Bank Loan Reliance and Inflation Inattention [1]

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[1] The views expressed here should not be interpreted as representing the views of the Bank of Italy or any other institution with which the authors are affiliated.

Motivation

- **Central banks care about firms' inflation expectations**

  Janet Yellen (2016): How (firms') expectations are formed has taken on heightened importance, . . . many central banks have adopted policies that are directly aimed at influencing expectations of future interest rates and inflation.

  While ...
  $\Rightarrow$ Dispersed inflation expectations among firms
  $\Rightarrow$ Limited understanding on inflation expectation formation (no causal evidence)

Motivation

Three natural questions:

1. Why firm's inflation expectation and attentiveness matter?
   - ⋆ Effectiveness of monetary policy
   - ⋆ Firms' decisions on financing, investment, etc.
2. Do firms' financing structure affect attention to inflation?
   - ⋆ Yes, through real financing costs
3. How firm's reliance on bank loans affect their inflation expectation formation and learning process?
   - ⋆ I find firms with higher loan reliance have more incentive to learn about inflation

- Identification is challenging without a reliable instrument and micro-level data
- Limited empirical evidence on rational inattention theory

Empirics

- **Causal empirical evidence on how financing composition affects inflation attentiveness and inflation expectations**
  - Data: merged administrative and survey micro-data on Italian firms
  - Identification
    1. Bartik instrument
    2. Exogenous information treatment (RCT)
  - Findings:
    1. Higher loan reliance $\Rightarrow$ More accurate inflation forecasts
    2. Higher loan reliance $\Rightarrow$ Smaller responses to treatment

Theory

- **Partial-equilibrium model with rational inattention**
  1. Inflation affects the relative cost of external v.s. internal financing
  2. External financing (bank loan) cost is affected by inflation via policy rate.
  3. $\uparrow$ Loan reliance $\Rightarrow$ $\uparrow$ exposure to inflation (financing cost) $\Rightarrow$ $\uparrow$ incentive to acquire and process information

- **Calibrate the information processing cost parameter by matching the model with empirics**

- **Replicating the empirical findings**
  1. Negative relationship between loan reliance and inflation inattention
  2. Simulated RCT: highly loan-reliant firms respond less

- **Novel policy implications**
  1. Inattention leads to under-reaction to cost-push shocks
  2. More aggressive inflation-targeting rule $\Rightarrow$ firms pay more attention

Related Literature

- **Firms' inflation expectations and action**
  From Expectations to Actions: Coibion et al. (2018, New Zealand), Coibion et al. (2019, US), Boneva et al. (2020, UK), Andrade et al. (2021, France), Ropele et al. (2022, Itlay), Ropele et al. (2024, Italy)
  From Traits to Expectations: Kumar (2020); Yang (2022); Afrouzi (2023)

  My Contribution: the first causal evidence on financing structure affecting expectation formation

- **Rational inattention**
  Sims (2003); Woodford (2009); Maćkowiak and Wiederhold (2009); Matějka (2016); Maćkowiak et al. (2018); Weber et al. (2023);

  My Contribution: findings on state-dependent inattention, the reference range for information processing cost

Road Map

- **Empirics**
  - Data and Measure
  - 2SLS with Bartik Instrument
  - RCT
- **Theory**
  - Rationally inattentive firms
  - Banking market and inflation pass-through
  - Implications

Data

- Data (2006 - 2019, quarterly)
  1. Survey of Inflation and Growth Expectations (SIGE)
     Firms' inflation expectations, a representative sample, RCT (since 2013Q1), conducted by the Bank of Italy
  2. Central Credit Registry (CCR)
     Firms' credit positions with banks and financial institutions
  3. Analytical Survey of Interest Rates (TAXIA)
     Loan interest rates, loan spread
  4. Company Accounts Data Service (CADS)
     Firm-level balance sheet data

Measurement

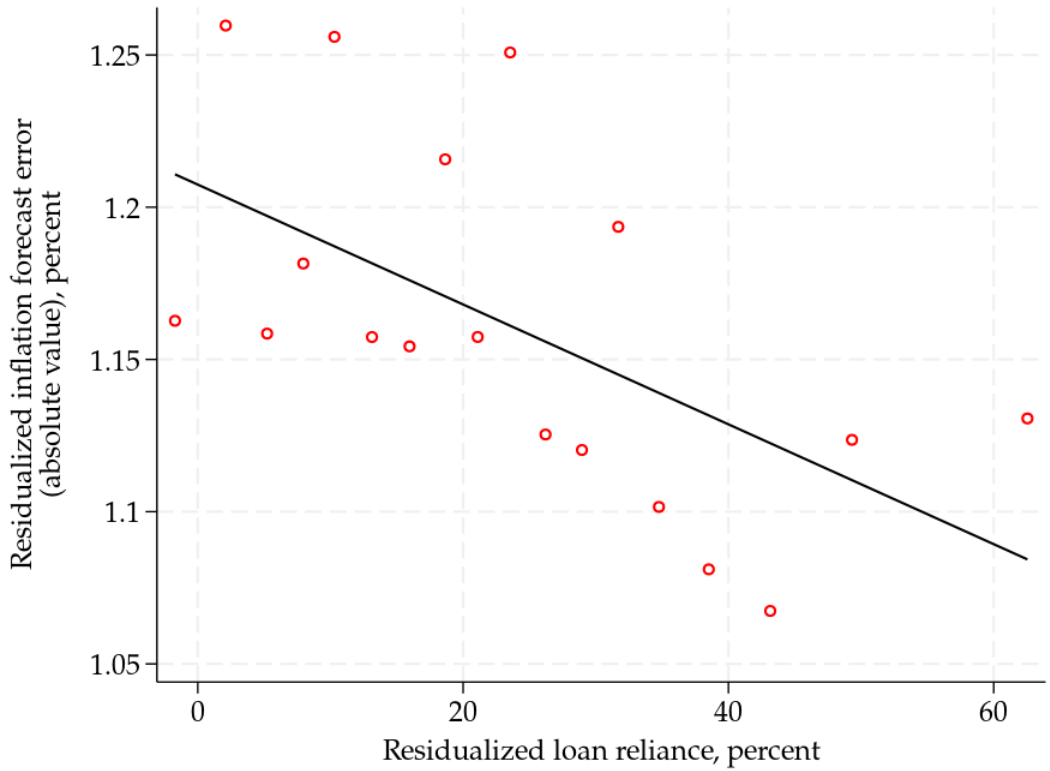
- Two main measures

1. Bank credit reliance: $\text{Loan Reliance}_{j,t} = \frac{\sum_{i \in \text{banks}} \text{Term Loan}_{i,j,t}}{\text{Asset}_{j,t}}$ plot
   - i, j, t for bank, firm, and time respectively
   - Term loan ($\sim$ 50% of total loans): loans mainly used for investment purposes (e.g. leasing, mortgages, and personal loans)
   - Asset: total balance sheet size

2. Inflation inattention: $\text{Inattention}_{j,t}^{(\pi)} \equiv \left| \pi_t^{(12m)} - F_j \pi_t^{(12m)} \right|$ plot
   - $\pi_t^{(12m)}$: 1-year ahead inflation
   - $F_j \pi_t^{(12m)}$: 1-year ahead inflation forecast

Suggestive Evidence: Loan Reliance and Inflation Inattention

Takeaway: higher loan-reliant firms exhibit lower forecast errors



Notes: loan reliance and inattention are residualized by controlling for observable fixed effects, including size, region, sector, and treatment status.

Causal Evidence I: Bartik Instrument

1. **Benchmark regression**

$$\text{Inattention}_{j,t}^{(\pi)} = \beta \text{ Loan Reliance}_{j,t} + \epsilon_{j,t}$$

2. **A Bartik instrument for loan reliance**

$$\bar{\delta}_{j,t} = \sum_{i \in \text{banks}} \underbrace{\frac{\text{Term Loan}_{i,j,t-1}}{\sum_{i \in \text{banks}} \text{Term Loan}_{i,j,t-1}}}_{\equiv \text{ Exposure}_{i,j,t-1}} \cdot \hat{\delta}_{i,t}.$$

- $Exposure_{i,j,t-1}$: (lagged) exposure of firm j to bank i
- $\hat{\delta}_{i,t}$: credit supply shock in bank i at time t (Khwaja and Mian 2008)

$$\ln R^B_{i,j,t} - \ln R_t = \underbrace{\delta_{i,t}}_{\text{credit supply}} + \underbrace{\lambda_{j,t}}_{\text{credit demand}} + \epsilon_{i,j,t}.$$

- $\ln R^B_{i,j,t}$: net loan interest rate between firm j and bank i at time t
- $\ln R_t$: net ECB deposit facility rate

Back to Local Projection

Causal Evidence I: 2SLS

	Dependent variable: Inattention$_{j,t}^{(\pi)}$					
	2SLS					OLS
	(1)	(2)	(3)	(4)	(5)	(6)
Loan Reliance	-0.121**	-0.120**	-0.101**	-0.116**	-0.0998**	-0.00206
	(0.0562)	(0.0553)	(0.0467)	(0.0523)	(0.0459)	(0.00128)
log(employees)		0.293*			0.231*	
		(0.151)			(0.117)	
ROE			-0.00385***		-0.00357***	
			(0.00131)		(0.00128)	
Liquid asset ratio				-0.0182***	-0.0163***	
				(0.00568)	(0.00548)	
Observations	16,886	16,886	15,467	15,885	15,282	16,886
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
RCT FE	Yes	Yes	Yes	Yes	Yes	Yes
1st stage F stat	13.33	13.68	16.07	14.76	16.67	
1st stage coeffi.	-0.0540	-0.0550	-0.0660	-0.0580	-0.0660	

Notes: Robust standard errors are used (Driscoll and Kraay, 1998).

Takeaway: 1 std ↑ in loan reliance (17 pp) → inattention decrease by 2 pp.

▸ Descriptive statistics

Causal Evidence II: RCT

- Randomized Controlled Trial (RCT) ▸ Survey Question
  - Treatment: information on current inflation ($\mathbb{I}_j = 1$)
  - Prior: one-year ahead inflation forecast in last quarter
  - Posterior: one-year ahead inflation forecast in this quarter
  - Two waves: (1) RCT first introduced; (2) treated firms redrawn

- Empirical Design:

$$\text{Posterior}_j = \alpha_1 \times \text{Prior}_j + \alpha_2 \times \text{Loan Reliance}_j \times \text{Prior}_j + \gamma_1 \times \mathbb{I}_j \times \text{Prior}_j + \gamma_2 \times \mathbb{I}_j \times \text{Loan Reliance}_j \times \text{Prior}_j + \cdots + \epsilon_j.$$

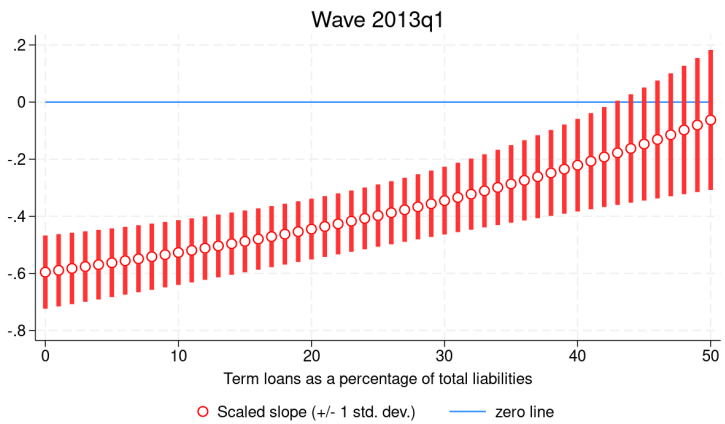
1. Control group: receive nothing, posterior = prior, $\alpha_1 = 1$
2. Treated group: receive treatment
   - 2.1 Treatment is new: posterior less persistent, $\alpha_1 + \gamma_1 < 1$
   - 2.2 Treatment isn't new = control group

$$\text{How } \textbf{persistent} \text{ are their posterior expectations} = \frac{\hat{\gamma}_1 + \hat{\gamma}_2 \text{Loan Reliance}}{\hat{\alpha}_1 + \hat{\alpha}_2 \text{Loan Reliance}}$$

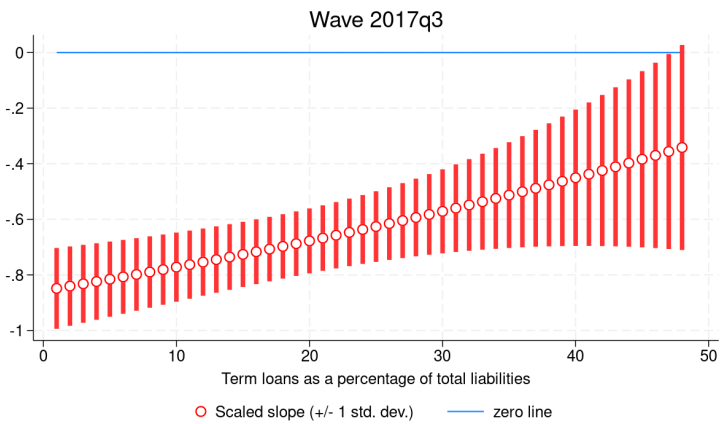
Causal Evidence II: RCT

$$\text{Scaled coefficient} = \frac{\hat{\gamma}_1 + \hat{\gamma}_2 \text{Loan Reliance}}{\hat{\alpha}_1 + \hat{\alpha}_2 \text{Loan Reliance}}$$

- Response to treatment, $\hat{\gamma} < 0$: treatment group places less weight (60% - 80%) on priors, more weight on the information treatment
- High loan-reliant firms respond less: inflation information is already known!



(a) First RCT



(b) Reshuffling

Empirical Evidence: Summary

Causal evidence about (in)attention:

1. High loan-reliant firms pay more attention to inflation and have more precise information
2. High loan-reliant firms respond less to information treatment because that is already in their information set

Why do firms with different financing structures have varying incentives to acquire and process information on aggregate inflation?

- ⋆ Theoretical model of rational (in)attention

Road Map

- **Empirics**
  - High loan-reliant firms pay more attention
  - High loan-reliant firms respond less to RCT
- **Theory**
  - Rational inattentive firms
  - Banking market and inflation pass-through
  - Implications: comparative statics, reference range of information costs, simulated RCT

The Model: Firms

- Two-stage problem with cash-in-advance capital investment

1. Cost minimization: share of internal funds ($\Gamma^I_{j,t}$) & bank loans ($\Gamma^B_{j,t}$)

$$\mathbf{M_{j,t}} \equiv \underset{\Gamma^I_{j,t},\Gamma^B_{j,t}}{\text{argmin}}\ \Gamma^I_{j,t} + \frac{R^B_{j,t}}{R_t}\Gamma^B_{j,t}, \text{ where: } \frac{R^B_{j,t}}{R_t} = \mathcal{F}(\Pi_t, \cdots),$$

2. Profit maximization: optimal capital $K_{j,t}$

$$\max_{K_{j,t}} \mathbb{E}_0 \sum_{t=1}^{\infty} \beta^t \left\{ K^{\phi}_{j,t} - \mathbf{M_{j,t}}[K_{j,t} - (1-\delta)K_{j,t-1}] \right\}.$$

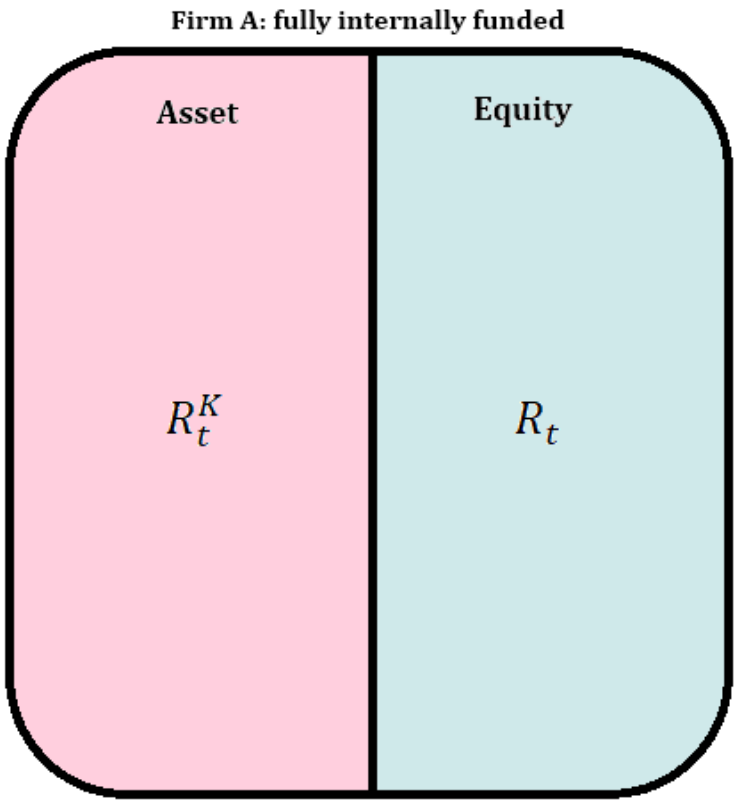
- $R^B_{j,t}/R_t$: interest rate spread between external and internal financing
- $\mathbf{M_{j,t}}$: unit financing cost for firm j at time t
- β: discount factor
- $\phi < 1$: decreasing return to scale
- δ: capital depreciation rate

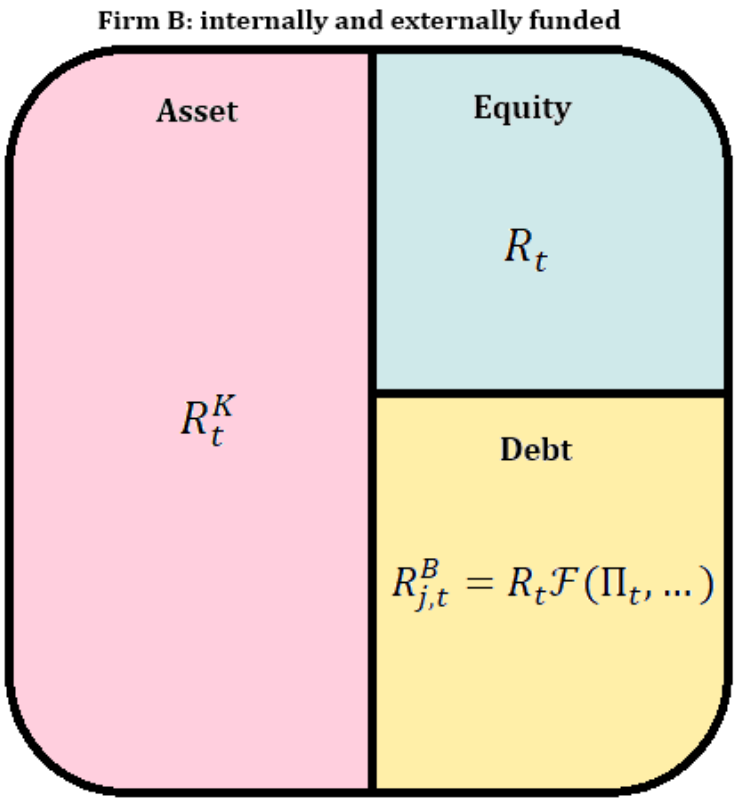
▸ $R^B_{j,t}/R_t$: micro-foundation

The Model: Why Do Firms Care about Inflation?

- **Mechanism:**

$$\underbrace{\pi_t \Rightarrow \text{loan spread } \mathcal{F}(\Pi_t, \cdots)}_{\text{Banking market}} \Rightarrow \text{financing cost } M_{j,t} \Rightarrow K_{j,t}$$





- **Inflation affects the real profits of the firm depending on its reliance on bank loans**

The Model: Banks

The banks operate in a monopolistically competitive market with

- Input: deposits (R_t)
- Output: bank loans (R_t^B)
- Calvo-type stickiness in setting the loan interest rate

The log-deviations in optimal loan interest rate is given by:

$$\hat{r}_t^{B,*} = (1 - \omega_b \beta)\mathbb{E}_t \sum_{s=0}^{\infty} \omega_b^s \beta^s \hat{r}_{t+s},$$

where

- $\hat{r}_t^{B,*}$: log-deviations in optimal loan rate if the bank could set rate
- ω_b : share of banks that could not adjust the loan interest rate
- $\hat{r}_{t+s}$: log-deviations in deposit rate at time $t + s$

The Model: Inflation and Loan Markup

- Monetary authority follows the Taylor rule:

$$R_t = R\left(\frac{\Pi_t}{\Pi}\right)^{\tau_\pi},$$

- Inflation follows an exogenous AR(1) process:

$$\Pi_t = \Pi_{t-1}^{\rho_\pi} exp(\epsilon_{\pi,t}).$$

How does inflation affect firms' financing costs?

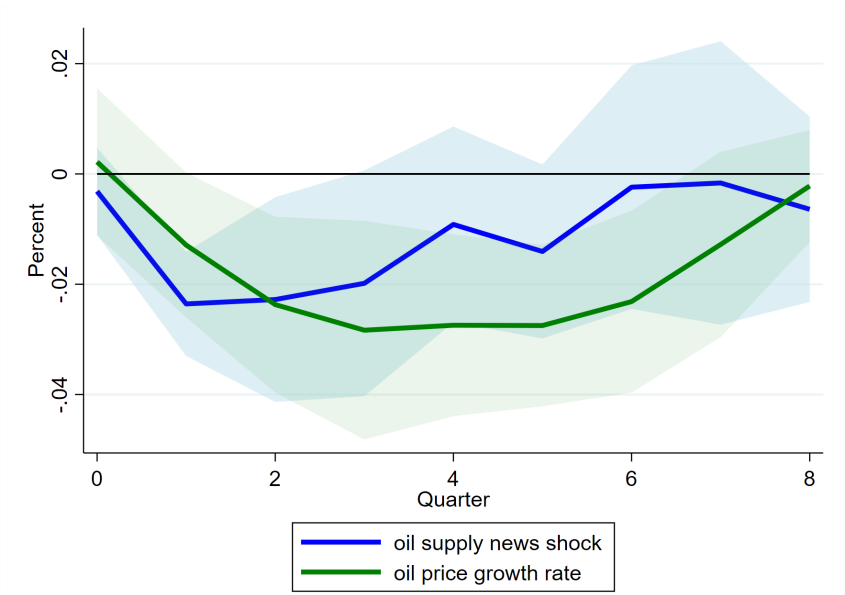
Cost-push shock $\epsilon_{\pi,t} \Longrightarrow$ Policy rate $R_t \Longrightarrow$ Loan rate $R_{i,t}^{B,*} \Longrightarrow \frac{R_{j,t}^B}{R_t}$

1. Higher inflation triggers increases in the policy rate
2. Higher policy rate leads to higher input price for banks, higher loan interest rate, and **lower loan spread**

Local Projection: Inflation and Loan Markup

$$\hat{\delta}_{t,t+h} = \sum_{q=1}^{4} \hat{\delta}_{t-q} + \sum_{m=0}^{4} \beta_{\mathbf{0,m}}^{(\mathbf{h})} \epsilon_{\pi,t-m} + \sum_{n=1}^{4} \text{control}_{t-n} + u_{t+h|t},$$

- Cost-push shock: 10 pp increase in real oil price $\Rightarrow$ CPI increases by 0.4 pp (Känzig 2021) $\Rightarrow$ loan spread decreases by 17 bp ($\beta_{\mathbf{0,0}}^{(\mathbf{h})}$ in my local projection)



Notes: The figure shows the IRFs of bank-side loans spread to 1 std shock in the oil price (1.8%). The oil supply news shocks are from Känzig (2021). $\hat{\delta}_t = \text{mean}_i(\hat{\delta}_{i,t})$ $\hat{\delta}_{i,t}$ is constructed from the decomposition by taking the average across banks. The shaded areas are 90% confidence intervals with Newey-West standard errors.

The Model - Rational Inattention

Following Mackowiak, Matejka, and Wiederholt (2018),

$$\min_{\kappa_j, h_j} \sum_{t=0}^{\infty} \beta^t \mathbb{E}_{-1} \left[(k_{j,t} - k^*_{j,t})^2 \right] + \lambda_\kappa \kappa_j,$$

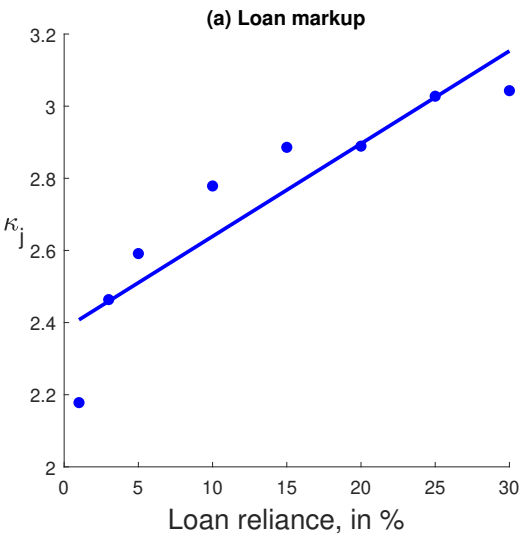
subject to:

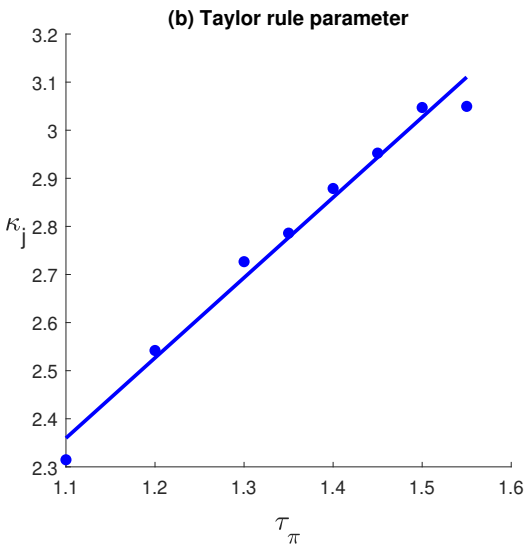
$$\begin{aligned}
\text{Optimal capital:} \quad & k^*_{j,t} = p_1 k^*_{j,t-1} + p_2 k^*_{j,t-2} + q^j_1 \epsilon_{\pi,t} + q^j_2 \epsilon_{\pi,t-1} + q^j_3 \epsilon_{\pi,t-2}, \\
\text{Perceived optimal capital:} \quad & k_{j,t} = \mathbb{E}(k^*_{j,t} | \mathcal{I}_t), \\
\text{Signal structure:} \quad & S_{j,t} = h'_j z_{j,t} + \psi_{j,t} \text{ , with } z_{j,t} = (k^*_{j,t} \; k^*_{j,t-1} \; \epsilon_{\pi,t} \; \epsilon_{\pi,t-1})', \\
\text{Information set:} \quad & \mathcal{I}_{j,t} = \mathcal{I}_{-1} \cup \{S_{j,0}, \ldots, S_{j,t}\}, \\
\text{Information processed:} \quad & \kappa_j = \frac{1}{1-\beta} \lim_{T \to \infty} \left[\mathcal{H}(k^*_{j,T} | \mathcal{I}_{j,T-1}) - \mathcal{H}(k^*_{j,T} | \mathcal{I}_{j,T}) \right].
\end{aligned}$$

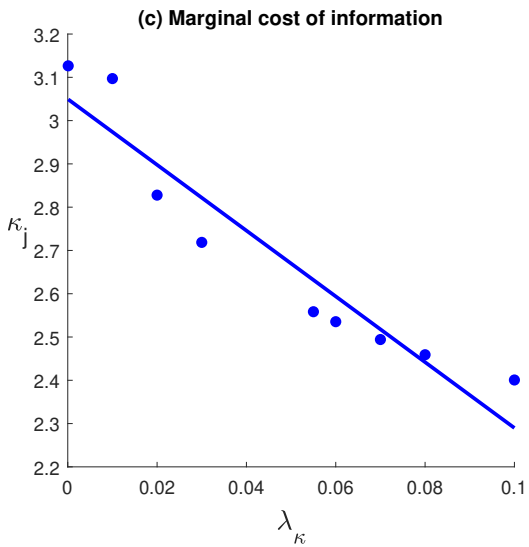
Proposition 1: $\partial q^j_1 / \partial \Gamma^B_{j,t} > 0$: higher loan-reliant firms have larger exposure to inflation shocks.

Implication 1 - Comparative Statics

- Steady-state κ (amount of information processed) varies with:
  1. More loan-reliant firms (less expensive bank loans)
  2. More aggressive central bank (higher τ_π)
  3. Higher information processing cost (higher λ_κ)

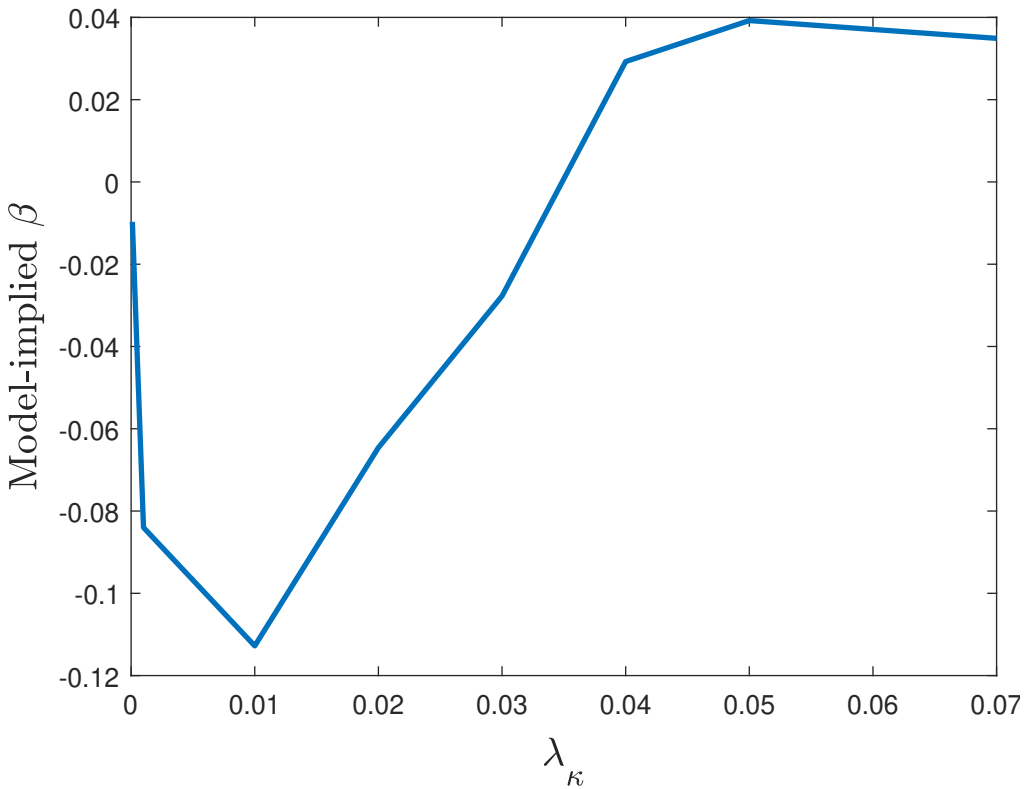






Implication 2 - Reference Range for λ_κ

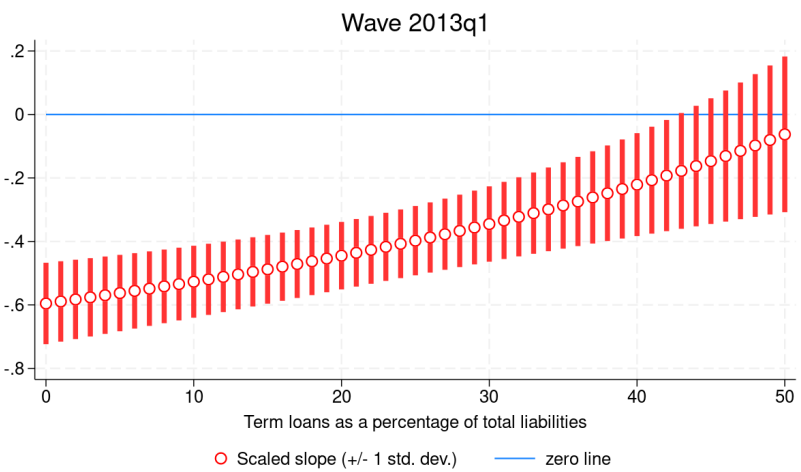
1. Simulated firms with average loan reliance matching the empirical distribution
2. Solve for each firm's rational inattention problem, simulate their signals and expectations, and measure inattention (absolute inflation forecast errors)
3. Calculate the correlation between loan reliance and inattention: ▸ $\hat{\beta}_{2sls}$



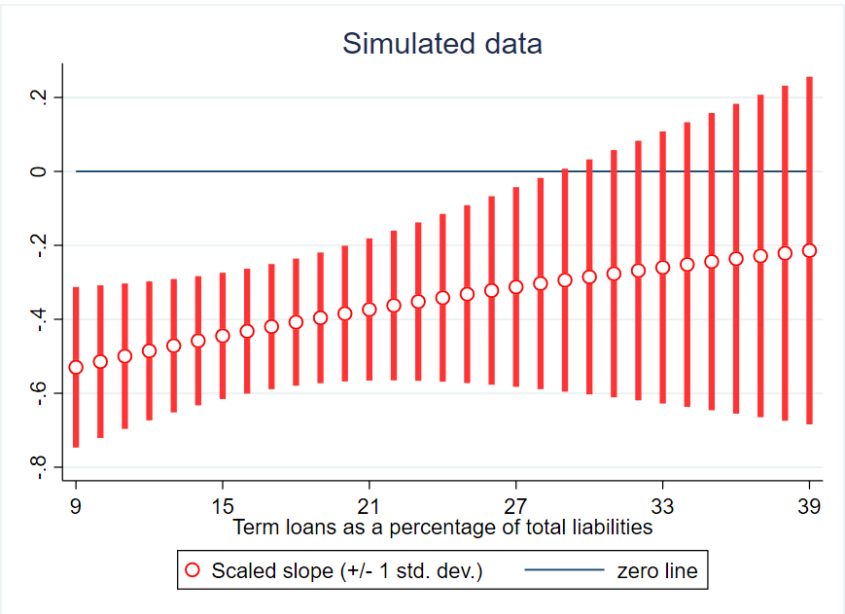
Implication 3 - Replicate RCT

1. With the simulation over firms from Implication 2
2. Introduce the RCT: one-time increase in signal precision

$$F_j\pi_t^{(12m)} = F_j\pi_{t-1}^{(12m)} + \text{signal-to-noise ratio} \cdot (S_t - S_{t|t-1}).$$



(c) First RCT



(d) Model implied

Conclusion

1. Financing composition as an important determinant for firms' inflation expectations
   - Incentive to acquire information
   - How firms learn from new information

2. An analytical model featuring endogenous financing composition and attention allocation
   - Explain the inflation-financing-cost channel
   - Provide a reference range for information cost
   - Replicate the empirical evidence

Preliminary GE results

- A general equilibrium framework (now with preliminary results) that incorporates:
  1. Dynamic inattention and feedback between financing composition and inattention
  2. Monetary policy implications and welfare analysis
  3. Attention allocation among multiple shocks
  4. Firm heterogeneity: HANK with rational inattention

- Discipline the general equilibrium model with more evidence using the current firm-level dataset

▸ IRFs from GE

Thank you very much!
(Appendix)

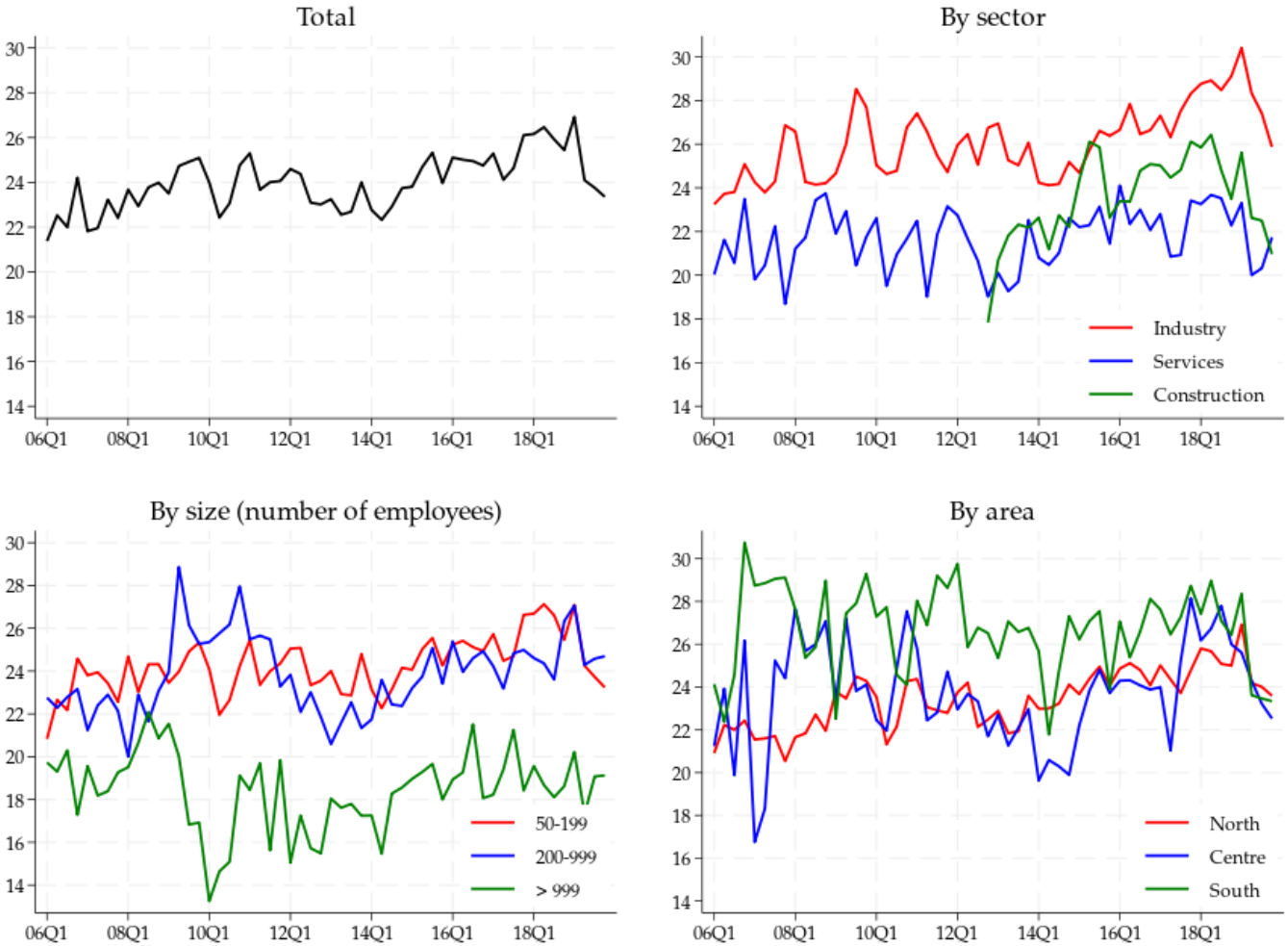
My Other Projects

1. **Scarring Effects of Macroeconomic Conditions on New Firms**
   - Explore the persistent impacts of macroeconomic conditions at the time of market entry on firms' profitability, employment, investment, and other outcomes.

2. **Endogenous Firm Entry and the Supply-Side Effects of Monetary Policy**, with Marc Dordal i Carreras (HKUST) and Seung Joo Lee (Oxford)
   - Introduce firms' endogenous entry decision to link the supply and demand sides of the economy
   - Create a sufficient statistic, 'policy room,' measuring the supply-side effects of monetary policy supported by empirical evidence.

3. **Diagnostic Expectations in Housing Price Dynamics**, with Byoungchan Lee (HKUST)
   - Empirical findings for forecast errors predictability in housing prices
   - A theoretical model incorporating Diagnostic Expectations helps to explain the boom-bust cycles in the housing market.

A.1: Loan reliance



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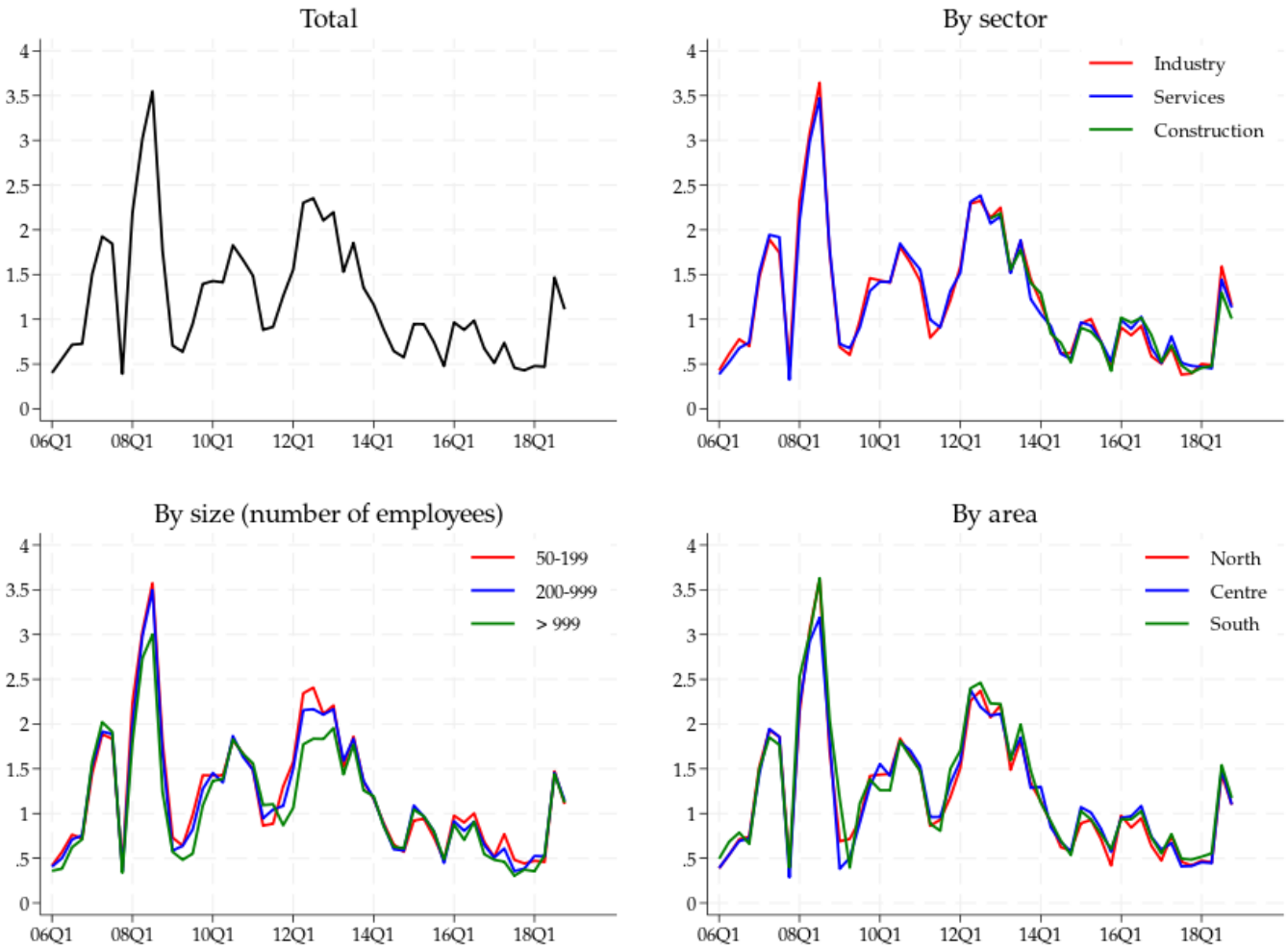
A.2: Inflation inattention



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A.3: Descriptive statistics

Table 1: Descriptive statistics

	p25	p50	p75	Mean	SD	N
Expected inflation (1-year ahead)	0.600	1.400	2.200	1.531	1.236	29793
Inflation inattention (in %)	0.400	1.000	1.700	1.160	0.997	26376
Term loan reliance (in %)	9.767	22.376	35.470	24.105	17.497	24805
Bank credit to debt ratio (in %)	58.156	94.649	100.000	73.184	36.817	27027
log(employees)	4.060	4.635	5.209	4.840	0.961	35316
ROE	0.102	4.105	11.924	4.119	25.967	28457
Liquid asset ratio (in %)	0.556	2.748	8.948	6.505	8.688	29091

Notes: The loan reliance based on term loans is calculated at the firm level. The summary statistics are computed with the sampling weights. The sample period is from 2006Q1 to 2019Q4.

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A.4: Randomized Controlled Trial

Survey Questionnaire:

- **Treated Group:** "In [previous month], consumer price inflation measured by the 12-month change in the Harmonized Index of Consumer Prices was [X.X]% in Italy and [Y.Y]% in the Euro area. What do you think it will be in Italy ... six-month ahead, one-year ahead, and two-year ahead."

- **Controlled Group:** "What do you think consumer price inflation in Italy, measured by the 12-month change in the Harmonized Index of Consumer Prices, will be ... "

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A.5: Micro-foundation for $\Phi_{j,t}$

The loan spread between bank loans (R_t^B) and internal financing (R_t) matters for real profits:

$$\max \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} Q_{0,t} \left(\text{Revenue}_{j,t} - (1-\gamma) \cdot \text{Borrowing}_{j,t} - \gamma \cdot R_{t-1}^B \cdot \text{Borrowing}_{j,t-1} \right) \right\},$$

$$\Rightarrow \max \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} Q_{0,t} \left(\text{Revenue}_{j,t} - \left[(1-\gamma) + \gamma \cdot \frac{Q_{0,t+1}}{Q_{0,t}} R_t^B \right] \cdot \text{Borrowing}_{j,t} \right) \right\},$$

$$\Rightarrow \max \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} Q_{0,t} \left(\text{Revenue}_{j,t} - \left[(1-\gamma) + \gamma \cdot \frac{\mathbf{R_t^B}}{\mathbf{R_t}} \right] \cdot \text{Borrowing}_{j,t} \right) \right\}.$$

- $Q_{0,t}$: stochastic discount factor after introducing household's problem

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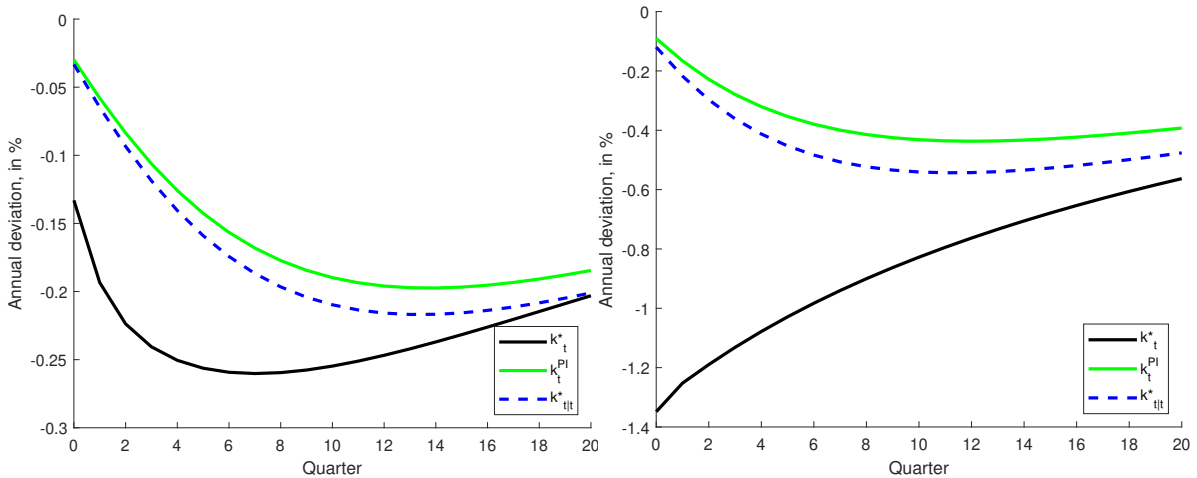
A.6: Implication from GE - Impulse Response of $k_{j,t}$

The IRFs are based on the general equilibrium with the endogenous inflation process:



(e) Monetary policy shock (f) Cost-push shock

Notes: This figure displays the impulse responses in capital level after one standard deviation monetary policy shock and cost-push shock. The y-axis is annualized and in percentage.

- Optimal capital levels under rational inattention (k_t^*) and perfect information (k_t^{PI}) are different
- Actual impacts on capital (k_t^{PI}) are reduced and delayed

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