2019 Sloan-Nomis Workshop

Behavioral Attention Phillips Curve

Theory and Evidences from Inflation Survey

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Motivation

- The US Phillips Curve $\pi_t = \beta \widetilde{\mathbb{E}}_t \pi_{t+1} + \kappa x_t$ is unstable:
  - It seems **flattened**:

$$\kappa_{1980s} >> \kappa_{2000s} >> \kappa_{2010s} \approx 0$$

  - Inflation (expectation) seems well-anchored.
    - Bernanke (2007), Cogley and Sargent (2005), Williams (2006)
    - With $\widetilde{\mathbb{E}}_t \pi_{t+1} = \pi_{t-1}$, measure $\beta_{1980} \approx 1$, and $\beta_{1980} \approx 0$.

Flattened Phillips Curve

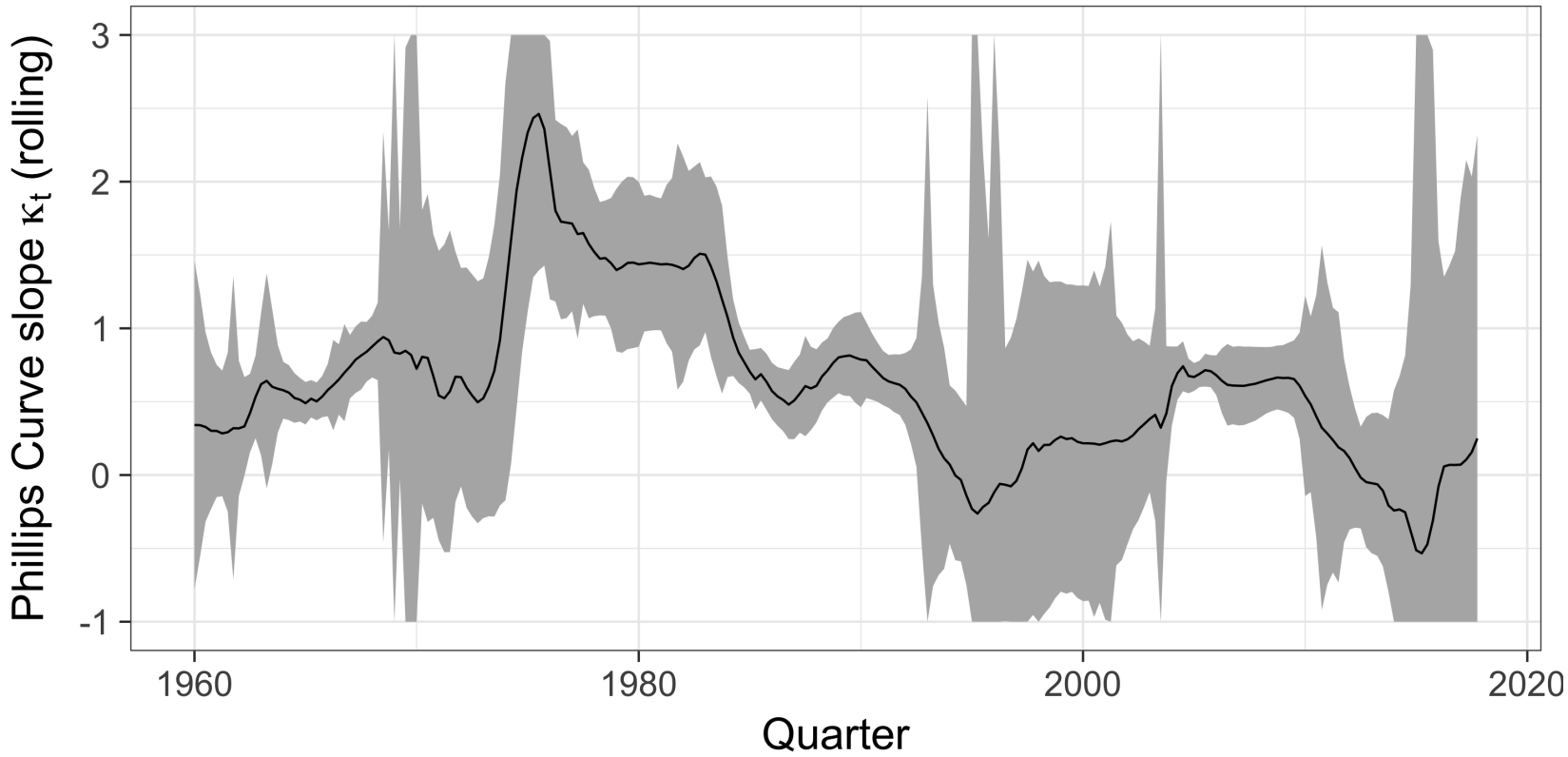


Figure: Rolling estimates for κ

Note: Estimated equation $\pi_t = \beta \mathbb{E}^{back} \pi_{t+1} + \kappa x_t + \varepsilon_t$, with $\mathbb{E}_t^{Back} \pi_{t+1} \equiv \frac{1}{4} \sum_{h=1}^{4} \pi_{t-h}$, x_t is negative CBO unemployment gap.
10-year window (centered from 1960Q1:2018Q1.

Inflation less persistent

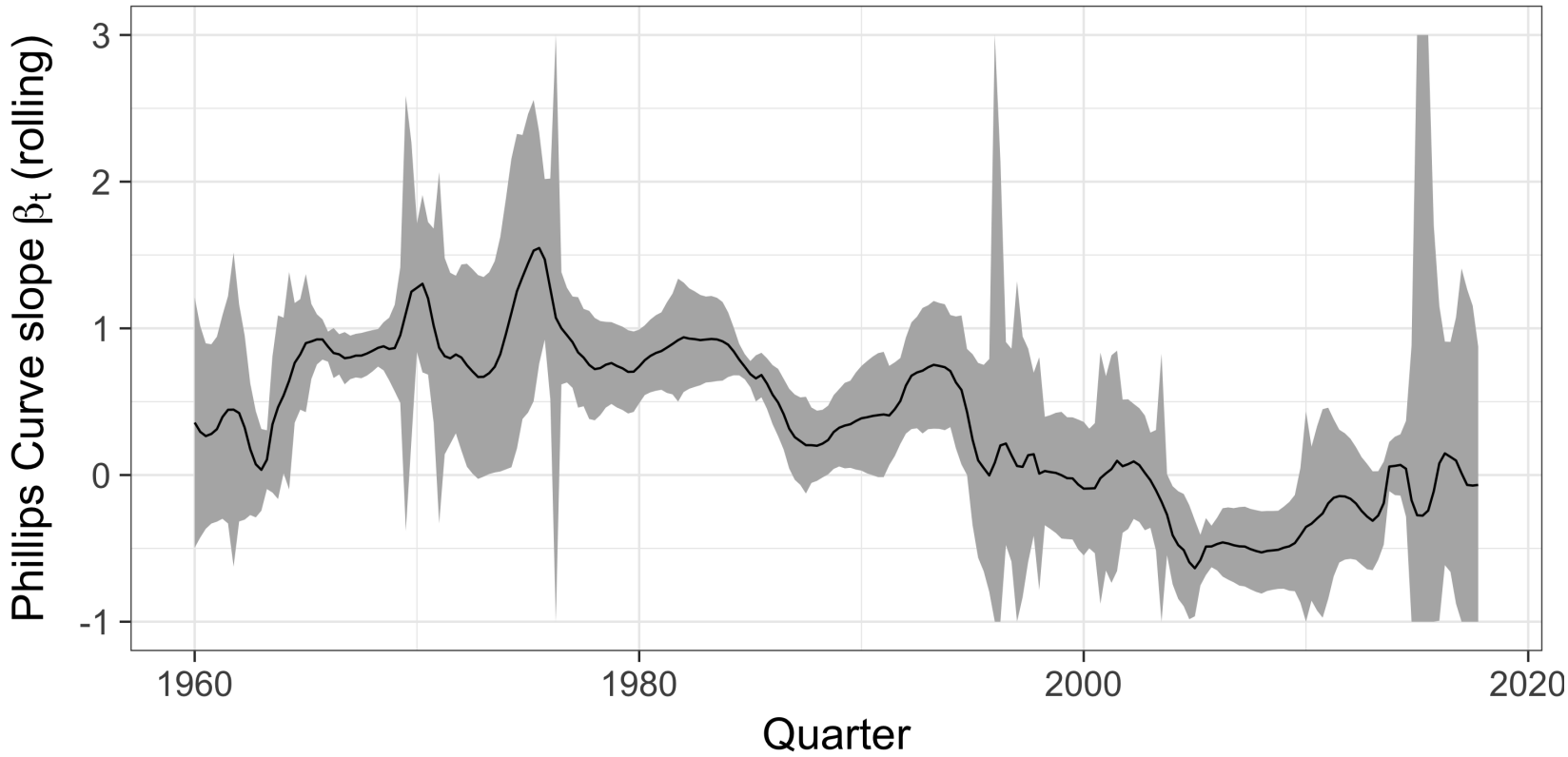
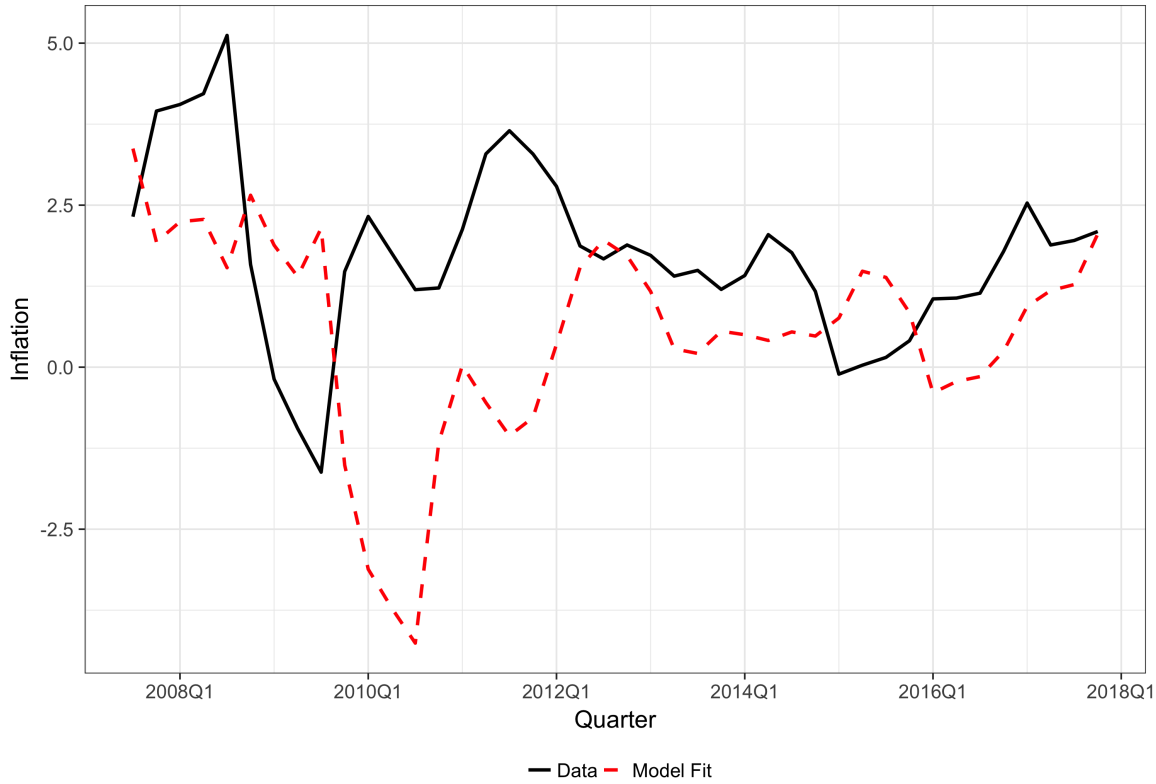


Figure: Rolling estimates for β

Note: Estimated equation $\pi_t = \beta \mathbb{E}^{back} \pi_{t+1} + \kappa x_t + \varepsilon_t$, with $\mathbb{E}_t^{Back} \pi_{t+1} \equiv \frac{1}{4} \sum_{h=1}^{4} \pi_{t-h}$, x_t is negative CBO unemployment gap. 10-year window (centered from 1960Q1:2018Q1.

Modeling and Policy concerns

- Modeling: missing disinflation puzzle



- Policy questions: $\kappa \approx 0$ despite QE?
- Similar problem in Europe.

My paper

- Provide unified theory for (κ, β) behavior based on behavioral inattention.

My paper

- Provide unified theory for (κ, β) behavior based on behavioral inattention.
- Prove and test empirically the Behavioral Attention Phillips Curve (BAPC)

$$\pi_t = \beta_t^d(m)\pi_t^d + \beta_t^f(m)\mathbb{E}_t\pi_{t+1} + \kappa_t(m)x_t$$

with $d\beta_t^d/dm < 0$, $d\beta_t^f/dm > 0$, $d\kappa_t/dm > 0$.

  - In early 1980s: $m \approx 1$, high β_t^f and κ_t, low β_t^d.
  - After 2000s: $m \approx 0$, low β_t^f and κ_t, high anchoring β_t^d.

- Empirics: Attention unobserved $\longrightarrow$ use inflation uncertainty from inflation surveys.

Key assumptions

- Key assumptions:
  1. Firms are behaviorally inattentive to endogenous variables:

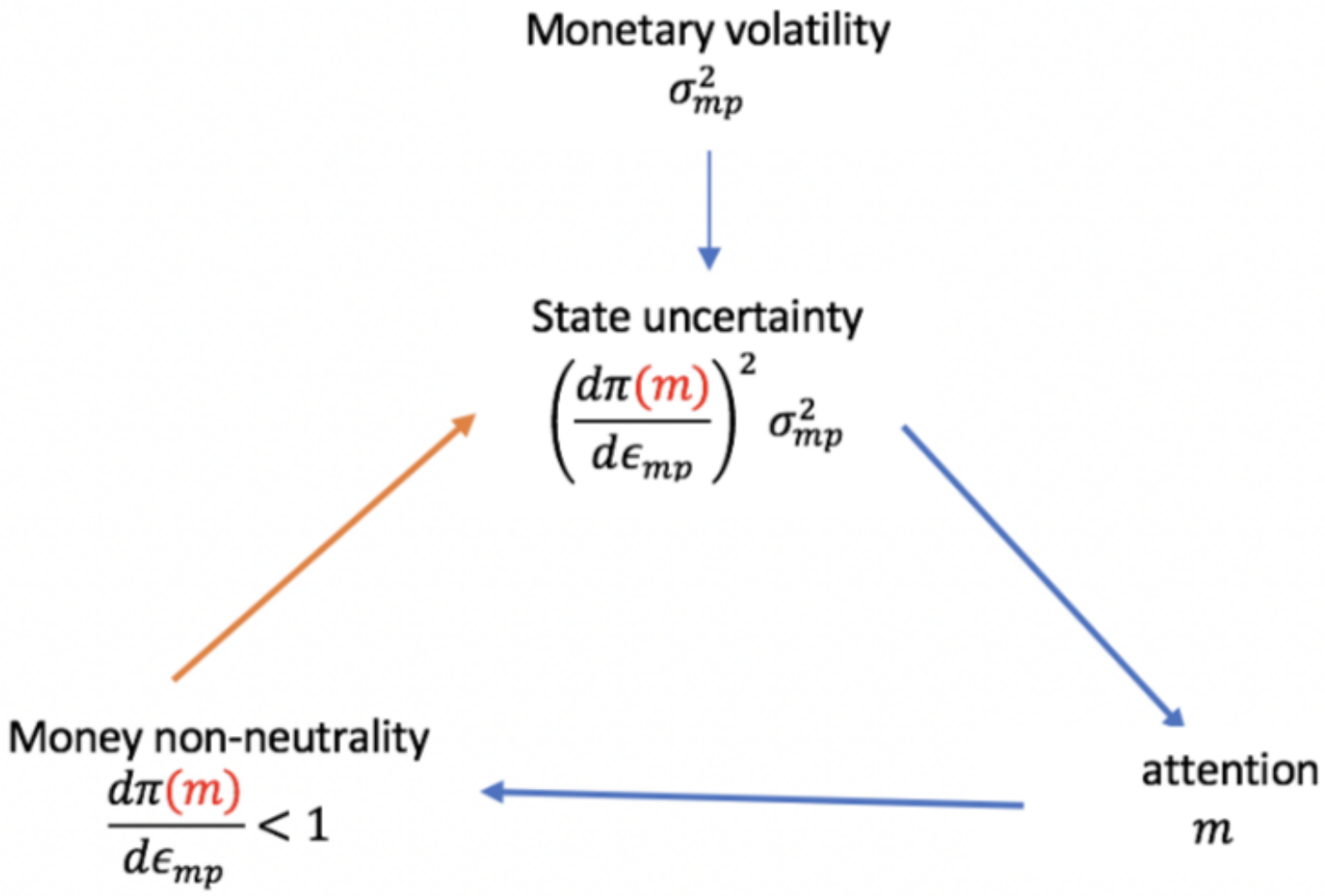
$$1 - m_t^X \propto \frac{1}{\sigma_{X,t}^2}$$

  2. Contemporaneously: $X_t^{perceive} = m_t^X X_t + (1 - m_t^X) X_t^{default}$.
  3. Dynamic: "Behavioral Law of Iterated Expectation"

$$\mathbb{E}_t^{BR}[a_{t+k}] = \mathbb{E}_t[\mathbb{E}_{t+1}^{BR}(a_{t+k})]$$

     - Needed only for sticky price analysis, i.e. β analysis.
     - Not needed to explain flattened κ.

Intuition


Monetary volatility
σ_{mp}^2
State uncertainty
$\left(\frac{d\pi(m)}{d\epsilon_{mp}}\right)^2 \sigma_{mp}^2$
attention
m
Money non-neutrality
$\frac{d\pi(m)}{d\epsilon_{mp}} < 1$

Baseline Model

- Household:
  - consume CES varieties (elasticity ε)
  - supply labor (Frish elas. $1/\psi$)
  - hold nominal bonds
  - No attention problem.
- Firms:
  - Monopolistic competition
  - DRS technology governed by α.
- Shocks:
  - Productivity shock: always fully observed.
  - Monetary policy shock (to Taylor rule): AR(1), not necessarily observed.
- Monetary policy: Taylor rule $i_t = r_t^n + \phi_x x_t + \phi_\pi \pi_t + \nu$

Attention and Price Setting

- Optimal price for rational agent: $p_t^*(w_t, a_t, y_t, p_t)$.
- Firms may (optimally) have wrong estimates $(y_t^p, \pi_t^p) \rightarrow$ deviate from optimality.
- Attention problem:

$$\min_{m_t^\pi, m_t^x} \quad -\frac{\Lambda}{2}(\varepsilon^2(1-m_t^\pi)^2\sigma_{\pi,t}^2 + (1-m_t^x)\sigma_{x,t}^2) - \mathcal{C}(m_t^\pi, m_t^x)$$

- With linear cost $\mathcal{C}(m^\pi, m^y) = \chi_\pi m^\pi + \chi_x m^x$:

$$1 - m_t^\pi = \frac{\chi_\pi}{\Lambda\varepsilon^2}\frac{1}{\sigma_{\pi,t}^2}, \quad 1 - m_t^x = \frac{\chi_x}{\Lambda}\frac{1}{\sigma_{x,t}^2}$$

BAPC without price rigidity

Theorem

The flexible price BAPC is:

$$\pi_t = \mathbb{E}_{t-1}\pi_t + \kappa_t x_t$$

where the slope κ_t is time-varying and increases with attention:

$$\kappa_t = \frac{\zeta - (1 - m_t^x)}{\varepsilon(1 - m_t^\pi)}$$

for $\zeta \equiv \frac{\sigma(1-\alpha)+\alpha+\varphi}{\alpha}$.

- Back of envelope: $\alpha = 0.3$, $\sigma = 1$, $\varphi = 0.5$, $\varepsilon = 6$. Suppose $m_t^\pi = 0$, then $m_t^x \in [0, 1]$ gives $\kappa \in [0.667, 0.833]$.
- Conditional on low inflation attention, output attention affects κ very little.

Equilibrium uniqueness

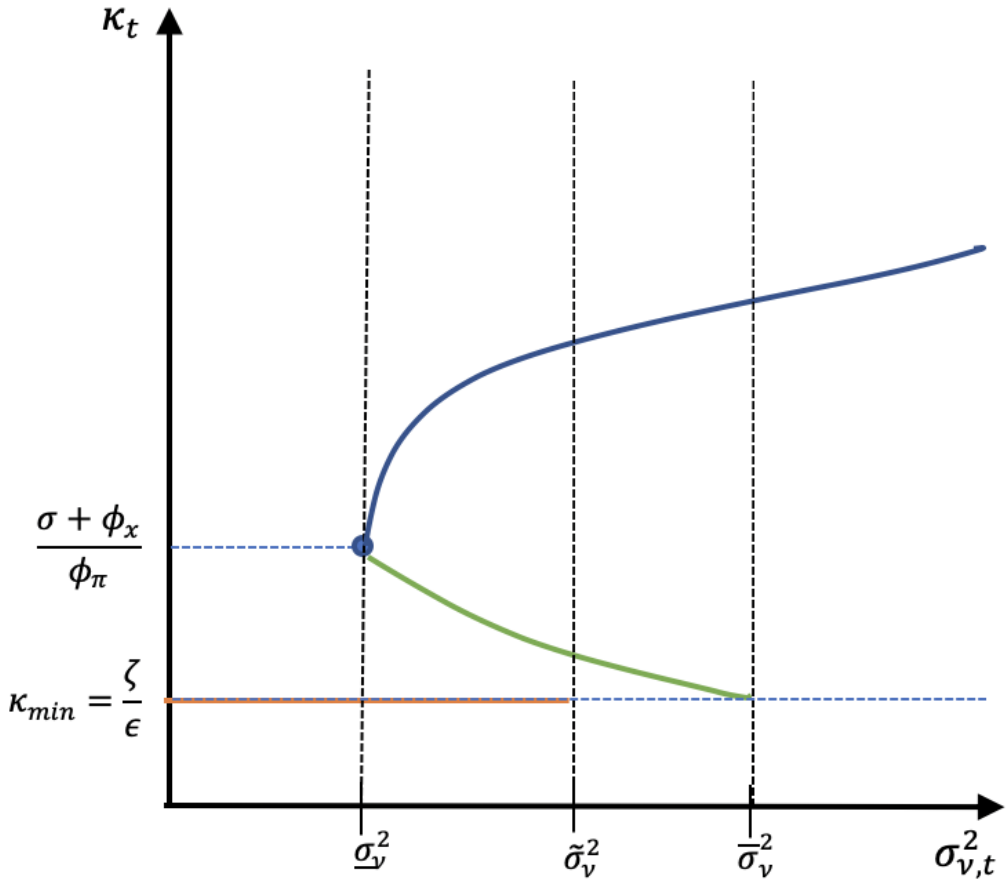


Figure: It is possible for PC to flatten when MP more volatile

- Now, add price rigidity à la Calvo, θ.

Theorem

The sticky price BAPC is:

$$\pi_t = \beta_t^d \pi_t^d + \beta_t^f \mathbb{E}_t \pi_{t+1} + \kappa_t x_t$$

with:

$$\beta_t^d \equiv \frac{\lambda(1 - m_t^\pi)}{1 + \lambda(1 - m_t^\pi)}$$

$$\beta_t^f \equiv \frac{1}{1 + \lambda(1 - m_t^\pi)} \beta$$

$$\kappa_t \equiv \frac{m_t^x}{1 + \lambda(1 - m_t^\pi)} \overline{\kappa}$$

Rational NKPC nested when $m_t^x = m_t^\pi = 1$.

Empirics: Flex Price BAPC

- Suppose only m_t^π and flexible price:

$$\kappa_t = \frac{\zeta}{\varepsilon(1 - m_t^\pi)} = \frac{\zeta\varepsilon\Lambda}{\chi_\pi}\sigma_{\pi,t}^2$$

  with $\sigma_{\pi,t}^2$ the uncertainty about price inflation.

- Thus, specification:

$$\pi_t = \mathbb{E}_{t-1}\pi_t + \left(\kappa_0 + \kappa_1\sigma_{\pi,t}^2\right) x_t + \varepsilon_t$$

- Want to test null hypothesis $\kappa_1 = 0$ vs. alternative hypothesis $\kappa_1 > 0$.

BAPC: Measuring Inflation Uncertainty

- Michigan Survey of Consumers: household inflation expectation survey since 1946.
- Consistent quarterly survey since 1969.
- 500 - 1,000 cases per month/quarter.
- Inflation uncertainty = variance of household level forecast:

$$\mu_{\pi,t} \equiv \frac{1}{N} \sum_i \mathbb{E}_{t-1}^{(i)} \pi_t$$

$$\sigma_{\pi,t}^2 \equiv \frac{1}{N} \sum_i (\mathbb{E}_{t-1}^{(i)} \pi_t - \mu_{\pi,t})^2$$

- "Disagreement" type measure
- Robust to "subjective uncertainty" type measures.

Measuring Inflation Uncertainty

Figure: Variance of MSC household inflation expectation measures Inflation Uncertainty

- Uncertainty was high in the 70s and early 80s
- But have stabilized since Volcker year.
- 2008 financial crisis tiny uncertainty compared to early years.

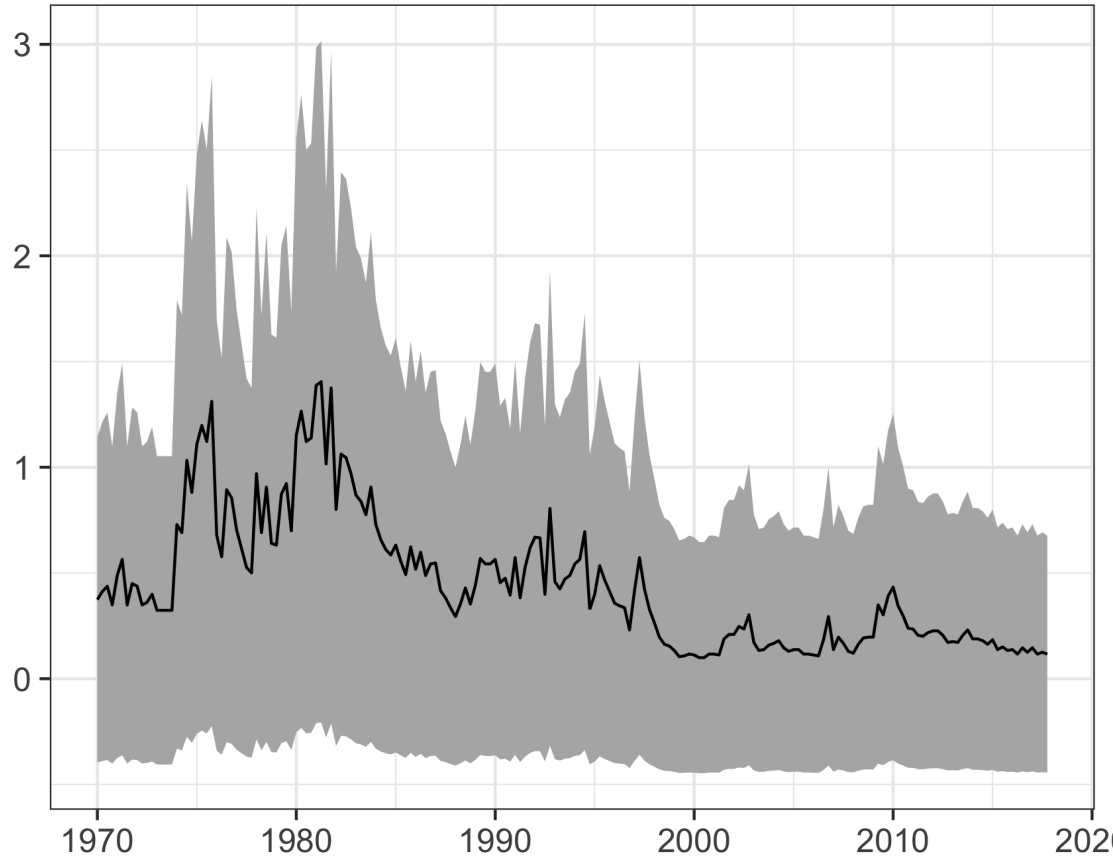
BAPC: Estimation

TABLE 1. Estimation Results for Specification (5.2)

	$\pi_t - \pi_t^e = \alpha + (\kappa_0 + \kappa_1\sigma^2_{\pi,t})x_t + (\beta_0 + \beta_1\sigma^2_{\pi,t})\pi_{t-1} + \delta \cdot \pi_t^{Oil} + \varepsilon_t$		
	Traditional PC (1)	Restricted BAPC (2)	Full BAPC (3)
κ_0	0.445*	−0.144	−0.019
	(0.236)	(0.273)	(0.230)
κ_1		139.060***	126.679**
		(37.837)	(52.746)
β_0			−0.592***
			(0.155)
β_1			51.307**
			(20.648)
δ	0.036***	0.036***	0.034***
	(0.006)	(0.005)	(0.004)
α	0.052	0.122	1.510***
	(0.280)	(0.260)	(0.400)
RMSE	1.96	1.386	0.981
N	192	192	192
R^2	0.516	0.606	0.696
Adjusted R^2	0.511	0.600	0.688
Notes:			***Significant at the 1 percent level.
			**Significant at the 5 percent level.
			*Significant at the 10 percent level.

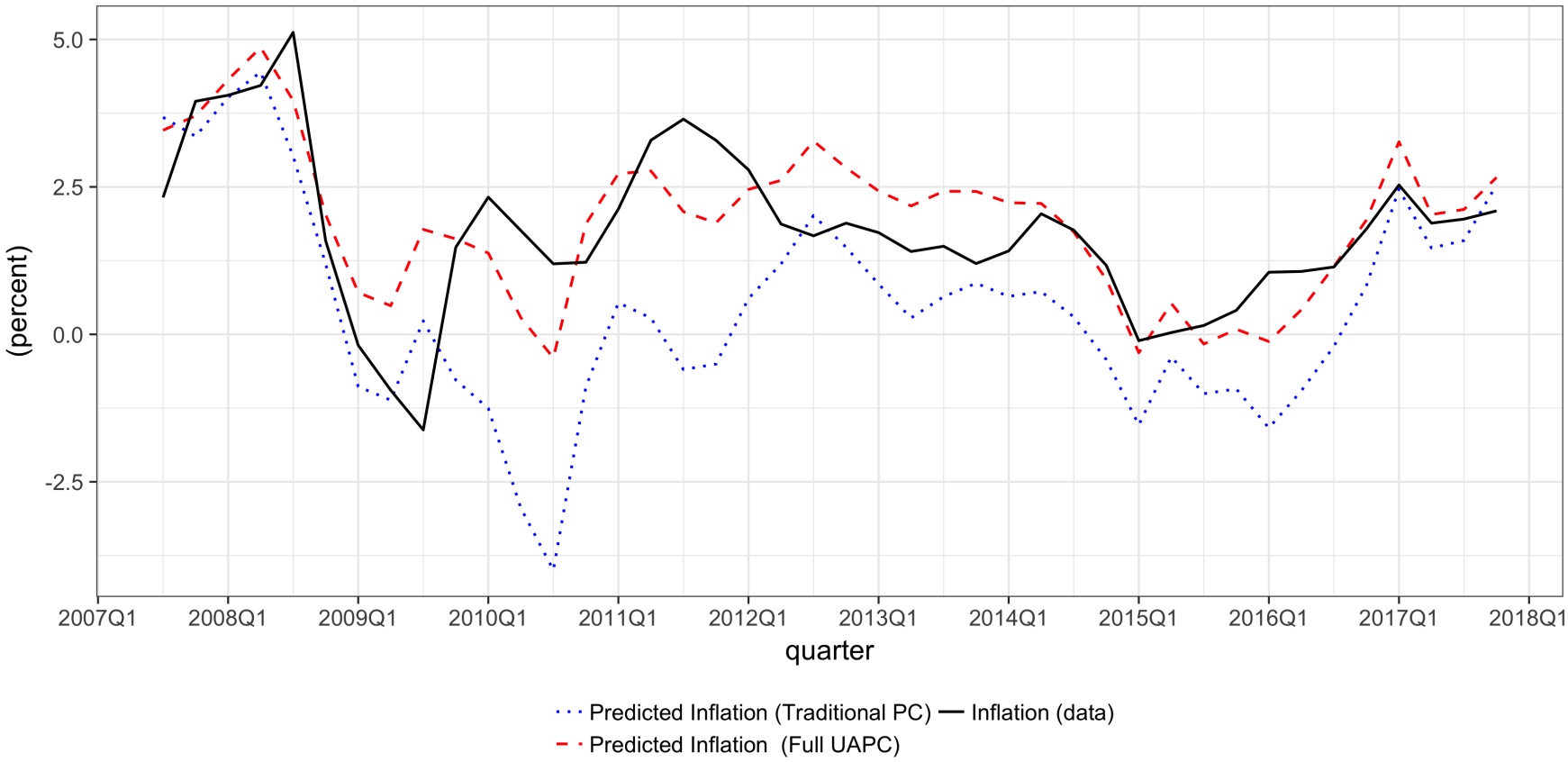
This table reports estimation result for the Traditional Phillips Curve (Traditional PC), Restricted Uncertainty-Augmented Phillips Curve (Rest. UAPC), and the Full Uncertainty-Augmented Phillips Curve (Full UAPC) using US data from 1970Q1-2018Q2. Heteroskedasticity Autocorrelation Consistent standard errors are reported in parentheses.
The RMSE row reports the root mean squared error statistic when specification (5.2) is estimated using data up to 2007Q3 and fitted out-of-sample for data after 2007Q3.

BAPC: Implied slope



Explain some of the constant-slope estimates of κ to be 0.3-0.5 post-Volcker, and 0.7-0.8 including pre-Volcker. (Lubik and Schorfeide, 2004; Smets and Wouter, 2007)

BAPC accounts for "missing disinflation"



- RMSE(BAPC) = 0.981 %, RMSE(Trad. PC) = 1.96%.

Robustness: Other measures of uncertainty

- MSC variance may measure disagreement, but not subjective uncertainty.
- To measure subjective uncertainty: look to probabilistic survey.
- Survey of Professional Forecasters (SPF) asks forecasters to provide not only point estimates, but a full probability measure on scenario bins.
- "What do you think is the chance of inflation being between 3-3.9%?"

GMM estimation of BANKPC

- Use GMM-IV to estimate

$$\pi_t = \beta_t^d \pi_t^d + \beta_t^f \mathbb{E}_t \pi_{t+1} + \kappa_t x_t$$

  similar to Gali & Gertler (1999).
- Using same set of instruments, estimate is significant and in line with theory.

Challenge and future research

- Identification of attention as **the** channel.
  - Coibion, Gorodnichenko, Ropele (2018) provides Italian firms evidence.
  - More micro-evidences are welcomed.
- Find cross-country evidence
  - Nominal demand shock more prevalent in many other countries.
  - Europe to control for monetary volatility? (in progress)