Asymmetric Investment Rates

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How to measure the firm-level (fixed) investment rate?

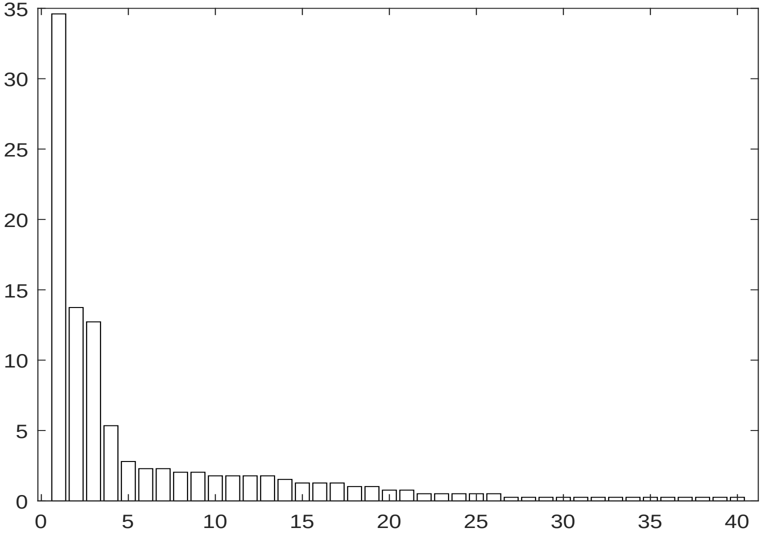
- Building the data infrastructure of firm-specific current-cost capital stocks for the entire Compustat sample

What are the basic properties of the firm-level investment rate?

- Characterizing accurately the key properties, including its asymmetry and lumpiness

Why?

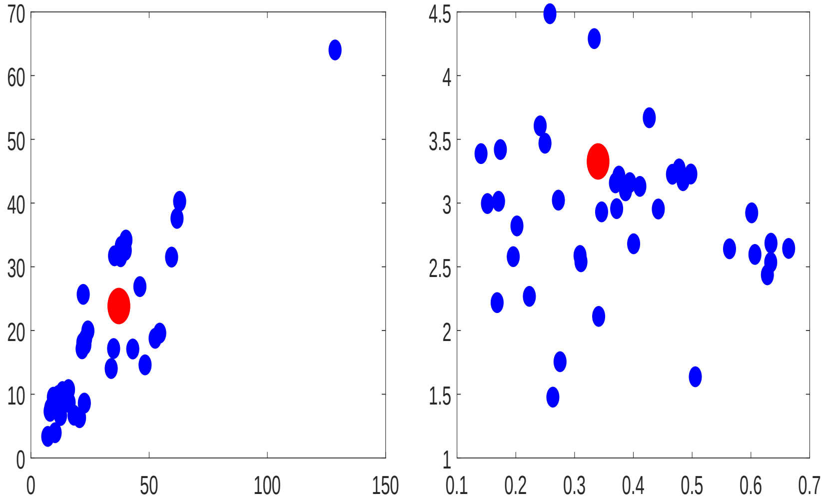
A meta-study of 347 articles with 393 appearances of 40 investment rate measures from 2000 onward in top-five finance journals; the frequency distribution of the 40 measures



(1) CAPX/AT
(2) CAPX/PPENT
(3) dAT/AT
(4) (dPPEGT+dINVT)/AT
(5) Inv/AT
(6) CAPX/PPEGT
(7) dPPEGT/AT
(8) (dPPENT+DP)/PPENT
(9) (CAPX−SPPE)/PPEGT
(10) (CAPX−SPPE)/AT
(11) dPPENT/AT
(12) (CAPX+AQC)/AT
(13) CAPXV/AT
(14) (CAPX−SPPE)/PPENT
(15) (CAPX+AQC−SPPE)/AT
(16) (CAPXV−SPPE)/AT
(17) dPPEGT/PPEGT
(18) dPPENT/PPENT
(19) (dPPENT+DP)/AT
(20) (CAPXV−SPPE)/PPEGT
(21) dBe/Be
(22) (CAPX−SPPE)/avePPENT
(23) dNoa/AT
(24) dLno/aveAT
(25) dNca/AT
(26) dBe/AT
(27) (CAPXV+AQC)/PPENT
(28) CAPXV/PPENT
(29) CAPXV/PPEGT
(30) (CAPX+IVCH−SIV)/(PPENT+IVAEQ+IVAO)
(31) (dPPENT+WDP+DPC)/PPEGT
(32) dNAT/NAT
(33) CAPX/(AT−INVT)
(34) (CAPX+AQC)/PPEGT
(35) CAPX/(PPENT−CAPX+DP)
(36) (CAPXV−SPPE)/(AT−ACT)
(37) (CAPXV−SPPE)/PPENT
(38) (CAPX−DP)/AT
(39) CAPX/(AT−CHE)
(40) dNCAT/NCAT

Why?

A giant mess: Mean versus standard deviation and skewness versus the serial correlation across the 40 investment rates in Compustat, 1963–2020



Investment as dPPENT+DP per Hayashi and Inoue (1991)

BEA's industry-specific capital/investment price deflators assigned to firms via a meticulous Compustat firm-NAICS mapping

BEA's industry economic depreciation rates assigned to firms

Initial values of current-cost capital based on PPEGT and asset age via perpetual inventory method (PIM)

How?

Another meta-study on prior 33 PIM studies at the firm level;
"death by a thousand cuts"? only 10 from 2000 onward in the top-five finance journals

Most use small samples with only manufacturing firms

Most measure investment as capital expenditures

Most use a single, aggregate capital price deflator for fixed nonresidential investment

Most estimate firm-specific but constant economic depreciation rates via the Salinger-Summers double-declining method

Prior 33 PIM studies at the firm level

	Sample	Investment flows	Price deflators	Depreciation rates
Lindenberg and Ross (1981)	246 firms, 1960–1977	"gross investment (book) in plant and equipment"	Nonresidential fixed investment price deflator	Accounting depreciation, also tech. progress
Salinger and Summers (1983)	30 Dow Jones companies, 1959–1978	proportional to aggregate investment and aligned with gross PPE in 1959	CPI	double declining
Smirlock, Gilligan, and Marshall (1984)	231 manuf. firms,	change in gross PPE	GNP implicit price deflator	5%
Fazzari, Hubbard, and Petersen (1988)	Manuf. firms, 1970–198, Value Line	"capital spending"	Implicit price deflator for fixed nonresid. investment	single declining
Hall (1990)	Compustat, 1979–1987		GNP deflator for fixed nonresidential investment	Accounting depreciation rate
Hoshi and Kashyap (1990)	580 Japanese manuf. firms	change in net PPE plus depreciation	the wholesale price index for investment goods	constant δ, average exponential rate, or $1 - \alpha^{1/\text{average life}}$
Hayashi and Inoue (1991)	687 Japanese manuf. firms, 1977–1986	change in net PPE plus accounting depreciation	nonresid. buildings and structures as the construction material part of Wholesale Price Index (WPI) from BoJ; machinery and instruments and tools as weighted averages of subcomponents in WPI; transportation equipment as the matching component of WPI; the urban land prices index	4.7% for nonresid. buildings; 5.64% for structures; 9.489% for machinery; 14.7% for transportation equipments; 8.838% for instruments and tools; 0% for land

	Sample	Investment flows	Price deflators	Depreciation rates
Blundell, Bond, and Devereux (1992)	532 U.K. manuf. firms, Datastream	total new fixed assets	implicit price deflator for gross fixed investment by manuf. industry	8.19% for plant and machinery; 2.5% for buildings
Whited (1992)	325 manuf. firms, 1972–1986	capital expenditure on PPE	GNP price deflator for nonresid. investment	double declining
Lang and Stulz (1994)	1,449 Compustat firms in 1984	change in gross PPE	implicit GNP price deflator	5%
Bond and Meghir (1994)	626 U.K. manuf. firms, Datastream	total new fixed assets	implicit price deflator for gross fixed investment by manuf. industry	8.19% for plant and machinery; 2.5% for land and buildings
Hubbard, Kashyap, and Whited (1995)	428 manuf. firms, 1976–1987	capital expenditure on PPE	GNP price deflator for nonresid. investment	double declining
Leahy and Whited (1996)	772 manuf. firms, 1981–1987	capital expenditure on PPE	GNP price deflator for nonresid. investment	double declining
Eberly (1997)	Global Vantage industrial database, 1981–1994	capital expenditure	implicit price deflator for nonresid. investment/ producer price index	2-digit SIC-industry, double declining
Lewellen and Badrinath (1997)	678 firms, 1975–1991	change in PPENT plus accounting depreciation	GNP deflator for fixed nonresid. investment	straight-line depreciation
Barnett and Sakellaris (1998)	manuf. firms from Hall (1990)	capital expenditure on PPE	GNP deflator for fixed nonresid. investment	accounting depreciation rate
Erickson and Whited (2000)	737 manuf. firms, 1992–1995	capital expenditure on PPE	nonresid. investment price deflator	double declining
Abel and Eberly (2001)	Compustat, 604 firms on average per year, 1974–1993	capital expenditure on PPE minus sales of PPE	implicit price deflator for nonresid. investment	2-digit SIC-industry, double declining

Prior 33 PIM studies at the firm level

	Sample	Investment flows	Price deflators	Depreciation rates
Gomes (2001)	Compustat, 1979–1988	spending on PPE minus capital retirements	deflator for nonresid. fixed investment	double declining
Chirinko and Schaller (2004)	193 Canadian firms, 1973–1986	capital expenditure on PPE	implicit price index for investment in machinery and equipment	double declining
Hennessy (2004)	278 manuf. firms, 1992–1995	capital expenditure on PPE	nonresid. investment price deflator	double declining
Bloom, Bond, and Reenen (2007)	U.K. manuf. firms, Datastream	total new fixed assets minus sales of fixed assets	an aggregate series for investment goods prices	8%
Gan (2007a)	847 Japanese manuf. firms	change in net PPE plus accounting depreciation	same in Hayashi and Inoue (1991)	same in Hayashi and Inoue (1991)
Gan (2007b)	420 Japanese manuf. firms	change in net PPE plus accounting depreciation	same in Hayashi and Inoue (1991)	same in Hayashi and Inoue (1991)
Gaspar and Massa (2007)	about 847 firms per year	change in net PPE	CPI	5%
Benfratello, Schiantarelli, and Sembenelli (2008)	Italian manuf. firms	investment in plants and machinery	the aggregate business investment price index	5%
Bloom (2009)	Compustat, 1981–2000	capital expenditure on PPE minus sales of PPE	industry-level investment price deflators, NBER-CES manuf. database	industry-level depreciation rates, NBER-CES manuf. database
Chirinko and Schaller (2009)	Compustat, 1980–2001	CAPX; for acquisition, change in PPEGT plus PPE retirements; for disinvestment, change in PPENT plus economic depreciation	industry-specific investment price deflators based on chain-type quantities from BEA	industry-specific current-cost depreciation rates based on chain-type quantities from BEA

How?

Prior 33 PIM studies at the firm level

	Sample	Investment flows	Price deflators	Depreciation rates
Eberly, Rebelo, and Vincent (2012)	776 firms, 1981–2003, top quartile on capital stock in 1981	capital expenditure on PPE	implicit price deflator for nonresid. investment	2-digit SIC industry, double declining
Panousi and Papanikolaou (2012)	Compustat, 1970–2005	CAPX	price deflator for fixed nonresid. investment	3-digit SIC industry, double declining
Moyen and Platikanov (2013)	Compustat, 1988–2009	CAPX	producer price index for finished goods: capital equipment	double declining
Bustamante (2016)	Compustat, 1980–2014	CAPX minus SPPE	nonresid. investment deflator	accounting depreciation
Belo, Gala, Salomao, and Vitorino (2022)	Compustat, 1975–2016	change in PPENT plus accounting depreciation	equipment and structure deflators	accounting depreciation

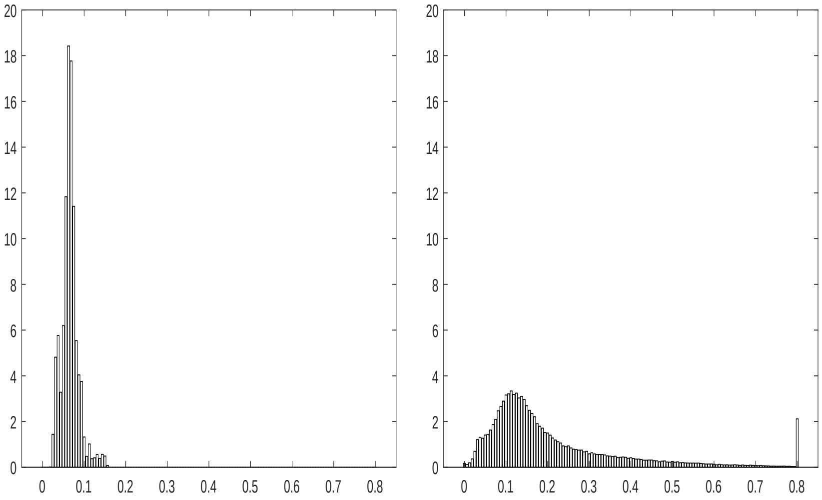
What?

Basic moments of $I^{\$}_{it}/K^{\$}_{it}$, the 1963–2020 sample, 169,828 firm-years

	$I^{\$}_{it}/K^{\$}_{it}$	I^{H}_{it}/K^{H}_{it}	$K^{\$}_{it}/K^{H}_{it}$	δ_{it}	δ^{H}_{it}
Mean	0.238	0.403	2.11	6.90	20.94
Median	0.130	0.228	1.61	6.86	16.10
Standard deviation	0.372	0.629	1.79	1.96	16.65
Autocorrelation	0.34	0.25	0.9	0.98	0.79
Skewness	3.33	3.47	3.58	0.65	2.01
Excess kurtosis	14.28	15.84	16.82	1.37	6.08

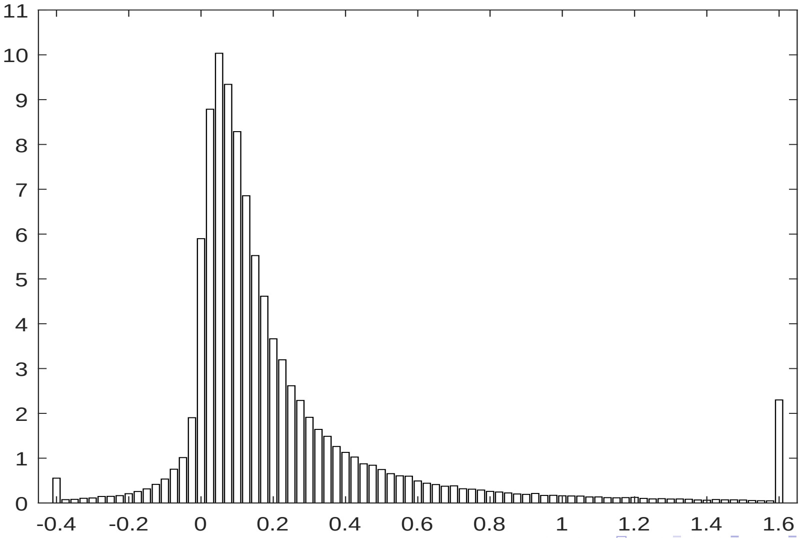
What?

Economic depreciation rates, δ_{it} (169,792 firm-years); accounting depreciation rates, δ_{it}^{H} (177,412 firm-years)

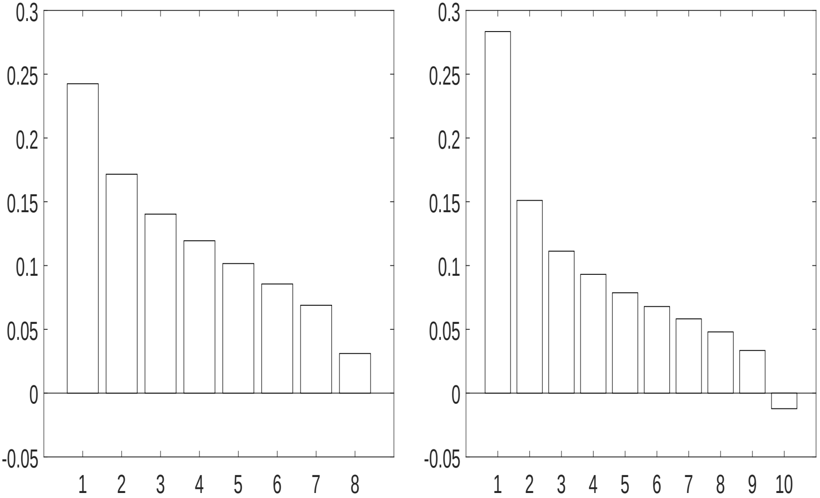


What?

The asymmetric firm-level $I_{it}^{\$}/K_{it}^{\$}$ distribution: The fractions of negative, inactive, and positive investment rates: 5.51%, 2.85%, and 91.64%, respectively; a rate of 1.26% for negative spikes (below −20%) versus 32.7% for positive spikes (above 20%)



Lumpy firm-level $I_{it}^{\$}$: For a typical firm, 39% of total $|I_{it}^{\$}|$ done within 20% of the years in the Doms-Dunne (1998) tests; balanced panels by decade: 1963–1970 and 2011–2020



Outline

1. Meta-Analysis: A Macro-Micro Disconnect

2. Economic Accounting of Investment Rates

3. Salient Properties of Investment Rates

Obtain the domestic supply of each capital good from production data of capital goods producing industries

Subtract capital purchases by government and consumers to compute gross investment flows by asset class

Distribute investment totals by asset class across industries with strong assumptions on the employment-capital relation

Form capital stocks by asset class by applying PIM on investment flows, depreciation profiles, and investment price deflators (PPIs)

Geometric depreciation, closer to actual profiles of used capital price declines in the data (Hulten and Wykoff 1981a, b)

The economic depreciation rate of asset a, $\delta_a = B_a/L_a$, in which B_a is its declining-balance rate, and T_a the average service life

B_a on average 1.65 for equipment and 0.91 for nonresidential structures; both lower than 2 (the double-declining-balance rate)

Cooper and Haltiwanger (2006):

- A "striking asymmetry between positive and negative investment": A fraction of 10.4% for negative, 8.1% for inactive, and 81.5% for positive investment rates

Doms and Dunne (1998):

- Lumpiness: For each plant, calculate the fraction of investment each year out of total investment; top 3 years account for 50.1%

Macro accounting: Top-down supply-based; geometric depreciation

Micro accounting: demand-based; straight-line depreciation

- Net PPE should be (net) capital stock; yet many studies scale investment with gross PPE or book assets
- Accounting much higher than geometric depreciation rates
- Scaling by gross PPE or book assets brings basic investment rate moments closer to the BEA's

Build current-cost capital stocks with economic depreciation rates

Outline

The quantity of capital stock accumulates as:

$$K_{it+1} = (1 - \delta_{it})K_{it} + I_{it}$$

δ_{it}: The economic depreciation rate

Rewriting in terms of current costs yields:

$$K^{\$}_{it+1} = \left((1 - \delta_{it}) \frac{K^{\$}_{it}}{P^{K}_{it}} + \frac{I^{\$}_{it}}{P^{I}_{it}} \right) P^{K}_{it+1}$$

P^{K}_{it}: Capital price deflator; P^{I}_{it}: Investment price deflator

PIM requires: (i) current-cost investment flows, $I^{\$}_{it}$; (ii) P^{K}_{it} and P^{I}_{it}; (iii) δ_{it}; and (iv) the initial current-cost capital stock, $K^{\$}_{i0}$

Net PPE equals gross PPE minus accumulated depreciation:

$$\text{PPENT}_t = \text{PPEGT}_t - \text{DPACT}_t$$

ACQ_t: Gross book value of acquired fixed assets;
SR_t: Gross value of disposed fixed assets:

$$\text{PPEGT}_{t+1} = \text{PPEGT}_t + \text{ACQ}_t - \text{SR}_t$$

ACDACQ_t: Accumulated depreciation of acquired fixed assets;
ACDSR_t: Accumulated depreciation for disposed fixed assets:

$$\text{DPACT}_{t+1} = \text{DPACT}_t + \text{DP}_t + \text{ACDACQ}_t - \text{ACDSR}_t$$

Economic Accounting

Assume current-cost equals historical-cost investment flows

$$
\begin{aligned}
I_{it}^{H} &= \text{PPENT}_{t+1} - \text{PPENT}_t + \text{DP}_t \\
&= \text{PPEGT}_{t+1} - \text{PPEGT}_t - (\text{DPACT}_{t+1} - \text{DPACT}_t) + \text{DP}_t \\
&= \text{PPEGT}_{t+1} - \text{PPEGT}_t - \text{ACDACQ}_t + \text{ACDSR}_t \\
&= (\text{ACQ}_t - \text{ACDACQ}_t) - (\text{SR}_t - \text{ACDSR}_t) \\
&= \text{NACQ}_t - \text{NSR}_t
\end{aligned}
$$

Change in gross PPE underestimates the magnitude of investment by 17.2%; poor coverage of $\text{NACQ}_t - \text{NSR}_t$

For acquired assets, historical costs are close to current costs; for disposed assets, typically, historical costs $\neq$ current costs

Sales of PPE underestimate disinvestment:

- Ignores asset-for-equity and asset-for-debt sales
- Ignores other disposition methods, such as exchanges of nonmonetary assets, involuntary conversion (fire, flood, theft, and condemnation), and retirements
- Ignores spin-offs and changes in consolidation status (when a subsidiary is no longer consolidated)

However, dPPENT+DP likely overstates disinvestment via restructuring charges, impairment losses, and FX translations

Ideally, if data were available on detailed asset types and their amounts that a firm employs in any period...

Could form firm-level price deflators and depreciation rates

Instead, assign the BEA's industry-specific price deflators and depreciation rates to all the firms in a given industry

Assume firms in the same industry have the same asset composition

Detailed tables for 63 private industries (the fixed assets accounts):

- Current-cost (current-dollar) capital stocks in private non-residential equipment, $K_{jt}^{\mathcal{E}\$}$, and structure, $K_{jt}^{\mathcal{S}\$}$
- Fixed-cost (constant-dollar) capital stocks in private non-residential equipment, $K_{jt}^{\mathcal{E}}$, and structure, $K_{jt}^{\mathcal{S}}$
- Current-cost investments in private non-residential equipment, $I_{jt}^{\mathcal{E}\$}$, and structure, $I_{jt}^{\mathcal{S}\$}$
- Fixed-cost investments in private non-residential equipment, $I_{jt}^{\mathcal{E}}$, and structure, $I_{jt}^{\mathcal{S}}$

Industry j's capital and investment price deflators:

$$P^K_{jt} = \frac{K^{\mathcal{E}\$}_{jt} + K^{\mathcal{S}\$}_{jt}}{K^{\mathcal{E}}_{jt} + K^{\mathcal{S}}_{jt}}; \qquad P^I_{jt} = \frac{I^{\mathcal{E}\$}_{jt} + I^{\mathcal{S}\$}_{jt}}{I^{\mathcal{E}}_{jt} + I^{\mathcal{S}}_{jt}}$$

Sector s's capital and investment price deflators:

$$P^K_{st} = \frac{\sum_{j\in s} K^{\mathcal{E}\$}_{jt} + \sum_{j\in s} K^{\mathcal{S}\$}_{jt}}{\sum_{j\in s} K^{\mathcal{E}}_{jt} + \sum_{j\in s} K^{\mathcal{S}}_{jt}}; \qquad P^I_{st} = \frac{\sum_{j\in s} I^{\mathcal{E}\$}_{jt} + \sum_{j\in s} I^{\mathcal{S}\$}_{jt}}{\sum_{j\in s} I^{\mathcal{E}}_{jt} + \sum_{j\in s} I^{\mathcal{S}}_{jt}}$$

Should not use chain-type quantity indexes in the denominator

Fixed-cost depreciation in private non-residential equipment, $D_{jt}^{\mathcal{E}}$, and structure, $D_{jt}^{\mathcal{S}}$; fixed-cost capital in private non-residential equipment, $K_{jt}^{\mathcal{E}}$, and structure, $K_{jt}^{\mathcal{S}}$; and fixed-cost investment in private non-residential equipment, $I_{jt}^{\mathcal{E}}$, and structure, $I_{jt}^{\mathcal{S}}$

Industry j's economic depreciation rate in year t:

$$\delta_{jt} = \frac{D_{jt}^{\mathcal{E}} + D_{jt}^{\mathcal{S}}}{(K_{jt-1}^{\mathcal{E}} + K_{jt-1}^{\mathcal{S}}) + 0.5 \times (I_{jt}^{\mathcal{E}} + I_{jt}^{\mathcal{S}})}$$

Different from current-cost depreciation rate, $\delta_{jt}^{\$}$

Left-censoring still in Compustat (no sampling rotation)

In year 0 (first year with available net and gross PPE), estimate asset age, A_i, as DPACT/DP times 2

Estimate $K_{i0}^{\$}$ from iterating from year $-A_i$ to year 0, with the initial capital of 0 and investment $\text{PPEGT}_{i0}/(A_i + 1)$ each year

Outline

1 Meta-Analysis: A Macro-Micro Disconnect

2 Economic Accounting of Investment Rates

3 Salient Properties of Investment Rates

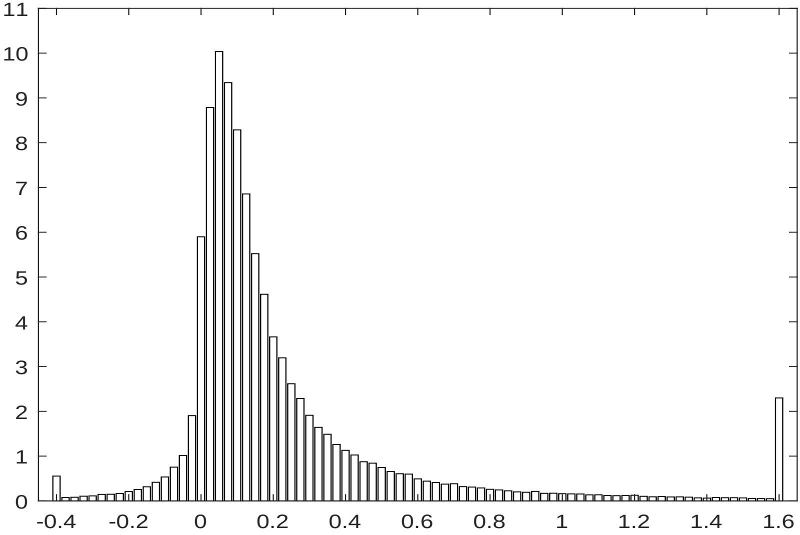
Results

Basic moments of firm-level current-cost investment rates in Compustat, 1963–2020; $I_{it}^{\$}/K_{it}^{\$}$: Current-cost investment rates; $I_{it}/K_{it} \equiv (I_{it}^{\$}/K_{it}^{\$})(P_{it}^{K}/P_{it}^{I})$: Real investment rates

	Mean	Std	Skew	Kurt	5th	25th	50th	75th	95th	ρ_1
$I_{it}^{\$}/K_{it}^{\$}$	23.84	37.20	3.33	14.28	−1.97	6.19	13.03	26.70	87.07	0.34
I_{it}/K_{it}	20.43	31.48	3.30	14.15	−1.72	5.42	11.37	23.07	73.97	0.33
$(\text{CAPX}-\text{SPPE})/K_{it}^{\$}$	19.36	24.71	3.08	11.99	1.44	6.46	11.89	22.00	63.80	0.51
	f_-	f_0	$f_{0.2}^-$	$f_{0.3}^-$	$f_{0.4}^-$	$f_{0.5}^-$	$f_{0.2}^+$	$f_{0.3}^+$	$f_{0.4}^+$	$f_{0.5}^+$
$I_{it}^{\$}/K_{it}^{\$}$	5.51	2.85	1.26	0.73	0.44	0.28	32.66	20.70	14.49	10.80
I_{it}/K_{it}	5.42	3.26	1.08	0.58	0.33	0.21	28.19	17.34	11.88	8.76
$(\text{CAPX}-\text{SPPE})/K_{it}^{\$}$	1.81	2.72	0.36	0.22	0.15	0.10	27.52	15.85	10.26	7.24

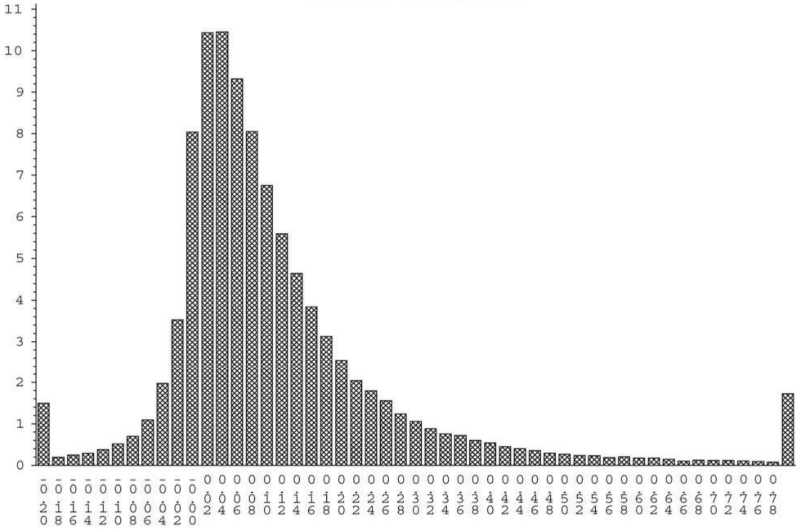
Results

Asymmetric firm-level investment rates; the fractions of negative, inactive, and positive rates: 5.51%, 2.85%, and 91.64%, respectively



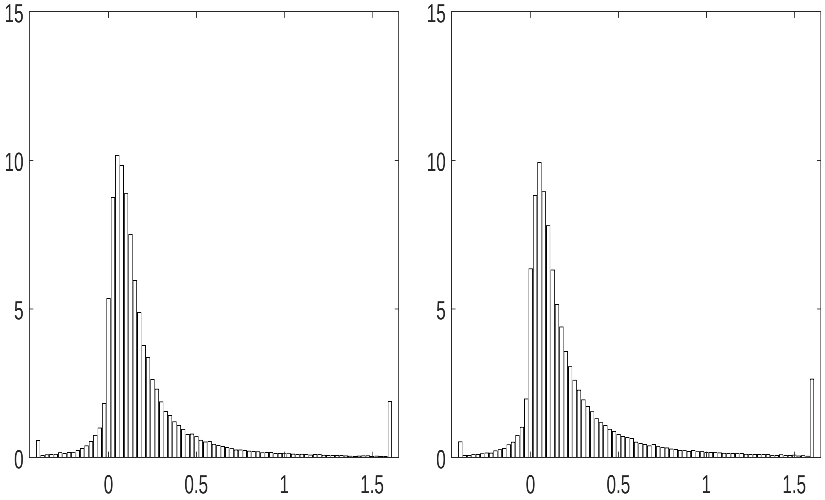
Results

Asymmetric plant-level investment rates (Cooper and Haltiwanger 2006); the fractions of negative, inactive, and positive rates: 10.4%, 8.1%, and 81.5%, respectively

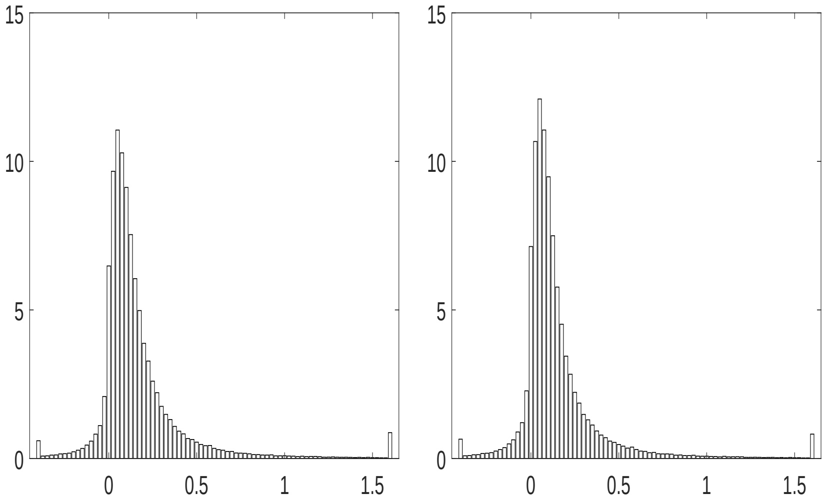


Results

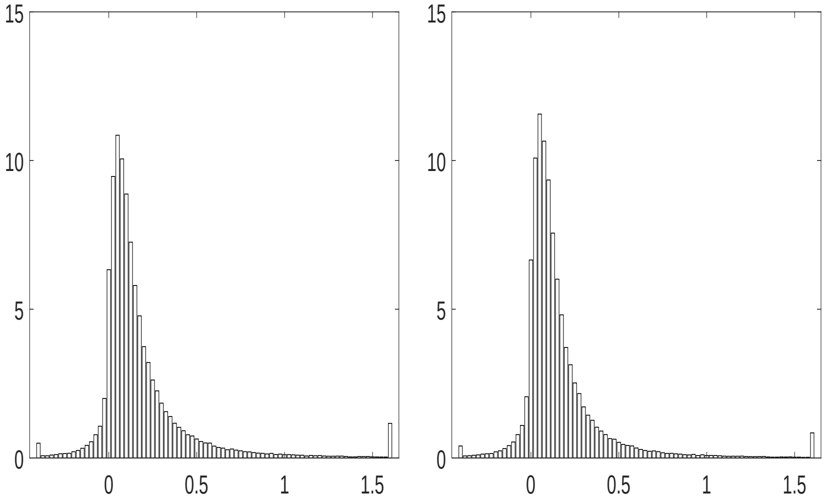
Asymmetric investment rates: 1963–1991 versus 1992–2020



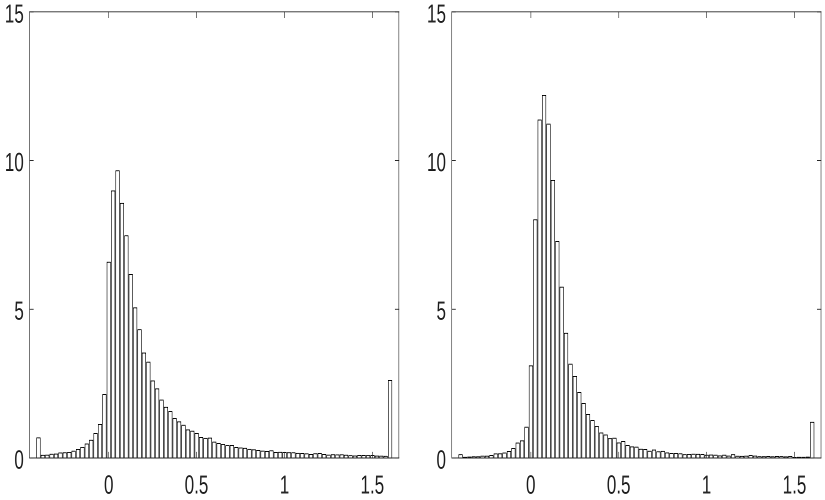
Asymmetric investment rates: $(I\text{–CAPX})/K^{\$} \leq 15\%$ versus $(I\text{–CAPX})/K^{\$} \leq 5\%$

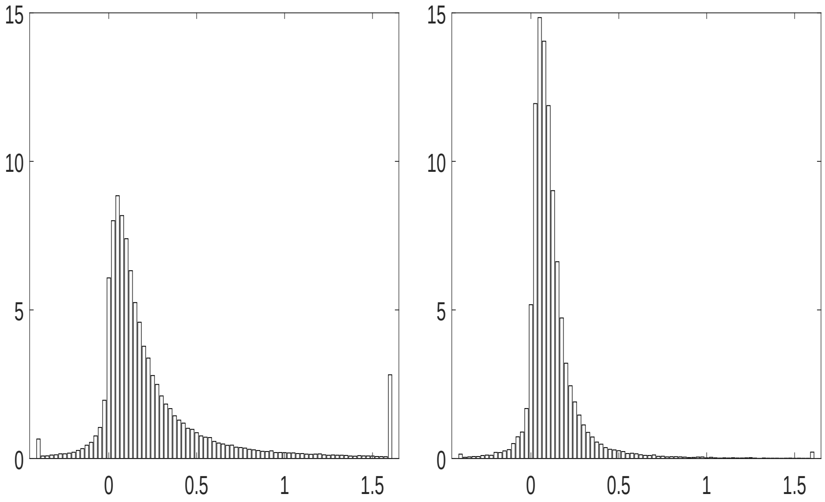


Asymmetric investment rates: No first 3 years versus no first 5 years of observations



Asymmetric investment rates: Small market equity versus big market equity

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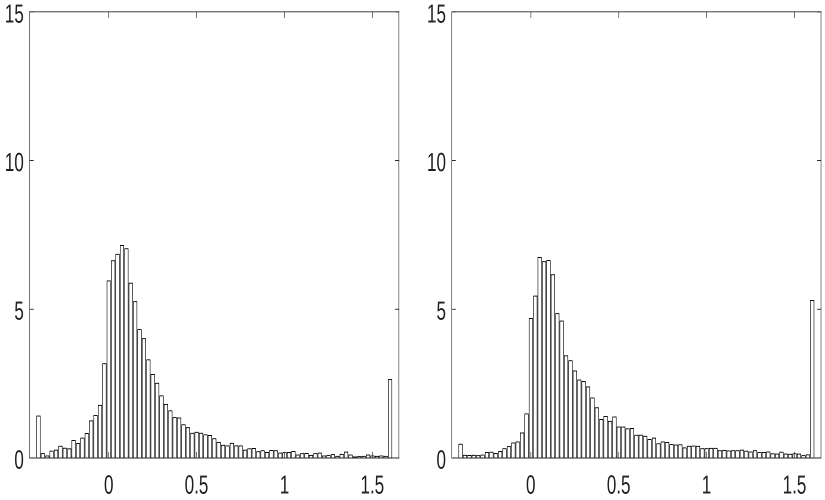
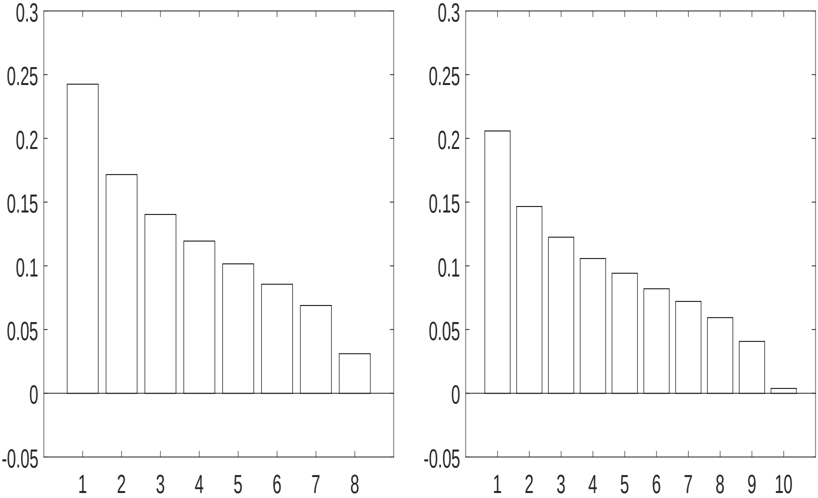
Asymmetric investment rates: Mining versus information sector (2 out of 19)

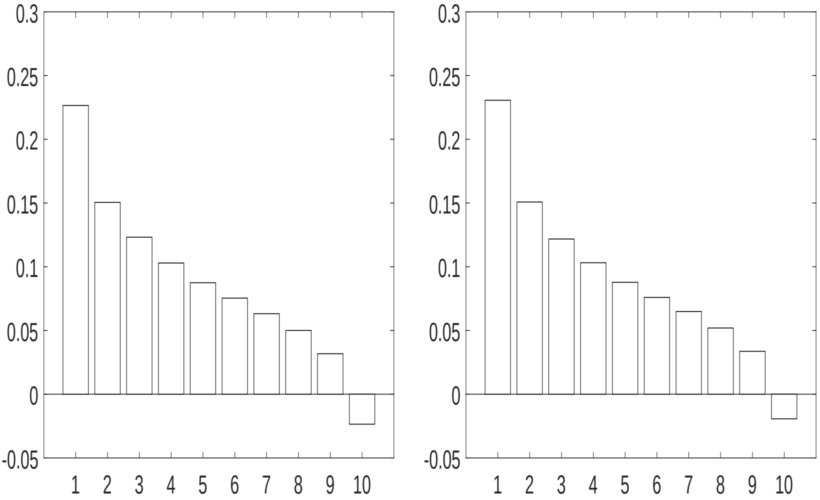


Results

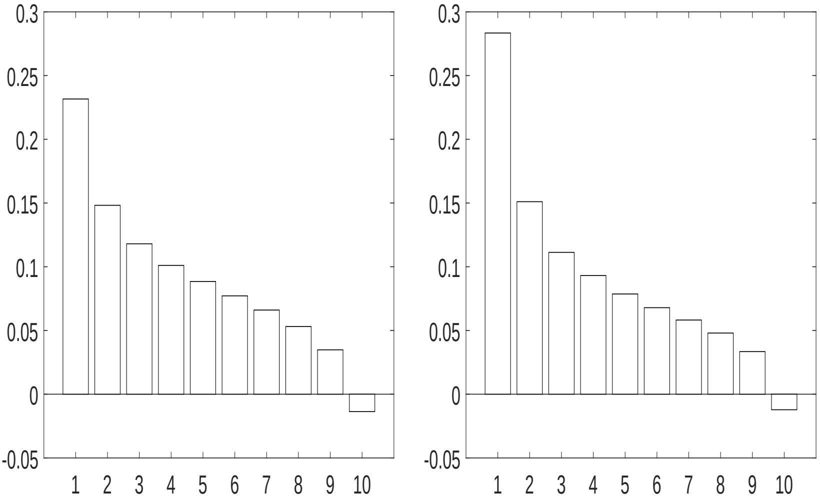
Lumpy investment: For a typical firm, 39% of total $|I_{it}^{\$}|$ done within 20% of the years in the Doms-Dunne (1998) tests; balanced panels by decade; 1963–1970 (768, 41.41%) and 1971–1980 (1,218, 35.24%)



Lumpy investment: 1981–1990 (1,361, 37.71%) and 1991–2000 (1,490, 38.14%)



Lumpy investment: 2001–2010 (1,637, 37.98%) and 2011–2020 (1,281, 43.45%)

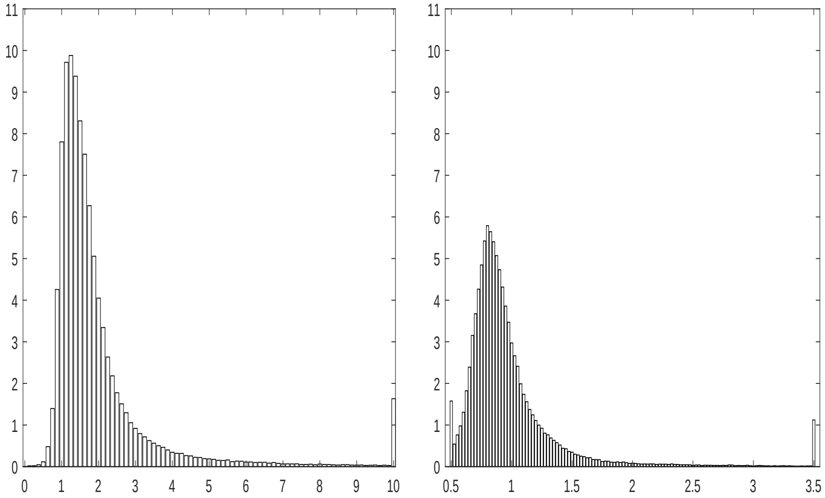


Differences between current- and historical-cost investment rates, 1963–2020

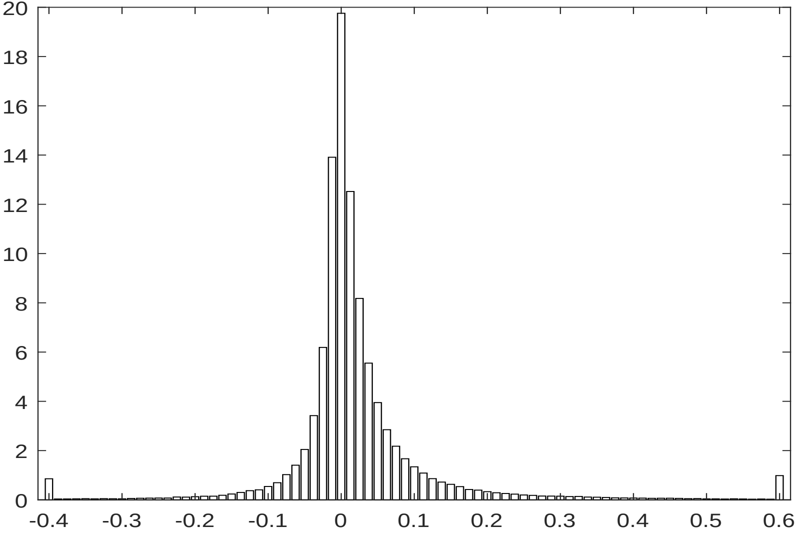
	Mean	Std	Skew	Kurt	5th	25th	50th	75th	95th	ρ_1
$I^{\$}_{it}/K^{\$}_{it}$	23.84	37.20	3.33	14.28	−1.97	6.19	13.03	26.70	87.07	0.34
I^{H}_{it}/K^{H}_{it}	40.27	62.90	3.47	15.84	−3.95	11.05	22.78	45.33	141.65	0.25
$K^{\$}_{it}/K^{H}_{it}$	2.11	1.79	3.58	16.82	1.01	1.29	1.61	2.16	4.85	0.90
δ_{it}	6.90	1.96	0.65	1.37	3.69	5.91	6.86	7.60	10.69	0.98
δ^{H}_{it}	20.94	16.65	2.01	6.08	4.75	10.81	16.10	26.23	50.69	0.79
$K^{\$}_{it}$/PPEGT	0.98	0.42	3.23	14.86	0.64	0.78	0.88	1.03	1.61	0.91
$K^{\$}_{it}$/AT	0.53	0.39	1.22	1.48	0.09	0.24	0.43	0.73	1.30	0.97
I^{H}_{it}/PPEGT	21.47	34.16	3.48	15.62	−2.11	5.82	11.82	23.66	77.37	0.33
$I^{\$}_{it}/K^{\$}_{it} - I^{H}_{it}$/PPEGT	2.66	9.64	1.04	10.89	−6.79	−0.39	1.35	4.22	16.91	0.48
	f_{-}	f_0	$f^{-}_{0.2}$	$f^{-}_{0.3}$	$f^{-}_{0.4}$	$f^{-}_{0.5}$	$f^{+}_{0.2}$	$f^{+}_{0.3}$	$f^{+}_{0.4}$	$f^{+}_{0.5}$
$I^{\$}_{it}/K^{\$}_{it}$	5.51	2.85	1.26	0.73	0.44	0.28	32.66	20.70	14.49	10.80
I^{H}_{it}/K^{H}_{it}	6.01	1.48	2.18	1.45	0.99	0.66	53.94	37.64	27.53	21.05
I^{H}_{it}/PPEGT	5.59	2.87	1.16	0.64	0.35	0.21	28.92	17.99	12.46	9.20

Results

$K_{it}^{\$}$/PPENT (169,828 firm-years) versus $K_{it}^{\$}$/PPEGT (169,509 firm-years)



$I^{\$}_{it}/K^{\$}_{it} - I^{H}_{it}/\text{PPEGT}$ (169,509 firm-years)



Conclusion

Broad impact on empirical finance, applied theories, and macroeconomics

Building the data infrastructure of firm-specific current-cost capital stocks for the entire Compustat sample

Characterizing accurately firm-level investment rate properties, including its asymmetry and lumpiness