State-Dependent Forecasting in Volatile Times

Isaac Baley
UPF, CREi, BSE, CEPR

Javier Turén
PUC Chile

PUC - Rio
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Motivation

- **Surveys of professional forecasters** have become central
  - **Central banks**—guide monetary policy decisions
  - **Economists**—tests theories of expectations (rational vs. behavioral)
- Forecasts reflect not only beliefs, but also **frictions**:
  - ✓ **Learning:** process information and update models
  - ✓ **Stability:** avoid appearing erratic, write narratives for clients
  - ✓ **Reputation:** concerns about diverging from consensus

  } Reported forecasts $\neq$ Actual Beliefs
- **Volatile times may change forecasting behavior:**
  - Are forecasts **more or less stable**?
  - Are forecasts **more or less aligned** with consensus?
  - Is the passthrough of shocks into forecasts **weaker or stronger**?

What We Do

- **Empirics:** In high volatility periods, forecast revisions are...
  - More **frequent** and **larger**
  - Less **aligned** with the consensus
- **Theory:** A model of **state-dependent forecasts**
  - Beliefs are rational and unbiased
  - Forecasts are shaped by fixed revision costs + strategic concerns
- **Results: Volatility vs. Responsiveness**
  - Volatility alone is not enough to explain data, shifts in frictions are essential
  - Jointly imply stronger pass-through of inflation shocks in volatile times

Contributions

- **Forecasting frictions**
  - Revision costs — Mankiw & Reis ('02), Andrade & Le Bihan ('13), Gaglianone et al ('22), Baley & Turen ('25)
  - Strategic concerns — Ottaviani & Sørensen ('06), Hansen, et al (14), Broer & Kohlhas ('22), Valchev & Gemmi ('23)
  - ⋆ **We study interaction with inflation volatility**
- **State-dependent expectations**
  - Rational inattention — Turen ('23), Pfäuti ('24), Joo Jo & Klopack ('25)
  - Diagnostic expectations — Bordalo, Gennaioli, Ma & Shleifer ('20), Bianchi & Ilut ('25)
  - Policy-driven (unanchoring) — Bonomo et al ('24)
  - ⋆ We offer an alternative view based on "rational inaction"
- **Pass-through in price-setting**
  - Increases with adjustment frequency — Gopinath & Itskhoki ('10), Blanco, *et al* ('24), Cavallo et al ('24)
  - Increases with volatility — Vavra ('14); Berger & Vavra ('19); Baley & Blanco ('19)
  - ⋆ We show that these relationships also hold for expectations

Roadmap

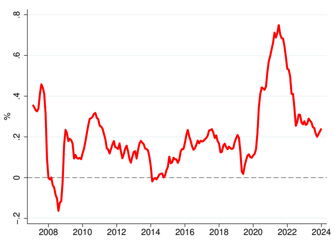
1. **Facts on forecasting in volatile times**
2. **A model of state-dependent forecasts**
3. **Volatility vs. Responsiveness**
4. **Application: Pass-Through of Shocks**

Data

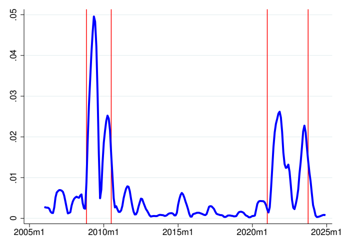
CPI Inflation

- Year-on-year monthly inflation: $x_t = \frac{1}{12}\left[\log(cpi_t) - \log(cpi_{t-1})\right]$
- Inflation volatility (rolling window): $\sigma_t^x = \frac{1}{18}\sqrt{\sum_{s=t}^{t-18}(x_s - \mathbb{E}[x_s])^2}$
- **Two volatility regimes:**
  - low (2010-20, 2024)
  - high (2008-09, 2021-23) – 50% increase

(a) YoY monthly inflation x_t



(b) Inflation volatility σ_t^x



Inflation forecasts

- Bloomberg's ECFC survey of professional forecasters
  - 16 years (2008–2024)
  - Around 100 forecasters per year

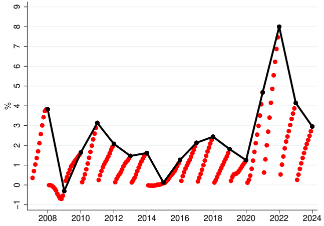
- Fixed-event forecasting
  - **Fixed event:** annual inflation π_y

$$\pi_y \;=\; \log(\overline{cpi}_y) - \log(\overline{cpi}_{y-1}) \;\approx\; \sum_{m=1}^{12} x_{m,y}$$

- **Forecast**: $f^i_{h,y}$ by agent i, in year y, at horizon h

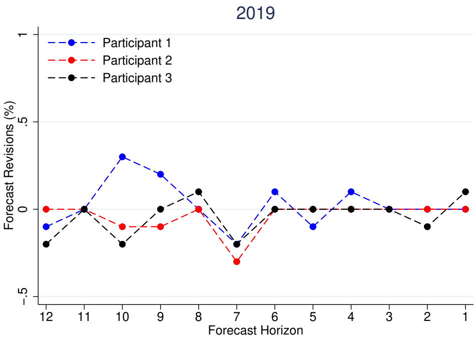
$$f^i_{h,y} \;=\; \underbrace{\mathcal{P}^i_{h,y}}_{\text{projection}} \;+\; \underbrace{\sum_{j=h+1}^{12} x_{j,y}}_{\text{observed realizations}}$$

Annual inflation π_y

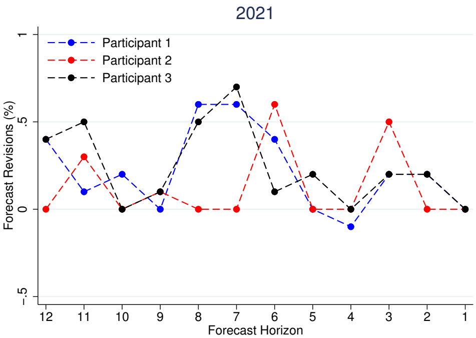


Example with 3 forecasters

(a) Low-volatility year



(b) High-volatility year

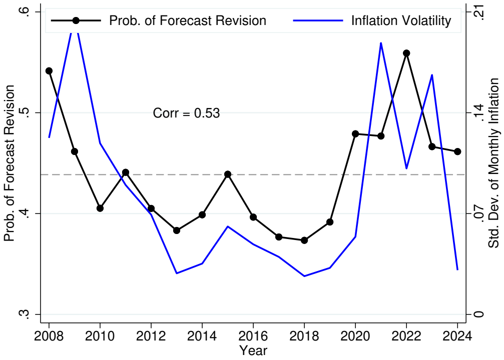


Facts on State-Dependent Forecasts

Fact 1: **More frequent** revisions in volatile times

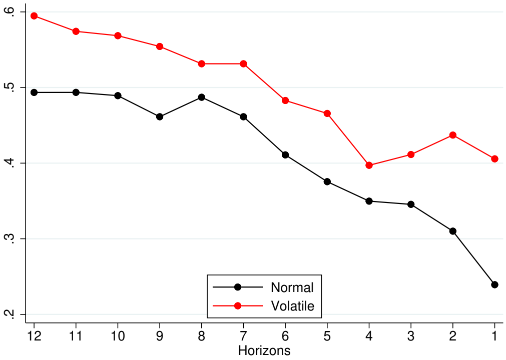
- Frequency increases by 18% in volatile times (from 0.42 to 0.50)

(a) Revision Frequency (across years)



Notes: Controls for forecaster and horizon FE.

(b) Revision Frequency (across horizons)

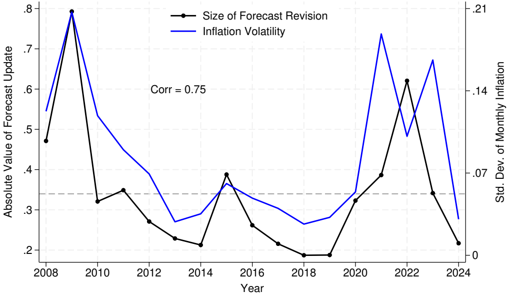


Notes: Normal= 2010–2020,2024. Volatile = 2008–09, 2021–23.

Fact 2: **Larger revisions** in volatile times

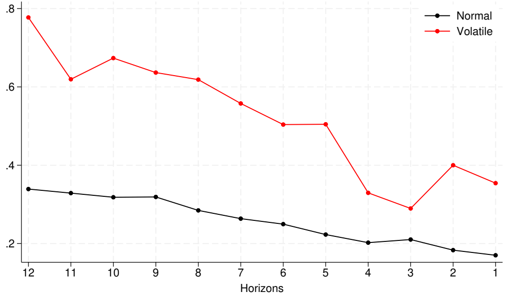
- Average size increases by 100% in volatile times (from 0.25 to 0.50)
  - Larger than the increase in fundamental volatility of 50%

(a) Revision Size (across years)



Notes: Controls for forecaster and horizon FE.

(b) Revision Size (across horizons)



Notes: Normal= 2010–2020,2024. Volatile = 2008–09, 2021–23.

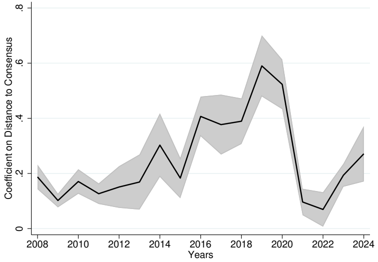
Fact 3: **Less alignment with consensus** in volatile times

- Effect of gap to consensus on probability of revision

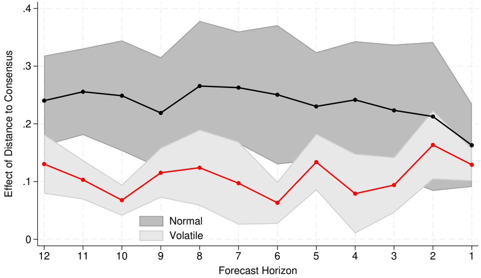
$$Prob(\Delta f_h^i < 0) \;=\; \beta_0 \;+\; \beta_1(f_{h+1}^i - F_h) \;+\; controls$$

- Alignment decreases by 56% in volatile times (from 0.25 to 0.11)

(a) Gap effect (across years)



(b) Gap effect (across horizons)



Recap of state-dependent forecasting

When inflation volatility σ_x rises:

1. Forecasts are revised more frequently
2. Revisions are larger
3. Alignment with consensus falls

Roadmap

1. Facts on forecasting in volatile times
2. **A model of state-dependent forecasts**
3. Volatility vs. Responsiveness
4. Application: Pass-Through of Shocks

Setup

- N forecasters i choose inflation forecast f_h^i to minimize sum of monthly losses

$$\min_{\{f_h^i\}_{h=12}^{1}} \mathbb{E}\left[\sum_{h=12}^{1} \underbrace{(f_h^i - \pi)^2}_{\text{accuracy}} + r \underbrace{(f_h^i - F_h)^2}_{\text{strategic}} + \underbrace{\kappa \mathbb{1}_{\{f_h^i \neq f_{h+1}^i\}}}_{\text{stability}}\right]$$

- **End-of-year inflation:** $\pi = \sum_{h=1}^{12} x_h \implies \hat{\pi}_h$ Details
  - AR(1) structure: $x_h = c_x + \phi_x x_{h+1} + \varepsilon_h^x,$ aggregate risk $\varepsilon_h^x \sim \mathcal{N}(0, \sigma_x^2)$
  - Private signal: $\widetilde{x}_h^i = x_h + \zeta_h^i,$ idiosyncratic noise $\zeta_h^i \overset{\text{iid}}{\sim} \mathcal{N}(0, \sigma_\zeta^2)$
- **Consensus:** $F_h = N^{-1} \sum_{i=1}^{N} f_h^i \implies \hat{F}_h$
  - Restricted perceptions equilibria: $\hat{F}_h = \hat{F}_{h+1} + \epsilon_h^{\hat{F}}, \quad \epsilon_h^{\hat{F}} \overset{\text{iid}}{\sim} \mathcal{N}(0, \sigma_F^2)$ RPE
- **Information set:** $\mathcal{I}_h^i = \widetilde{x}_h^i \cup \mathcal{I}_h = \widetilde{x}_h^i \cup \{x_{h+1}, x_{h+2}, \ldots, F_{h+1}, F_{h+2}, \ldots\}$
- **Uncertainty:** $\Sigma_h \equiv \Sigma_h^\pi + r\sigma_F^2$

Equilibrium [Evans and Honkapohja (1993), Marcet and Nicolini (2003), Moll (2025)]

- A **restricted perceptions equilibrium** consists of
  - a perceived consensus process $\hat{F}_h$ given by a function g parametrized by (δ, σ_F)

$$\hat{F}_h \;=\; g(\hat{F}_{h+1}, \delta) \;+\; \epsilon_h^{\hat{F}}, \quad \epsilon_h^{\hat{F}} \sim_{i.i.d.} \mathcal{N}(0, \sigma_F^2)$$

  - inflation beliefs $\{\hat{\pi}_h^i\}_{i,h}$ and forecasts $\{f_h^i\}_{i,h}$ for all agents i and horizons h

such that

1. Given perceived consensus $\hat{F}_h$, forecast policies $\{f_h^i\}_{i,h}$ are optimal
2. (δ, σ_F) are such that prediction errors $\epsilon_h^F \equiv F_h - g(F_{h+1}, \delta)$ satisfy:
   - $Cov[\epsilon_h^F, \epsilon_j^F] = 0$
   - $\mathbb{V}ar[\epsilon_h^F] = \sigma_F^2$

Consistency

Recursive problem and optimal policy

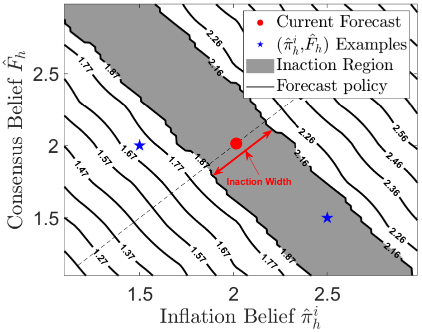
$$\mathcal{V}_h(\hat{\pi}, \hat{F}, f) \;=\; \min\{\, \underbrace{\mathcal{V}_h^I(\hat{\pi}, \hat{F}, f)}_{\text{inaction}},\; \underbrace{\mathcal{V}_h^A(\hat{\pi}, \hat{F})}_{\text{action}} \,\}$$

$$\begin{aligned}
\mathcal{V}_h^I(\hat{\pi}, \hat{F}, f) &= \Sigma_h + (f - \hat{\pi})^2 + r(f - \hat{F})^2 + \mathbb{E}[\mathcal{V}_{h-1}(\hat{\pi}', \hat{F}', f)|\mathcal{I}] \\
\mathcal{V}_h^A(\hat{\pi}, \hat{F}) &= \kappa + \Sigma_h + \min_{f^*}\left\{(f^* - \hat{\pi})^2 + r(f^* - \hat{F})^2 + \mathbb{E}[\mathcal{V}_{h-1}(\hat{\pi}', \hat{F}', f^*)|\mathcal{I}]\right\}
\end{aligned}$$

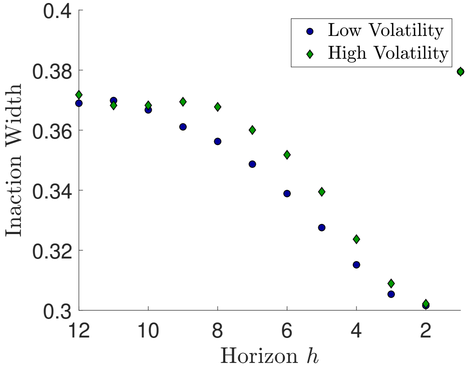
- Optimal policy is horizon-dependent:
  - Inaction region: $\mathcal{R}_h \equiv \{(\hat{\pi}, \hat{F}, f) : \mathcal{V}_h^I(\hat{\pi}, \hat{F}, f) \geq \mathcal{V}_h^A(\hat{\pi}, \hat{F})\}$
  - Reset forecast: ${f_h}^*(\hat{\pi}, \hat{F})$
  - Revisions: $\Delta f_h = \begin{cases} 0, & \text{if } f \in \mathcal{R}_h \\ {f_h}^* - f & \text{if } f \notin \mathcal{R}_h \end{cases}$

Inaction Region and Reset Forecast

(a) Inaction Region and Reset Forecast f_h^{i*}

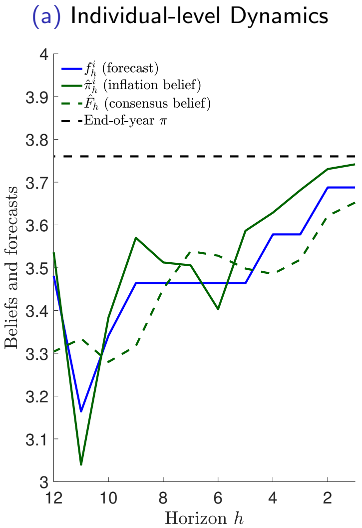


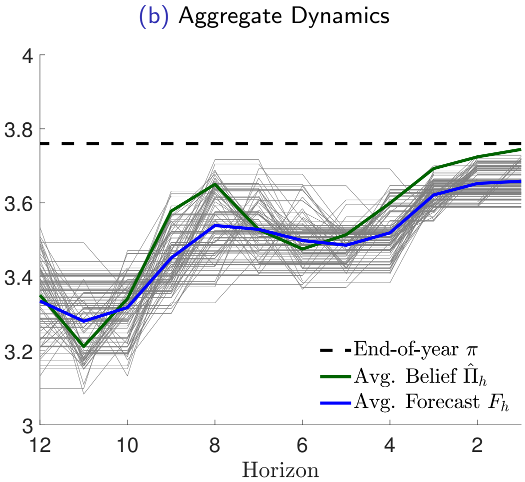
(b) Width of Inaction Region



Different r Different κ

Beliefs and forecasts





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Strategy

To study the role of volatility vs. responsiveness in shaping forecasts:

1. Discipline parameters $(\kappa, r, \sigma_\zeta, \sigma_F)$ in low-volatility years
2. Keep all parameters constant, increase inflation volatility $\sigma_x \uparrow$
3. Reestimate parameters in high-volatility years

Baseline calibration ⇒ Match moments in low-volatility years

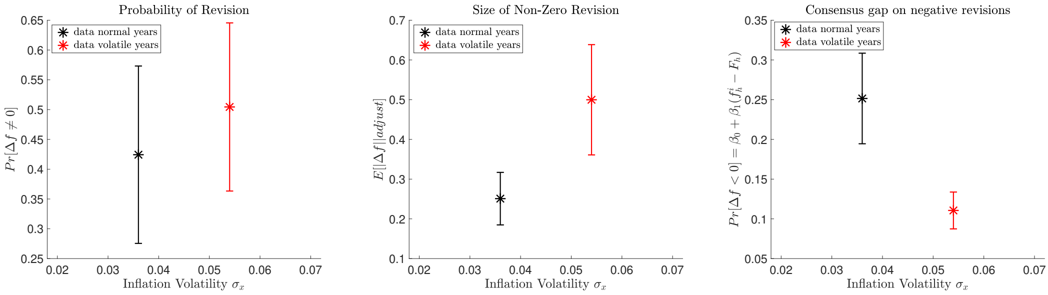
- **Inflation process**
  - $(c_x, \phi_x, \sigma_x) = (0.013, 0.932, 0.036)$ Estimation Inflation
- **Calibration (low-volatility)**

Parameter		Value	Moment	Data	Model
κ	adjustment cost	0.06	$\Pr[\Delta f \neq 0]$	0.43	0.40
r	strategic concerns	0.73	$\mathbb{E}[\lvert\Delta f\rvert \mid \text{adjust}]$	0.25	0.19
σ_ζ	private noise	0.03	hazard slope	-0.04	-0.04
σ_F^2	consensus volatility	0.13	Internal Rationality	—	—

- **Microdata implies:**
  - ⋆ Stability: $\kappa > 0$
  - ⋆ Strategic complementarity: $r > 0$
  - ⋆ Use of private information: $\alpha = \frac{\sigma_\zeta^{-2}}{\sigma_x^{-2} + \sigma_\zeta^{-2}} = 0.43$

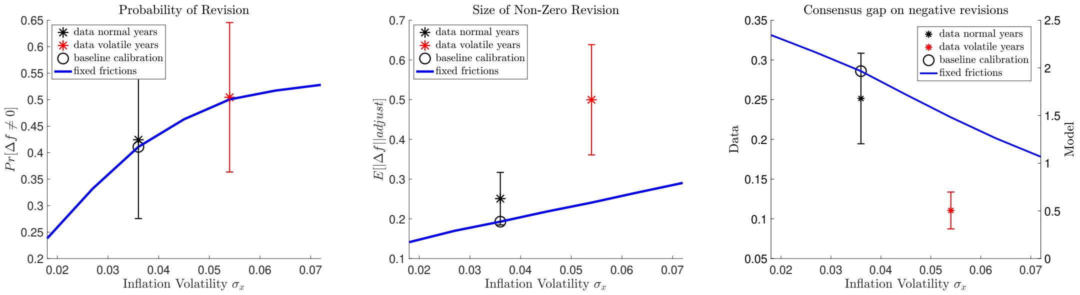
How do moments change across volatility regimes?

- More frequent, larger, and misaligned revisions in volatile times
- Average across horizons h



Does higher inflation volatility ($\sigma_x \uparrow$) explain patterns?

- Keep **baseline parameters** and increase volatility
- Qualitatively explains empirical patterns, but it is not enough



Mechanisms driven by volatility

- Higher volatility σ_x has two effects on frequency:

  1. **Volatility effect:** More volatile beliefs hit action threshold more often, *frequency* $\uparrow$
  2. **Option effect:** Inaction bands widen to save on revision costs, *frequency* $\downarrow$

  Volatility effect dominates $\Rightarrow$ Increase in frequency

  Vavra (2014), Bachmann et al. (2019), Baley and Blanco (2019)

- Wider inaction bands $\Rightarrow$ Increase in revision size

Volatile calibration ⇒ Match moments in volatile times

- **Inflation process**
  - $(c_x, \phi_x, \sigma_x^2) = (0.011, 0.950, 0.054)$ Estimation Inflation
- **Calibration (volatile times)**

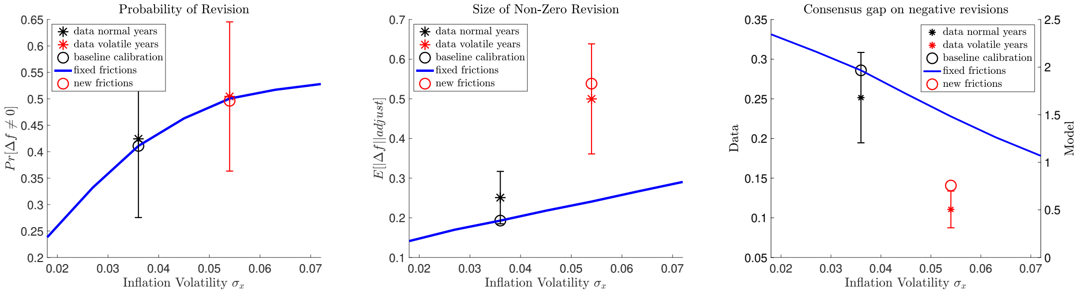
	Value			Moment (Data / Model)	
Parameter	Normal	Volatile	**Moment**	Normal	Volatile
κ	0.06	0.14	$\Pr[\Delta f \neq 0]$	0.43 / 0.40	0.50 / 0.49
r	0.73	-0.35	$\mathbb{E}[\|\Delta f\| \mid \text{adjust}]$	0.25 / 0.19	0.50 / 0.54
σ_ζ	0.03	0.07	hazard slope	-0.04 / -0.04	-0.035 / -0.033
σ_F^2	0.13	0.32	Internal Rationality	—	—

- **In volatile times:**
  - ⋆ Fixed cost κ doubles
  - ⋆ Strategic complementarity $r > 0$ turns into substitutability: $r < 0$
  - ⋆ Weight on private information falls: $\alpha = 0.37$

Volatility alone is not enough → frictions also change

When reestimating frictions:

- Lower r compensates for higher κ and frequency is not affected (18% increase)
- Size increase is now correctly matched (100% increase)
- Alignment decreases ($\approx -60\%$)



Roadmap

1. **Facts on forecasting in volatile times**
2. **A model of state-dependent forecasts**
3. **Volatility vs. Responsiveness**
4. **Application: Pass-Through of Shocks**

Pass-Through of Shocks

- How shocks are incorporated into **beliefs** and **forecasts**?
- Our approach:
  - Inflation follows a reduced-form AR(1)

$$x_h = c_x + \phi_x x_{h+1} + \varepsilon_h^x$$

  - Shocks ε_h^x capture any disturbance: monetary policy, demand, supply, or news.
  - We stay agnostic about the source — focus on the transmission.
- What we test:
  - Measure pass-through of ε_h^x into forecast revisions across normal vs. volatile regimes.

Pass-through of inflation shocks

- Let $P^h \equiv \frac{1-\phi_x^h}{1-\phi_x}$ and assume $\kappa = 0$

- Forecast revision between *consecutive* horizons h and $h+1$:

$$\begin{aligned} f_h^i - f_{h+1}^i &= \frac{1}{1+r}\left[(z_h - z_{h+1}) \ + \ r\left(\hat{F}_h - \hat{F}_{h+1}\right) \ + \ (\nu_h^i - \nu_{h+1}^i)\right] \\ &= \frac{1}{1+r}\left[P^h\alpha(\varepsilon_h^x + \zeta_h^i) \ + \ r\varepsilon_{h+1}^F \ + \ P^{h+1}((1-\alpha)\varepsilon_{h+1}^x - \alpha\zeta_{h+1}^i)\right] \end{aligned}$$

- Forecast revision between any horizons h and $h+\tau$:

$$f_h^i - f_{h+\tau}^i = \frac{1}{1+r}\left[P^h\alpha\underbrace{(\varepsilon_h^x + \zeta_h^i)}_{\text{shocks at } h} + \underbrace{r\sum_{j=1}^{\tau}\varepsilon_{h+j}^F + \sum_{i=1}^{h+\tau-1} P^{h+j}\varepsilon_{h+j}^x + P^{h+\tau}((1-\alpha)\varepsilon_{h+\tau}^x - \alpha\zeta_{h+\tau}^i)}_{\text{constant at } h}\right]$$

Pass-Through in the Model and Data

- Pass-through of inflation shock at h:

$$\gamma(\sigma_x) \equiv \frac{\partial(f^i_h - f^i_{h+\tau})}{\partial\epsilon^x_h} = \frac{\alpha(\sigma_x)}{1+r(\sigma_x)} P^h$$

- With higher inflation volatility σ_x:

$$\left.\begin{array}{l}\text{(a) Bayesian weight on private signals} \quad \alpha(\sigma_x)\downarrow \\ \text{(b) Strategic concerns} \quad r(\sigma_x)\downarrow\downarrow\end{array}\right\} \implies \gamma(\sigma_x) \textbf{ increases by 75\%}$$

- In the data, we estimate:

$$f^i_{h,t} - f^i_{h+\tau,t} = \gamma_0 + \gamma_1 \underbrace{(x_{h,t} - x_{h+1,t})}_{c_x+(\phi^x-1)x_{h+1}+\epsilon^x_h} + \text{controls} + \epsilon^i_{h,t}$$

  - $\widehat{\gamma}_1 = 0.733$ for normal and $\widehat{\gamma}_1 = 1.447$ for volatile $\Rightarrow$ a **68% increase**

Next Steps

Next Steps

- Today: Evidence of state-dependent professional forecasts that vary with inflation volatility
- **Microfound state-dependent frictions**
  - Writing and justifying narratives are costlier in volatile times $\Rightarrow \kappa'(\sigma_x) > 0$
    Jiang, Pittman & Saffar ('21); Jung & Kim ('24), Lombardelli ('25)
  - Contests (winner-take-all publicity) pushes away from consensus in volatile times $\Rightarrow r'(\sigma_x) < 0$
    Laster, Bennett & Geoum ('99); Lamont ('02); Ottaviani & Sørensen ('06)
- **Transitions across volatility regimes**
  - Quantitatively model regime shifts in volatility
- **Differentiate shocks**
  - Distinguish supply vs. demand (and policy) shocks in pass-through

Thank you!

jturen@uc.cl

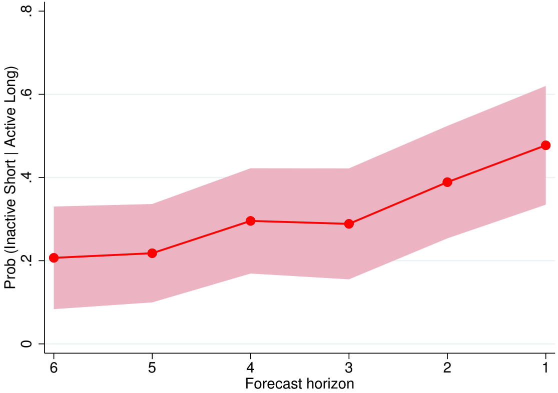
isaac.baley@upf.edu

Inflation Volatility Regimes

- Regime identification robust to
  1. Realized vs. AR(1) Residual
  2. Rolling window width: 12 vs. 18 months
  3. Stock and Watson

A preference for stability?

- Focus on horizon overlaps:
  - Long term revisions
    f^i_{18} to f^i_{12} about π_{t+1}
  - Short term revisions:
    f^i_6 to f^i_1 about π_t
- **Stability:** Actively revise long-term forecast, but keep short-term forecast



Heterogenous frictions?

- Strategic concerns (and other incentives) may differ across forecaster types
- Cross-sectional moments by type

	Financial Inst.		Banks		Consulting		Universities	
Moment	Data	Model	Data	Model	Data	Model	Data	Model
$\Pr[\Delta f \neq 0]$	0.45	0.40	0.38	0.37	0.47	0.49	0.34	0.35
$\mathbb{E}[\lvert\Delta f\rvert \,\vert\, adjust]$	0.25	0.18	0.26	0.24	0.27	0.18	0.29	0.30
hazard slope	−0.05	−0.05	−0.02	−0.02	−0.05	−0.05	−0.01	−0.01
N		5,366		2,567		2,982		1,440

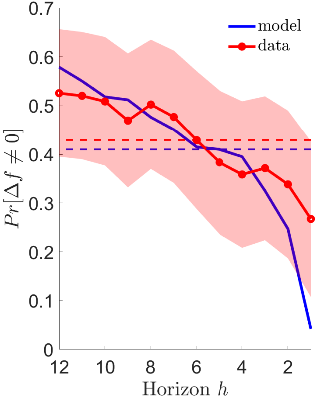
- Relative parameters by forecaster type, within group consensus

Parameter	Financial Inst.	Banks	Consulting	Universities
κ	1.00 (0.06)	1.08	0.94	1.29
r	1.00 (0.81)	0.62	0.89	0.50
σ_ζ	1.00 (0.04)	1.16	1.14	2.28
σ_F	1.00 (0.10)	1.13	1.08	1.33

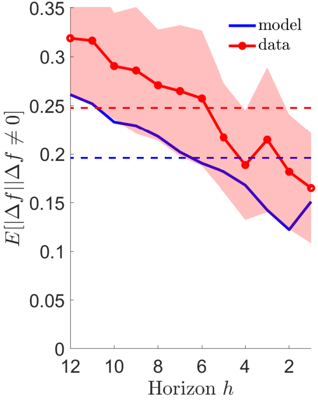
⋆ Universities are the least strategic and the most lumpy

Term structure of revisions

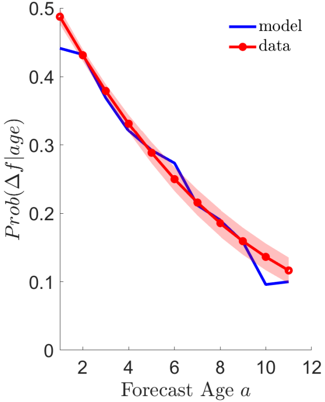
(a) Frequency of revisions



(b) Size of non-zero revisions

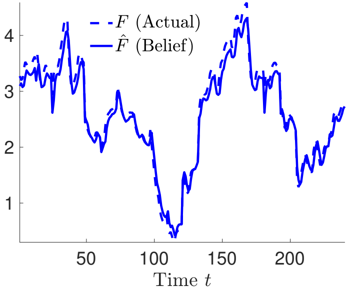


(c) Hazard rate



Consistency of perceived vs. actual consensus back

- Perceived process: $\hat{F}_t = \hat{F}_{t-1} + \eta_t^{\hat{F}} \quad \eta_t^{\hat{F}} \sim_{i.i.d.} \mathcal{N}(0, 0.11^2)$
- Let $\eta_t^F \equiv F_t - F_{t-1}$ be forecast errors of actual consensus under perceived process.
  - $Cov[\eta_h^F, \eta_j^F] = 0$ and $\mathbb{V}ar[\eta_h^F] = 0.11^2$
- Dickey-Fuller tests cannot reject $H_0 : F_t$ is a random walk



Estimation of Inflation Process π

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- We estimate (c_x, ϕ_x, σ_x) with a rolling structure.
- Average estimates (normal times): $\hat{c}_x = 0.013$, $\hat{\phi}_x = 0.932$ and $\hat{\sigma}_x = 0.036$
- Average estimates (volatile times): $\hat{c}_x = 0.011$, $\hat{\phi}_x = 0.950$ and $\hat{\sigma}_x = 0.054$.

Rolling Estimates AR(1) parameters