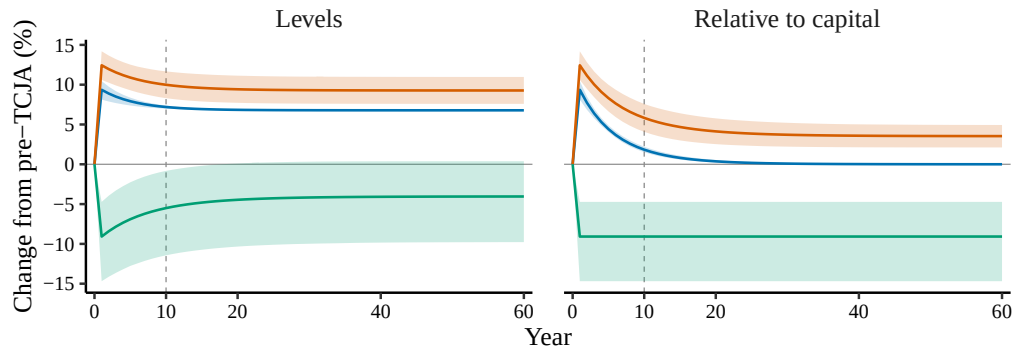
$$|\widetilde{\varepsilon}_I| = \frac{|\widehat{\varepsilon}_I|}{1 - s_m}.$$

- Investment also offsets the depreciation response:

$$\phi^M \approx \frac{1}{\delta(m) (|\widetilde{\varepsilon}_I| - |\varepsilon_\delta|)}.$$

Local formulas at a no-tax baseline with normalized prices. Adjustment costs vanish in steady state.

Baseline GE: Investment and Maintenance



— Investment (standard) — Investment (maintenance) — Maintenance

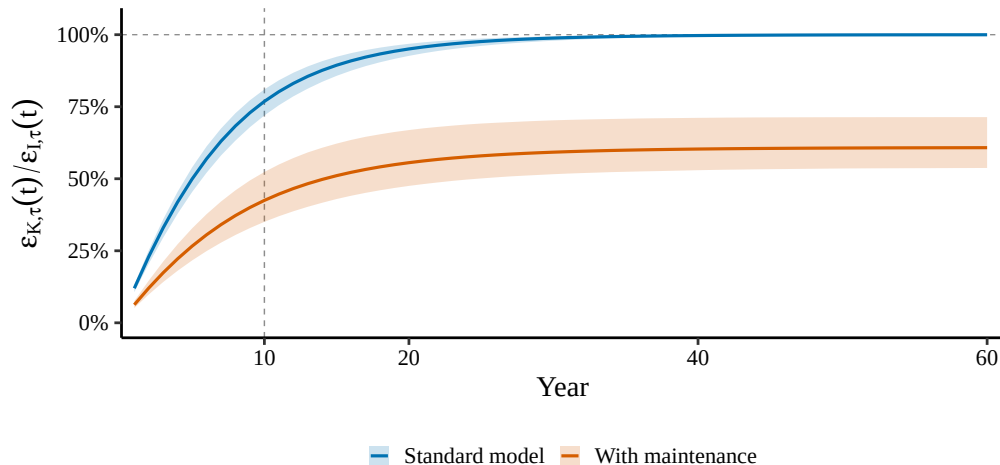
Shaded bands: conditional 95% intervals. Dashed vertical line: year 10.

► Theory

◄ Adjustment costs

► Next: Elasticities

Baseline GE: Investment and Capital Elasticities



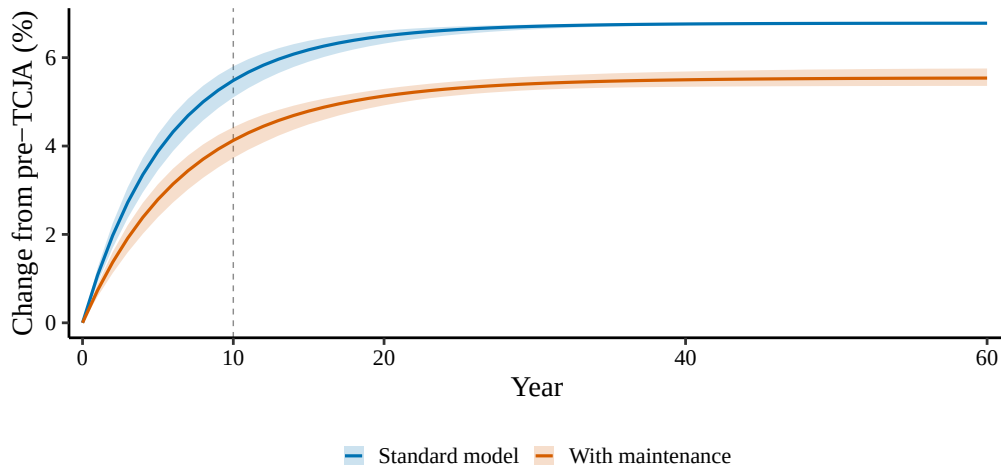
Shaded bands: conditional 95% intervals. Dashed vertical line: year 10.

► Theory

◀ Inputs

► Next: Capital path

Baseline GE: Capital Response over Time



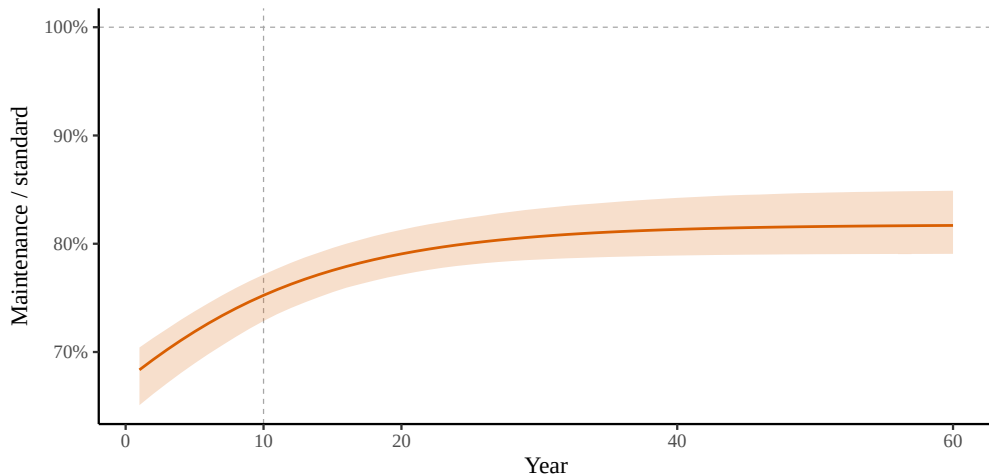
Shaded bands: conditional 95% intervals. Dashed vertical line: year 10.

► Theory

◄ Elasticities

► Next: Capital ratio

Baseline GE: Capital Attenuation over Time



Ratio of the capital responses with maintenance and in the standard model; conditional 95% intervals.

► Theory

◄ Capital path

► Next: Revenue

Baseline GE: Ten-Year Revenue Effects

Baseline two-sector GE model; ten-year scoring horizon.

	Standard model	With maintenance
Corporate capital	5.48%	4.13%
Output	0.56%	0.43%
Revenue offset	7.02%	5.20%

Revenue offsets are the share of the static fiscal cost recovered through growth. Values are drawn from means; this exercise uses the baseline GE closure.

Calibration Details: Parameters

From Chodorow-Reich et al. (2025):

- Discount rate $r = 0.06$
- Production elasticities $\alpha_K = 0.245$ and $\alpha_L = 0.65$
- Short-run investment elasticity $\hat{\epsilon}_I \approx 4.3$
- Pre- and post-TCJA tax rates (assume bonus depreciation permanent)

Calibrated to match pre-reform moments:

- $K_c/K = 0.7$ (corporate share of capital)
- $I/Y = 0.109$ (investment rate from NIPA)
- These pin down δ_0 and passthrough productivity A_{nc}

TCJA Uncertainty

- 5,000 maintenance-demand draws, conditional on $\omega > 1.3$:
 - Recover γ from the SOI sample means for each draw.
- Transition dynamics also draw the investment elasticity: 4.27 (SE 0.51).
- Crowding out draws the debt coefficient: 3.20 (SE 1.22).
- Display draw means and the 2.5th–97.5th percentiles.
- Intervals condition on production parameters, calibration targets, taxes, and closure. Recalibrate the explicit maintenance sector in each draw with $\eta = 0.30$.

Steady-State Capital Responses Across Closures

Percent change in corporate capital from the pre-TCJA steady state.

Closure	Standard	Maintenance	95% interval	Ratio
PE	12.09	9.82	[9.49, 10.23]	0.813
GE	6.78	5.54	[5.36, 5.77]	0.818
GE + crowding out	4.63	3.40	[1.82, 5.03]	0.734
GE + maintenance sector	6.78	5.05	[4.77, 5.39]	0.745

Ratios compare the capital responses with maintenance and in the standard model. The displayed interval is for the response with maintenance.

► Main results

► Model closures

► Uncertainty

Implications for Measurement

Standard Investment Regressions Understate the Response to User Cost

Standard specification:

$$\log I = \alpha + \hat{\beta} \log \left[p^I (r + \delta) \frac{1 - \tau^c z - c}{1 - \tau^c} \right] + e$$

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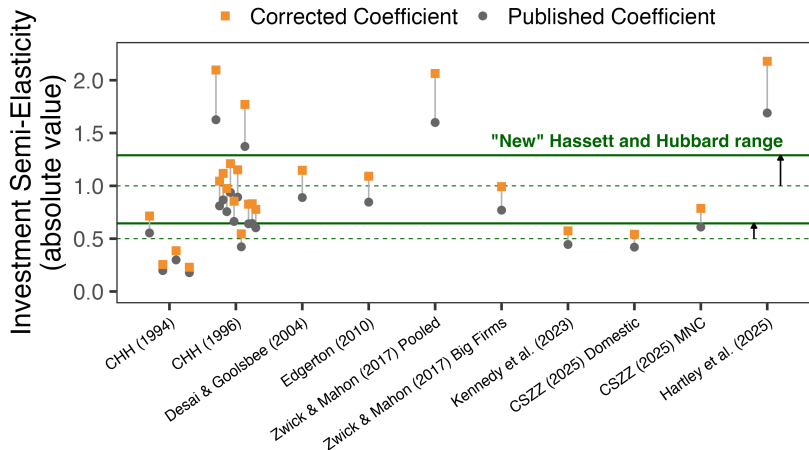
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Standard user cost falls more than true user cost, pushing the estimated coefficient toward zero, and the empirical investment elasticity is *larger* with maintenance:

$$\beta \approx \frac{\hat{\beta}}{1 - s_m}$$

Correcting User Cost in Investment Regressions



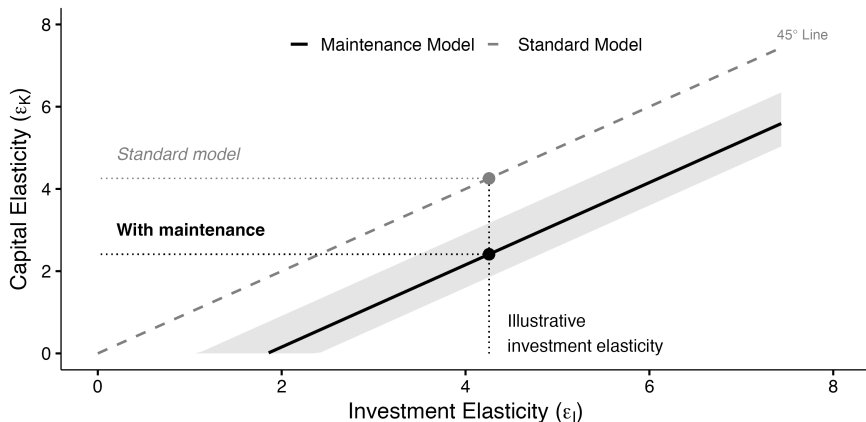
One-sector illustration: $\alpha_K = 1/3$, $r = 0.06$, $I/Y = 0.109$, no-tax baseline; SOI draws satisfy $\omega > 1$.

► Specification

► Elasticity gap

► TCJA calibration

Illustrating the Investment–Capital Elasticity Gap



One-sector illustration: $\alpha_K = 1/3$, $r = 0.06$, $I/Y = 0.109$, no-tax baseline; SOI draws satisfy $\omega > 1$.
Investment elasticity is held fixed; shading is the 5th–95th percentile range (90%).

► Specification

► User-cost correction

► TCJA results