Sticky Discount Rates

Masao Fukui (Boston University)
Niels Joachim Gormsen (University of Chicago)
Kilian Huber (University of Chicago)

Introduction

Modern Macro

- Price/wage rigidity crucial for fiscal and monetary policy

Introduction

Modern Macro

- Price/wage rigidity crucial for fiscal and monetary policy

This paper: New type of rigidity

- Firm discount rates (required returns to capital) are sticky w.r.t. inflation
- Inflation affects real discount rates and investment

Introduction

Modern Macro

- Price/wage rigidity crucial for fiscal and monetary policy

This paper: New type of rigidity

- Firm discount rates (required returns to capital) are sticky w.r.t. inflation
- Inflation affects real discount rates and investment

Sticky discount rates lead to

1. New source of monetary non-neutrality
2. Demand shocks or fiscal spending "crowd in" investment
3. Interest rate policy less effective, inflation target more effective

Conceptual Overview

Firm Investment and Textbook Neutrality

Firms' typical decision rule

- Invest in projects for which

$$\text{nominal expected return} > \delta,$$

where $\delta =$ nominal discount rate (required return)

Firm Investment and Textbook Neutrality

Firms' typical decision rule

- Invest in projects for which
$$\text{nominal expected return} > \delta,$$
where δ = nominal discount rate (required return)

Textbook approach

- δ should be the project's cost of capital: $i = r + \pi$
  - r = real cost of capital (long-run interest rate)
  - π = expected inflation (long-run)

Firm Investment and Textbook Neutrality

Firms' typical decision rule

- Invest in projects for which
$$\text{nominal expected return} > \delta,$$
where δ = nominal discount rate (required return)

Textbook approach

- δ should be the project's cost of capital: $i = r + \pi$
  - r = real cost of capital (long-run interest rate)
  - π = expected inflation (long-run)
- Implies inflation neutrality of discount rates
  - $\delta^{\text{real}} = \delta - \pi = r$
  - Real investment depends on Δr and not $\Delta\pi$

Stickiness in Investment Decisions

Textbook approach

- $\delta^{\text{real}} = \delta - \pi = r$
  - $r =$ real cost of capital (long-run interest rate)
  - $\pi =$ expected inflation (long-run)

Stickiness in Investment Decisions

Textbook approach

- $\delta^{\text{real}} = \delta - \pi = r$
  - $r =$ real cost of capital (long-run interest rate)
  - $\pi =$ expected inflation (long-run)

Sticky discount rate approach

- What if frictions prevent firms from constantly changing δ?

Stickiness in Investment Decisions

Textbook approach

- $\delta^{\text{real}} = \delta - \pi = r$
  - $r =$ real cost of capital (long-run interest rate)
  - $\pi =$ expected inflation (long-run)

Sticky discount rate approach

- What if frictions prevent firms from constantly changing δ?
- In short run: $\Delta\delta \approx 0 \Rightarrow \Delta\delta^{\text{real}} \approx -\Delta\pi$
- Inflation directly impacts real investment

Stickiness in Investment Decisions

Textbook approach

- $\delta^{\text{real}} = \delta - \pi = r$
  - $r =$ real cost of capital (long-run interest rate)
  - $\pi =$ expected inflation (long-run)

Sticky discount rate approach

- What if frictions prevent firms from constantly changing δ?
- In short run: $\Delta\delta \approx 0 \Rightarrow \Delta\delta^{\text{real}} \approx -\Delta\pi$
- Inflation directly impacts real investment
- Not today: potential frictions
  - Commitment device against managerial empire building (Jensen 1986)
  - Prevent internal power struggles (Rajan et al. 2000; Graham 2022)
  - Inattention, but only w.r.t. discount rate (Reis 2006; Coibion and Gorodnichenko 2015)

Data

Data from Corporate Conference Calls

Use data on δ from conference calls (Gormsen and Huber 2024)

Data from Corporate Conference Calls

Use data on δ from conference calls (Gormsen and Huber 2024)

Example Nasdaq 100 firm Intuit, Q1-2014:
We invest in opportunities that yield 15%-plus. Our weighted average cost of capital is about 9 or 9.5% ... Our IRR hurdle is a 15% rate of return.

- Discount rate: 15%
- Perceived COC: 9.25%

Data from Corporate Conference Calls

Use data on δ from conference calls (Gormsen and Huber 2024)

Example Nasdaq 100 firm Intuit, Q1-2014:
We invest in opportunities that yield 15%-plus. Our weighted average cost of capital is about 9 or 9.5% ... Our IRR hurdle is a 15% rate of return.

Data features

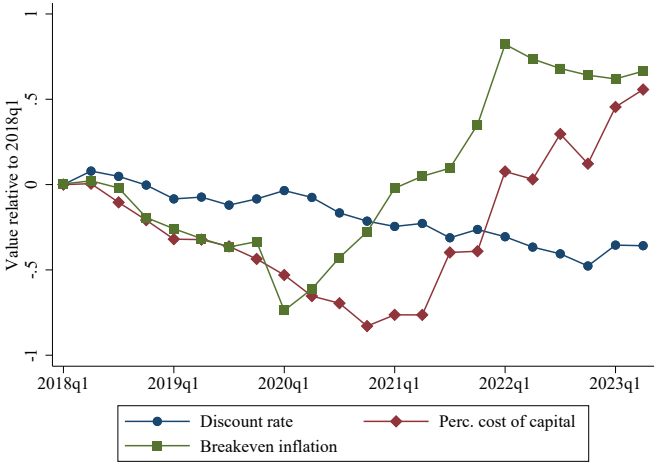
- based on repeated, high-stakes interactions, calls cited in lawsuits (Rogers et al. 2011)
- firms with multiple discount rates cover 18% of total global Compustat assets
- firms representative, except larger
- predicted data: costofcapital.org

Data Verification

- Extensive analysis in Gormsen and Huber (2024)
- Key finding: discount rates predict investment

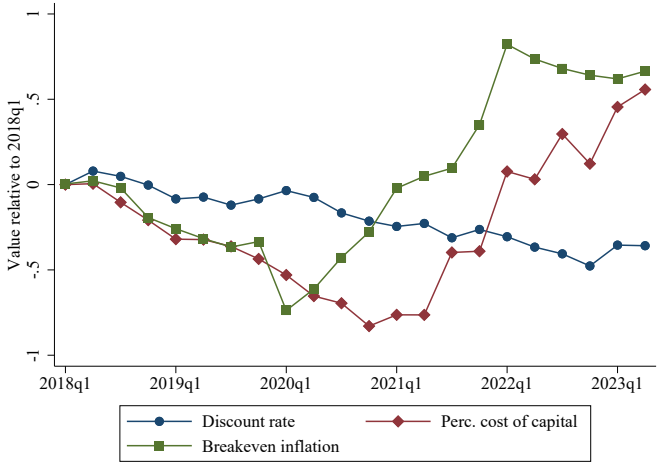
Empirical Evidence

Example of the “Soaring 20s”



Fin. markets expect inflation (10 yr breakeven, long run)

Example of the “Soaring 20s”



Fin. markets expect inflation (10 yr breakeven, long run)

Firms expect inflation (also in Coibion-Gorodnichenko survey) and increase perceived COC

But: discount rates are sticky

Global Evidence of Stickiness wrt. Inflation: 2002-23

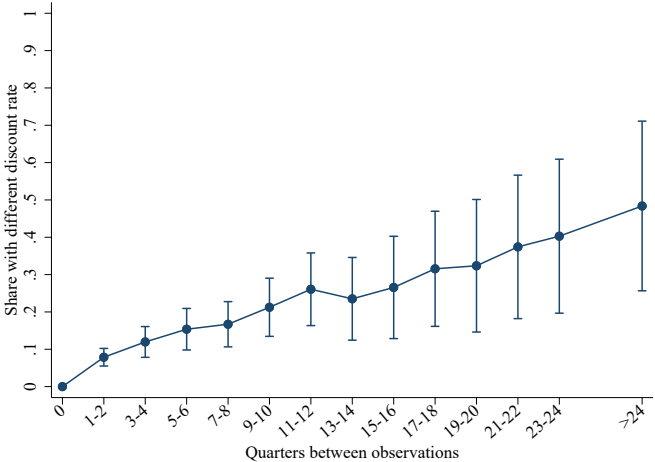
	CoC	DiRa	Real Dira	Dira - CoC
Breakeven inflation (10 yr)	0.20**	-0.040	-1.04***	-0.23**
	(0.093)	(0.086)	(0.086)	(0.099)
Observations	1,547	1,546	1,546	1,546
FE	Firm	Firm	Firm	Firm

Cost of capital perceived by firms moves with expected inflation

Discount rates do not

Wedge statistically significant, so empirical approach has power

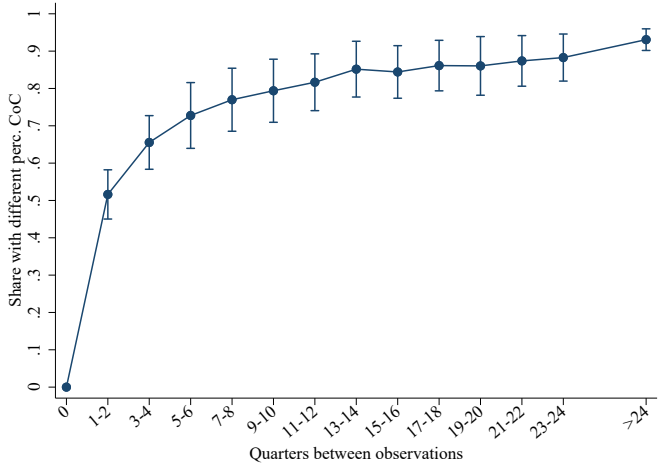
Changes in Discount Rates Are Rare



$\tilde{5}$% of firms change discount rate in first quarters

Consistent with survey by Graham (2022) and Sharpe and Suarez (2021)

Majority Change Their Perceived CoC



Consistent: firm cash flows and prices respond to expected inflation (Coibion et al. 2020; Meyer et al. 2021; Andrade et al. 2022; Bunn et al. 2022)

Expected Inflation Raises Investment of Stickier Firms

Expected Inflation Raises Investment of Stickier Firms

	Net investment rate	
I(Stickiness = 1) × Breakeven (10 yr)	1.99**	
	(0.84)	
Stickiness × Breakeven (10 yr)		2.12***
		(0.66)
Observations	6,053	6,053
Firm & year FE	Yes	Yes

Stickiness = firm-level fraction of observations where firm has same discount rate

Expected Inflation Raises Investment of Stickier Firms

	Net investment rate	
I(Stickiness = 1) × Breakeven (10 yr)	1.99**	
	(0.84)	
Stickiness × Breakeven (10 yr)		2.12***
		(0.66)
Observations	6,053	6,053
Firm & year FE	Yes	Yes

Stickiness = firm-level fraction of observations where firm has same discount rate

Interaction not driven by other observables (e.g., size, market power, leverage, CoC, sector)

Partial Equilibrium Model

Firm Problem with Sticky Discount Rates

Two-step setup: (1) Choose δ. (2) Choose investment given δ.

(2) Textbook investment problem:

$$V_t^I(k,\delta_t) = \max_{k',I} \Omega_t(k) - P_t(I+\Phi(I,k)) + \frac{1}{1+\delta_t}\mathbb{E}_t V_{t+1}^I(k',\delta_t)$$
$$\text{s.t.} \quad k' = (1-\xi)k + I$$

Solution: investment policy $I_t(k,\delta_t)$

Choice of Optimal Discount Rate

(1) Random fraction $1-\theta$ can adjust δ_t

Adjusters max. fin. market value:

$$V_t^a(k) = \max_{\delta_t} \Omega_t(k) - P_t(I + \Phi(I,k)) + \frac{1}{1+i_t}\mathbb{E}_t\left[\theta V_{t+1}^n(k',\delta_t) + (1-\theta)V_{t+1}^a(k')\right]$$

$$\text{s.t.} \quad k' = (1-\xi)k + I,$$

$$I = I_t(k,\delta_t)$$

Choice of Optimal Discount Rate

(1) Random fraction $1-\theta$ can adjust δ_t

Adjusters max. fin. market value:

$$V_t^a(k) = \max_{\delta_t} \Omega_t(k) - P_t(I + \Phi(I,k)) + \frac{1}{1+i_t}\mathbb{E}_t\left[\theta V_{t+1}^n(k',\delta_t) + (1-\theta)V_{t+1}^a(k')\right]$$

$$\text{s.t.} \quad k' = (1-\xi)k + I,$$

$$I = I_t(k,\delta_t)$$

First-order solution:

$$\delta_t = \theta\hat{\delta}_{t-1} + (1-\theta)\hat{\delta}_t^*$$

$$\hat{\delta}_t^* = \frac{1+r-\theta}{1+r}\widehat{coc}_t + \frac{\theta}{1+r}\hat{\delta}_{t+1}^*$$

Choice of Optimal Discount Rate

(1) Random fraction $1-\theta$ can adjust δ_t

Adjusters max. fin. market value:

$$V_t^a(k) = \max_{\delta_t} \Omega_t(k) - P_t(I+\Phi(I,k)) + \frac{1}{1+i_t}\mathbb{E}_t\left[\theta V_{t+1}^n(k',\delta_t) + (1-\theta)V_{t+1}^a(k')\right]$$

$$\text{s.t.} \quad k' = (1-\xi)k + I,$$

$$I = I_t(k,\delta_t)$$

First-order solution:

$$\delta_t = \theta\hat{\delta}_{t-1} + (1-\theta)\hat{\delta}_t^*$$

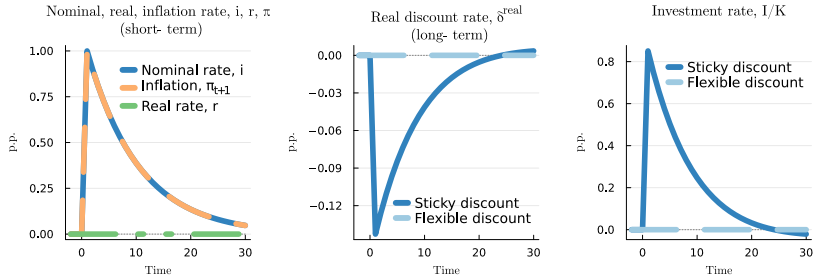
$$\hat{\delta}_t^* = \frac{1+r-\theta}{1+r}\widehat{coc}_t + \frac{\theta}{1+r}\hat{\delta}_{t+1}^*$$

$\theta = 0 \Rightarrow \hat{\delta}_t = \widehat{coc}_t \Rightarrow$ textbook solution

$\theta \neq 0 \Rightarrow \hat{\delta}_t \neq \widehat{coc}_t \Rightarrow$ investment differs from textbook

$\theta = 0.95$ in data, 5% change per quarter

Key Mechanism 1: Expected Inflation and Investment



Recall: $i = r + \pi$

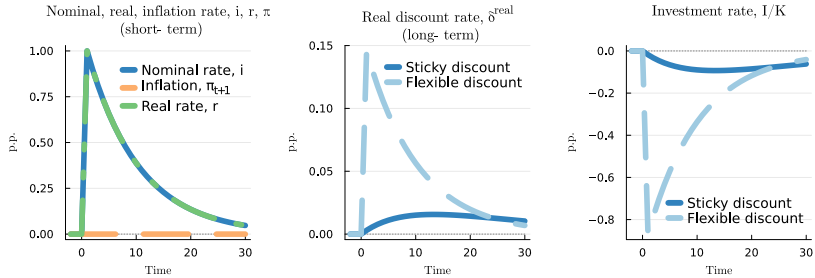
$\delta^{real} = \delta - \pi$

Shock only π (partial equilibrium)

Flexible: $\pi \uparrow \Rightarrow i \uparrow \Rightarrow \delta \uparrow \Rightarrow \delta^{real} \not\downarrow$

Sticky: $\pi \uparrow \Rightarrow i \uparrow \Rightarrow \delta \not\uparrow \Rightarrow \delta^{real} \downarrow$

Key Mechanism 2: Interest Rate Sensitivity



Recall: $i = r + \pi$

Shock only r (partial equilibrium)

Flexible: $r \uparrow \Rightarrow i \uparrow \Rightarrow \delta \uparrow \Rightarrow \delta^{\text{real}} \uparrow$

Sticky: $\pi \uparrow \Rightarrow i \uparrow \Rightarrow \delta \nearrow \Rightarrow \delta^{\text{real}} \nearrow$

Helps resolve the puzzle of why investment sensitivity is often too high

General Equilibrium Model

General Equilibrium

Augment standard NK model with sticky discount rates

- Sticky prices (0.75, Nakamura and Steinsson 2008) and hand-to-mouth households (30%)
- Taylor rule with shocks and inflation target: $\hat{i}_t = \pi_t^{\infty} + \phi_{\pi}(\hat{\pi}_t - \pi_t^{\infty}) + \varepsilon_t^m$
- Fiscal spending financed by initial deficit

General Equilibrium

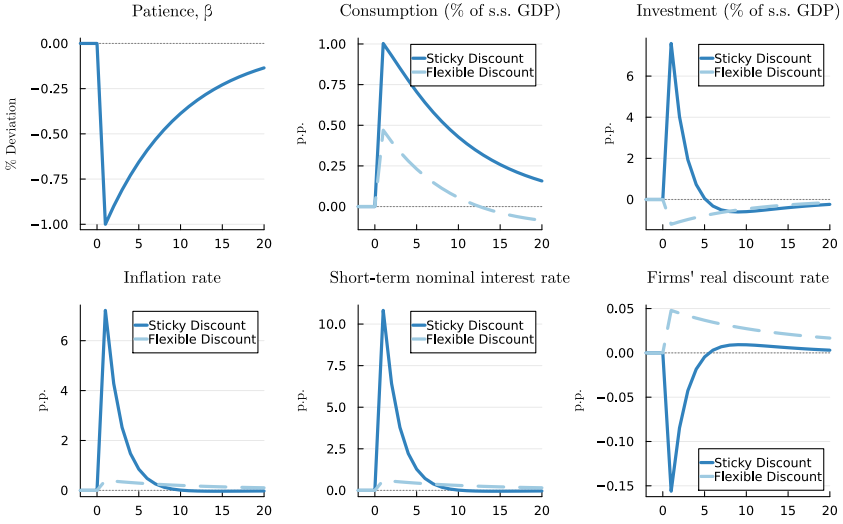
Augment standard NK model with sticky discount rates

- Sticky prices (0.75, Nakamura and Steinsson 2008) and hand-to-mouth households (30%)
- Taylor rule with shocks and inflation target: $\hat{i}_t = \pi_t^{\infty} + \phi_{\pi}(\hat{\pi}_t - \pi_t^{\infty}) + \varepsilon_t^m$
- Fiscal spending financed by initial deficit

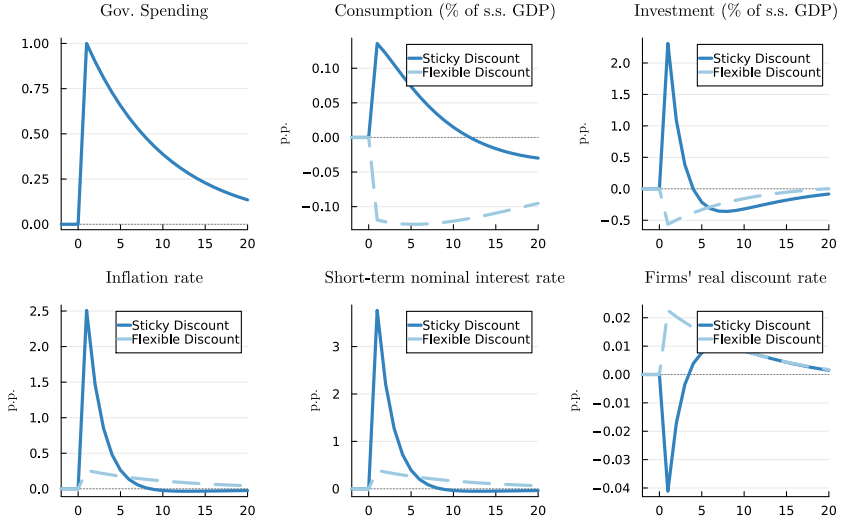
Findings

1. Household demand $\uparrow \Rightarrow$ consumption and investment $\uparrow \Rightarrow$ addresses "comovement puzzle" (Barro and King 1984)
2. Fiscal spending can "crowd in" investment
3. Monetary non-neutrality (even with flexible prices): inflation target $\uparrow \Rightarrow$ investment $\uparrow$
4. Policy rate shock $\Rightarrow$ investment $\nearrow$ (less than textbook)

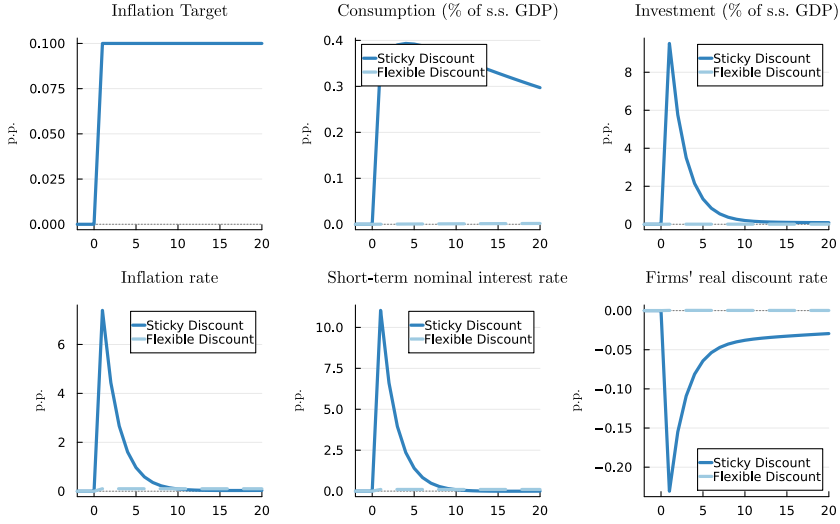
Demand Shocks Generate Comovement



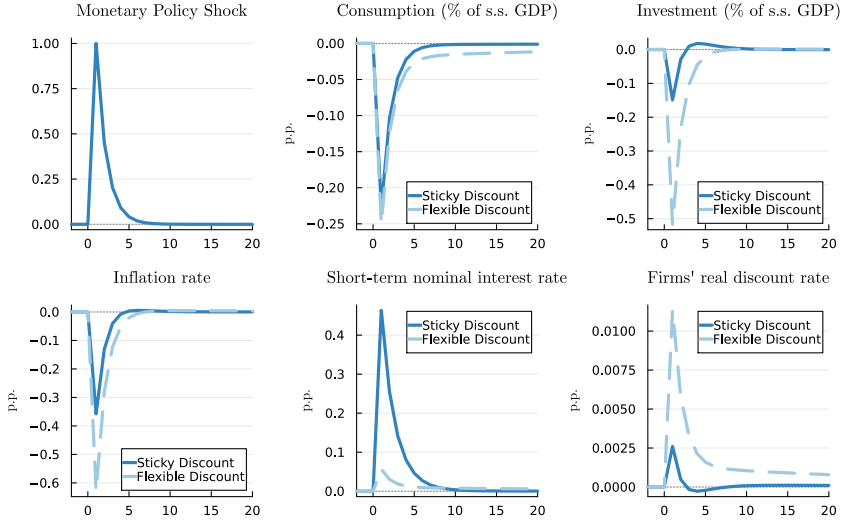
Fiscal Spending Can Crowd In Investment



Long-Run Inflation Target Raises Investment



Monetary Policy Shocks Work, But Less Strongly



Lessons for Optimal Policy

Sticky discount rates introduce new inefficiencies

1. misallocation across firms: same technology, different investment
2. suboptimal aggregate investment

Central banks with credible future policy

- change long-run target in response to temporary shocks
- most effective way of closing discount rate wedges
- low welfare losses from sticky discount rates, albeit (small) cost due to long-run inflation

Summary

Discount rates are sticky w.r.t. inflation

Direct link from exp. inflation to investment

Implications for macro models

1. Monetary non-neutrality (even with flexible prices)
2. Changes in inflation targets can stimulate the economy
3. Demand shocks or fiscal policy can crowd in investment
4. Changes in exp. inflation and inflation targets may be effective policy tools

Details on First-Order Solution

Discount rate choice:

$$\hat{\delta}_t = \theta\hat{\delta}_{t-1} + (1-\theta)\hat{\delta}^*_t$$
$$\hat{\delta}^*_t = \frac{1+r-\theta}{1+r}\widehat{coc}_t + \frac{\theta}{1+r}\hat{\delta}^*_{t+1},$$

Details on First-Order Solution

Discount rate choice:

$$\hat{\delta}_t = \theta\hat{\delta}_{t-1} + (1-\theta)\hat{\delta}^*_t$$
$$\hat{\delta}^*_t = \frac{1+r-\theta}{1+r}\widehat{coc}_t + \frac{\theta}{1+r}\hat{\delta}^*_{t+1},$$

- $\theta = 0 \Rightarrow \hat{\delta}_t = \widehat{coc}_t \Rightarrow$ textbook solution
- $\theta \neq 0 \Rightarrow \hat{\delta}_t \neq \widehat{coc}_t \Rightarrow$ investment differs from textbook
- $\theta = 0.95$ in data, 5% change per quarter

Investment choice:

$$\hat{I}_t - \hat{K}_t = \frac{1}{\xi\phi}\left[\hat{q}_t - \frac{1+r}{r}\underbrace{\left(\hat{\delta}_t - \widehat{coc}_t\right)}_{\text{discount rate wedge}}\right]$$

Global Evidence 2002-19

	CoC	DiRa	Wedge	Wedge
Breakeven inflation (10 yr)	0.23**	0.06	-0.23*	-0.29**
	(0.11)	(0.11)	(0.12)	(0.13)
Observations	1,547	1,546	1,546	1,546
FE	Firm	Firm	Firm	Firm/year

Similar results in sample up to 2019

Global Evidence 2002-23

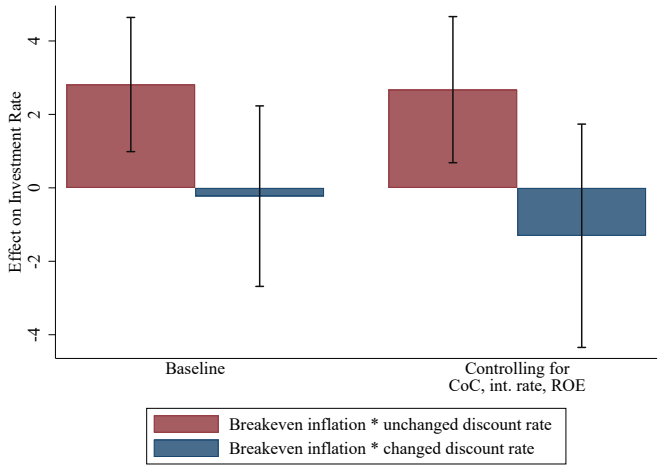
	CoC	DiRa	Wedge	Wedge
Breakeven inflation (10 yr)	0.49***	0.07	-0.65***	-0.64***
	(0.14)	(0.10)	(0.11)	(0.15)
Real CoC (10 yr CAPM)	0.36***	0.10**	-0.36***	-0.48***
	(0.11)	(0.02)	(0.06)	(0.09)
Observations	1,547	1,546	1,546	1,546
FE	Firm	Firm	Firm	Firm/year

Cost of capital perceived by firms moves with expected inflation

Discount rates do not

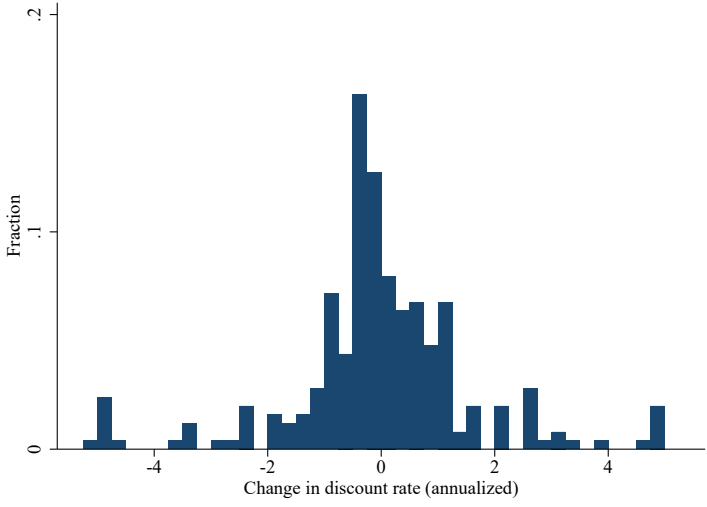
Wedge statistically significant, so empirical approach has power

Expected Inflation Raises Investment If Discount Rates Unchanged



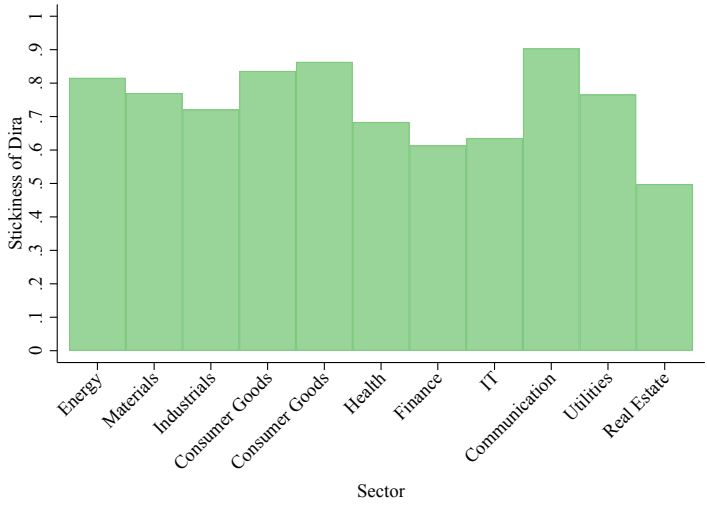
Unchanged discount rate = firm has same discount rate across two observations

Non-Zero Annualized Changes in Discount Rates



Dispersed changes in discount rates, analogous to Calvo (1983) (see Alvarez et al. 2016)

Sticky Discount Rates Across Sectors



Examples of Firm Behavior

Attention to COC

Premier, CFO, Q1-2017: *"We obviously, with changing markets, always reassess what our weighted average cost of capital is and whether that return hurdle needs to change."*

Partial incorporation

Spectra Energy, CFO, Q3-2014: *"We didn't lower our hurdle rates all the way down with long-term rates. We are still looking at returns of, say 10%, on average for our projects."*

No change

Ball Corp, CFO, Q3-2015: *"The discount rate has been 9% for a long time. In fact, our weighted average cost of capital is less than 6% now, so people have said: why don't you lower the hurdle rate?"*

References

Alvarez, Fernando, Hervé Le Bihan, and Francesco Lippi, "The Real Effects of Monetary Shocks in Sticky Price Models: A Sufficient Statistic Approach," *American Economic Review*, 2016, *106* (10), 2817–2851.

Andrade, Philippe, Olivier Coibion, Erwan Gautier, and Yuriy Gorodnichenko, "No Firm is an Island? How Industry Conditions Shape Firms' Expectations," *Journal of Monetary Economics*, 2022, *125*, 40–56.

Barro, Robert J. and Robert G. King, "Time-Separable Preferences and Intertemporal-Substitution Models of Business Cycles," *Quarterly Journal of Economics*, 1984, *99* (4), 817–839.

Bunn, Philip, Lena S. Anayi, Nicholas Bloom, Paul Mizen, Gregory Thwaites, and Ivan Yotzov, "Firming up Price Inflation," 2022.

Calvo, Guillermo A., "Staggered Prices in a Utility-Maximizing Framework," *Journal of Monetary Economics*, 1983, *12* (3), 383–398.

Coibion, Olivier and Yuriy Gorodnichenko, "Information Rigidity and the Expectations Formation Process: A Simple Framework and New Facts," *American Economic Review*, 2015, *105* (8), 2644–2678.

——, ——, and Tiziano Ropele, "Inflation Expectations and Firm Decisions: New Causal Evidence," *Quarterly Journal of Economics*, 2020, *135* (1), 165–219.

Gormsen, Niels J. and Kilian Huber, "Corporate Discount Rates," 2024.

Graham, John R., "Presidential Address: Corporate Finance and Reality," *Journal of Finance*, 2022, *77* (4), 1975–2049.

Jensen, Michael C., "Agency Costs of Free Cash Flow, Corporate Finance, and Takeovers," *American Economic Review*, 1986, *76* (2), 323–329.

Meyer, Brent, Nicholas Parker, and Xuguang Sheng, "Unit Cost Expectations and Uncertainty: Firms' Perspectives on Inflation," 2021. FRB Atlanta Paper 2021-12a.

Nakamura, Emi and Jón Steinsson, "Five Facts about Prices: A Reevaluation of Menu Cost Models," *Quarterly Journal of Economics*, 2008, *123* (4), 1415–1464.

Rajan, Raghuram, Henri Servaes, and Luigi Zingales, "The Cost of Diversity: The Diversification Discount and Inefficient Investment," *Journal of Finance*, 2000, *55* (1), 35–80.

Reis, Ricardo, "Inattentive Producers," *Review of Economic Studies*, 2006, *73* (3), 793–821.

Rogers, Jonathan L., Andrew Van Buskirk, and Sarah L.C. Zechman, "Disclosure Tone and Shareholder Litigation," *Accounting Review*, 2011, *86* (6), 2155–2183.

Sharpe, Steven A. and Gustavo A. Suarez, "Why Isn't Business Investment More Sensitive to Interest Rates? Evidence from Surveys," *Management Science*, 2021, *67* (2), 720–741.