THE PEOPLE VS. THE MARKETS:
A PARSIMONIOUS MODEL OF INFLATION EXPECTATIONS

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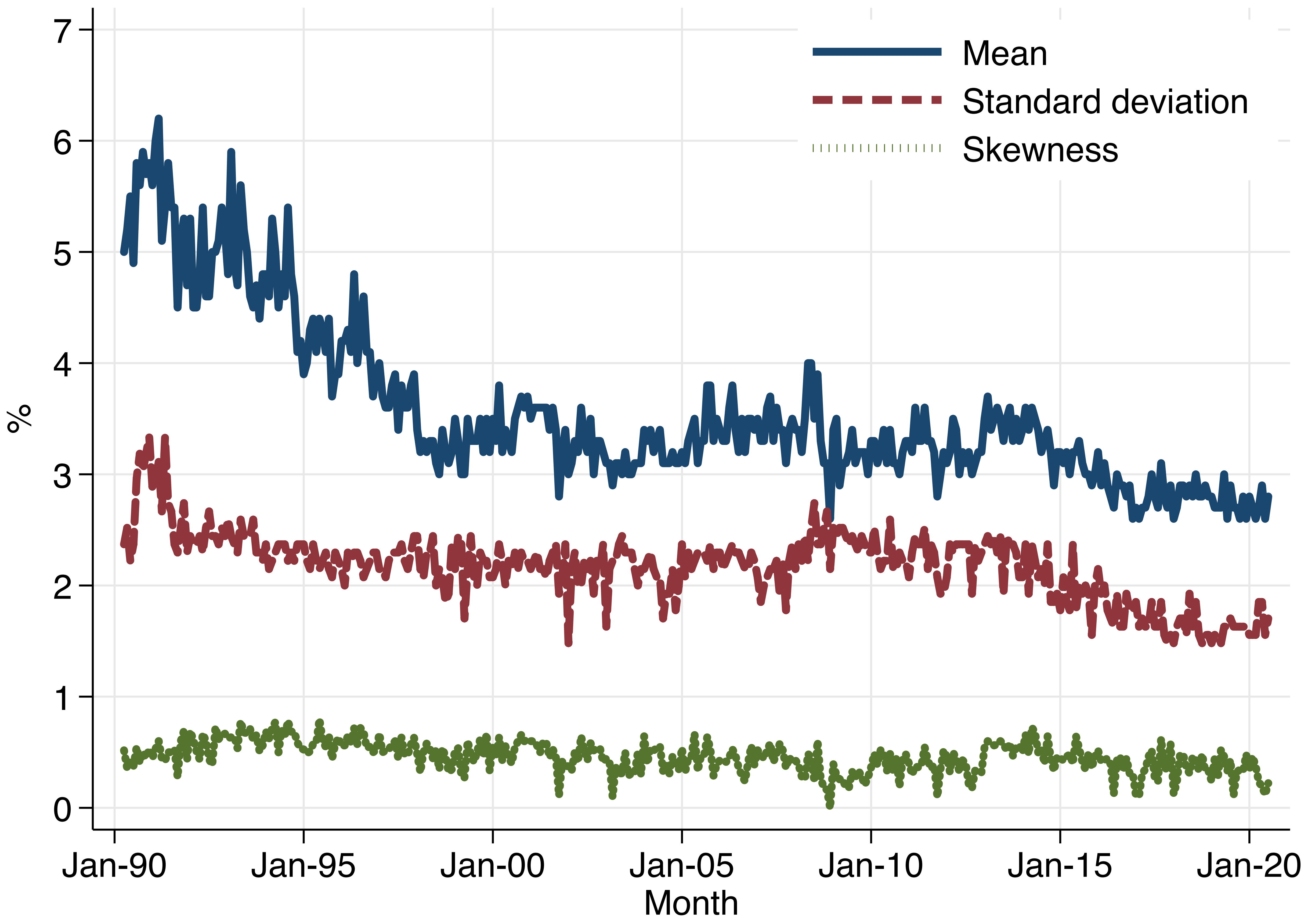
LSE

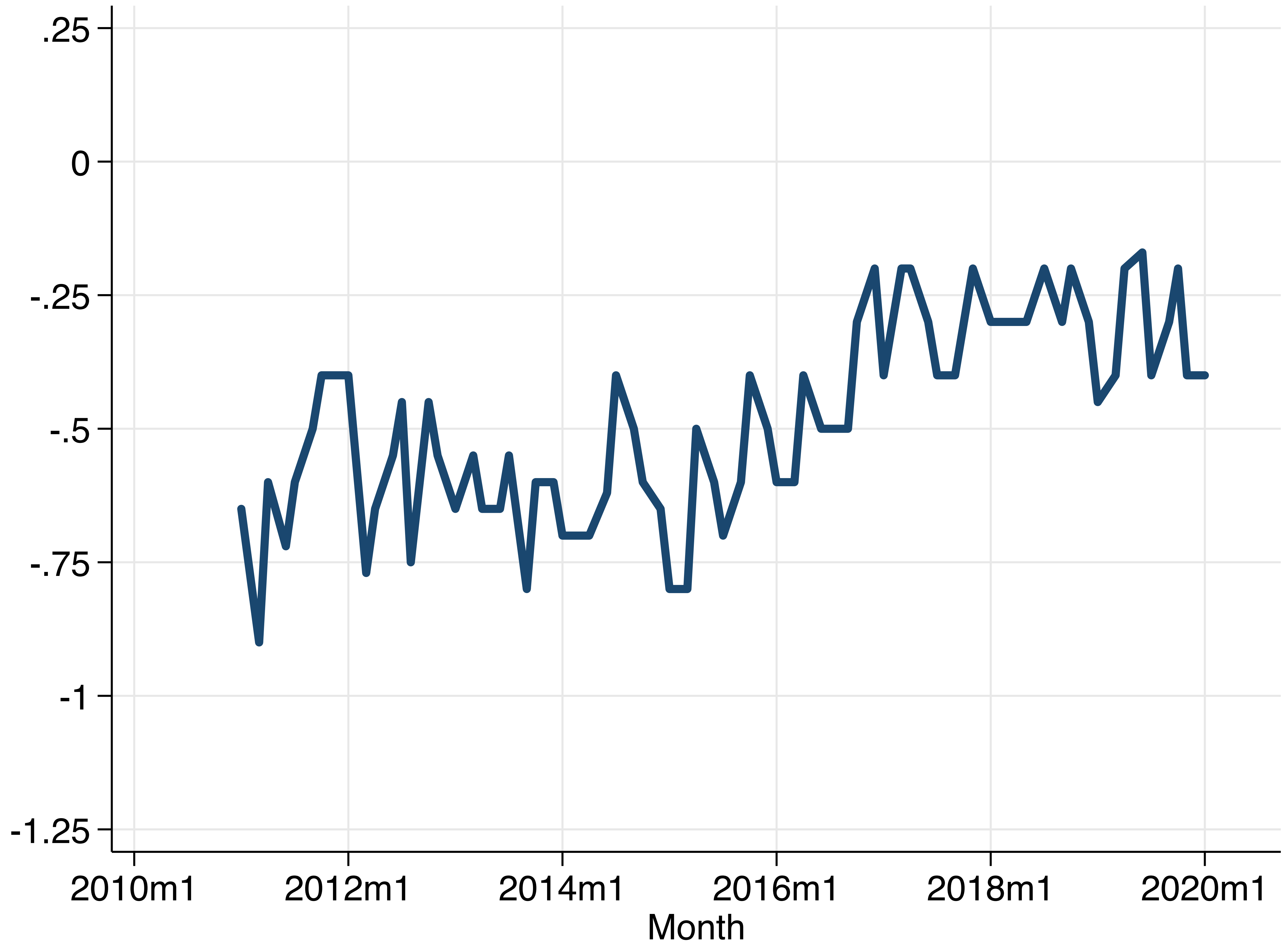
6th of December, 2021
RIDGE virtual forum
workshop international macro

People disagree about long-run inflation

Within people (Michigan)



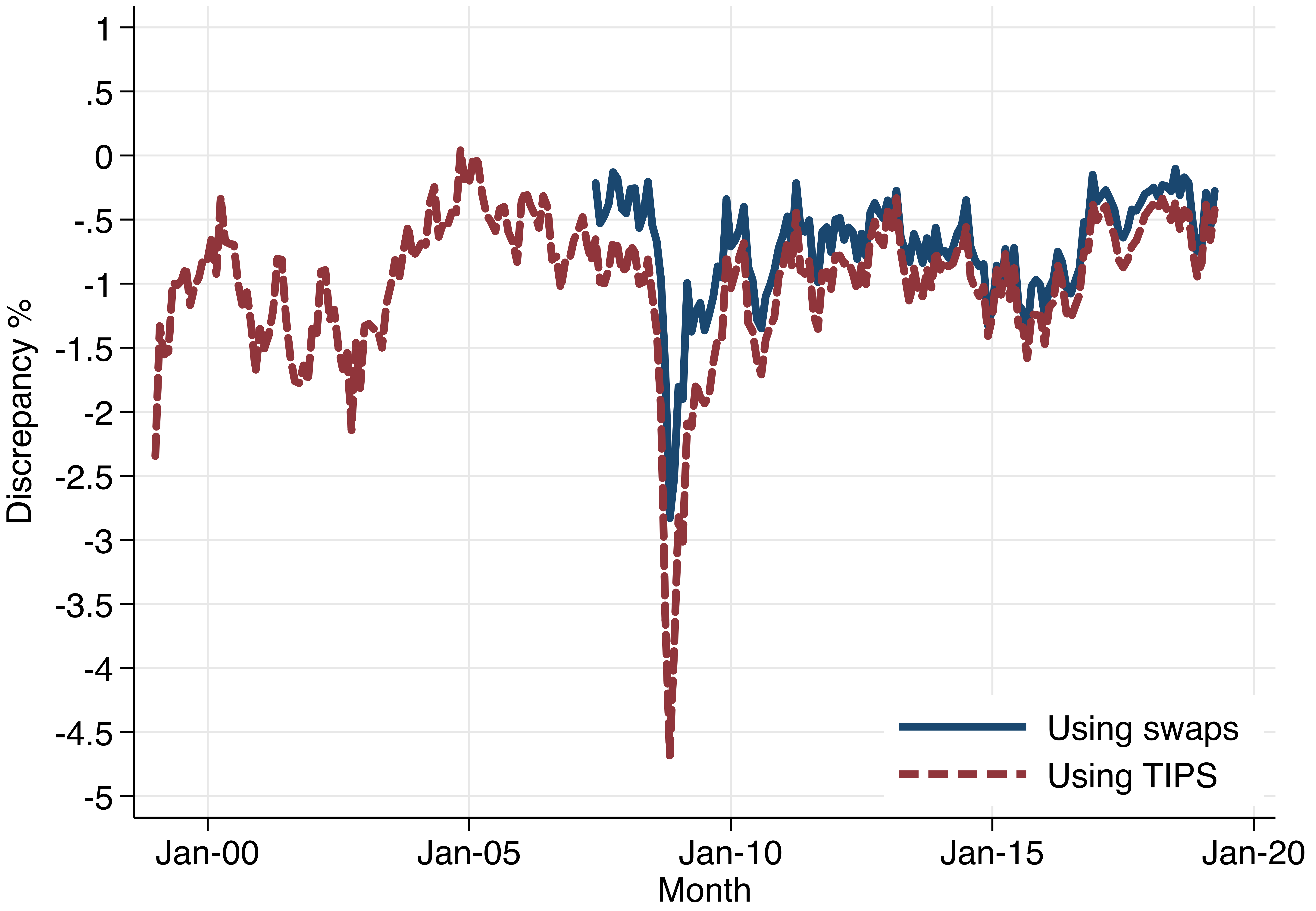
Across people (Households - Dealers)

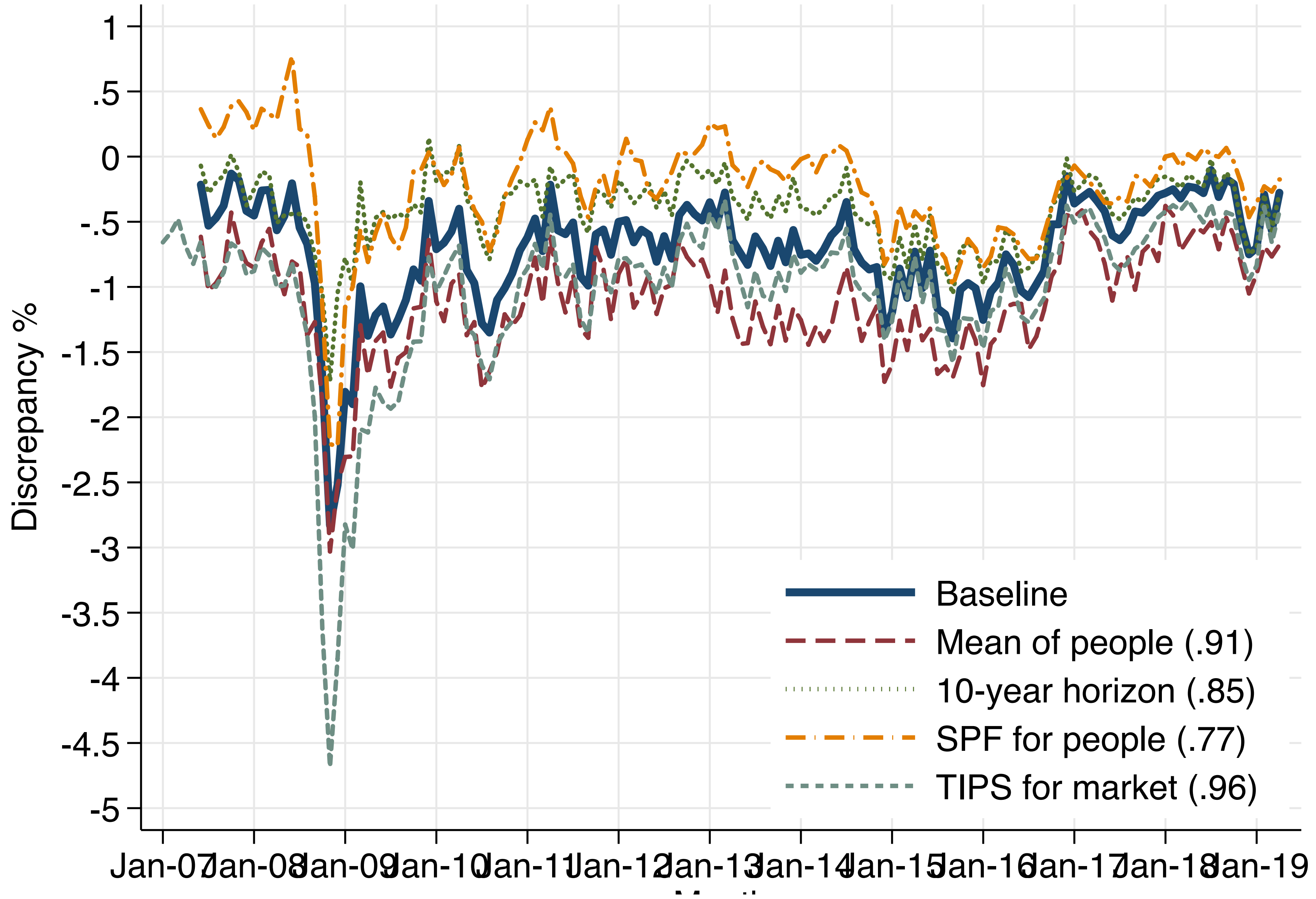


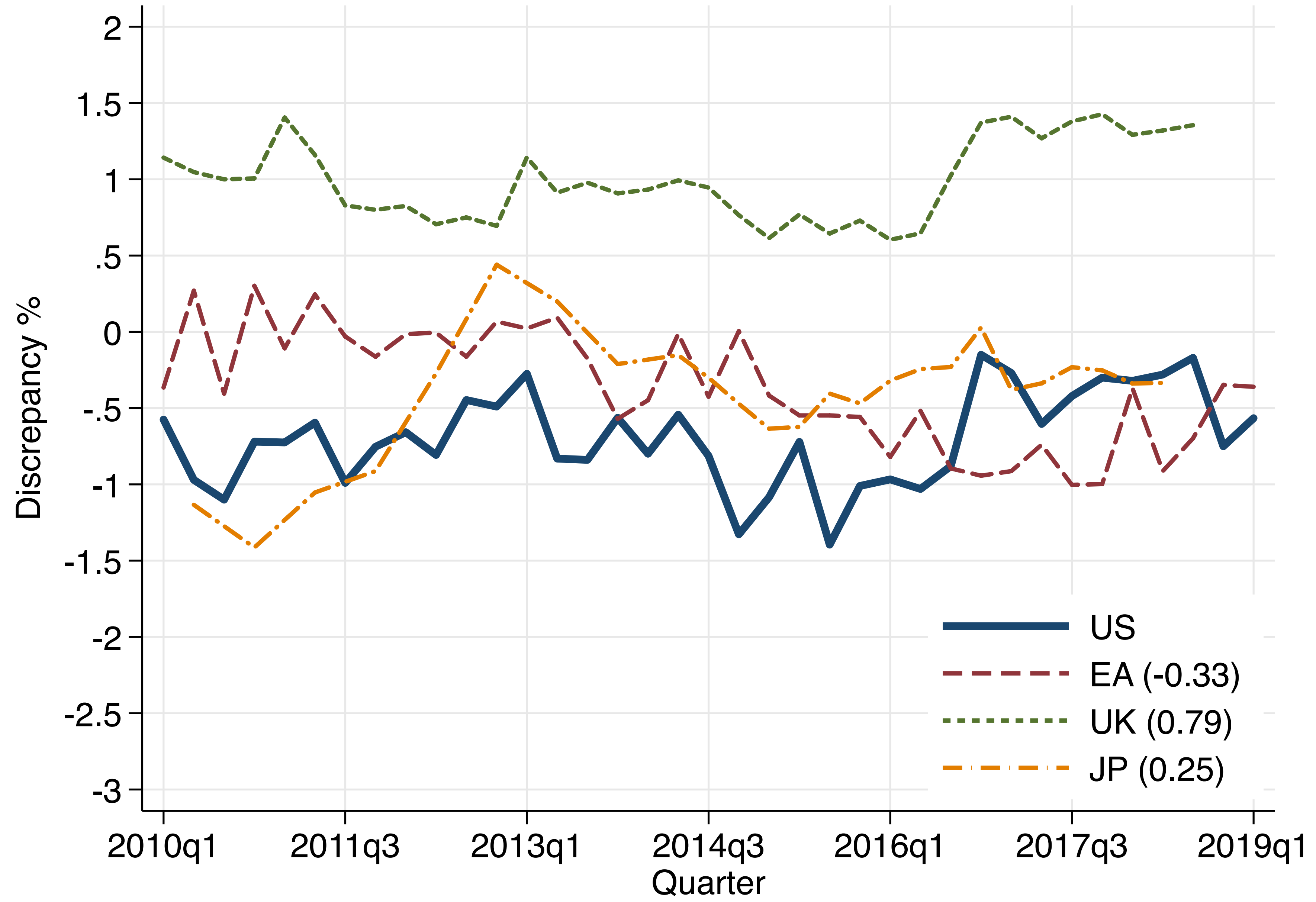
The people versus the markets

Subjective long-run expected inflation risk premium

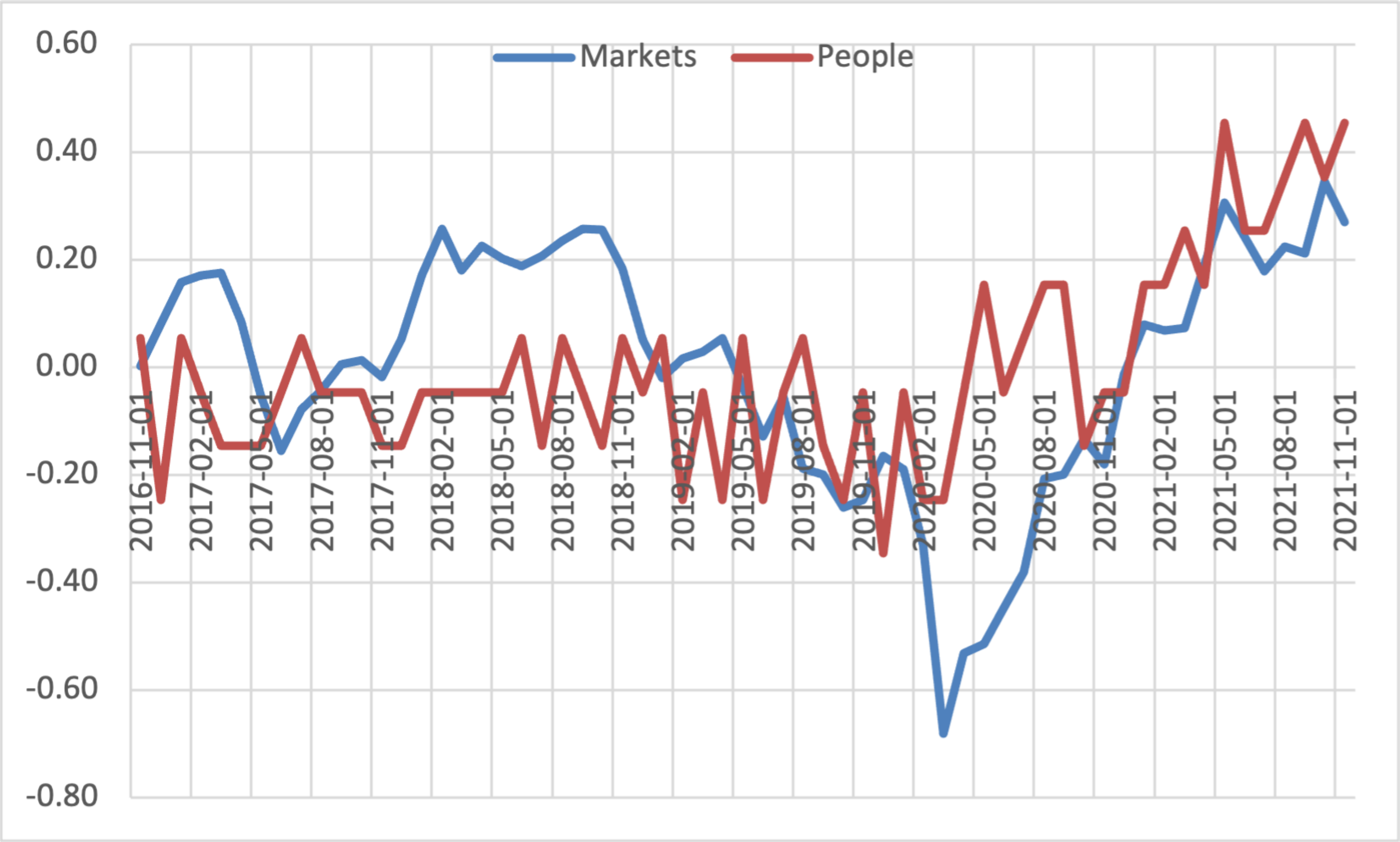
$$\phi_t = \mathbb{E}_t^*(\pi_{t,T}) - \mathbb{E}_t^p(\pi_{t,T})$$







The last few years



2. A parsimonious model of people's expectations

$$v_t \sim F_t(.) = Exp_t + Gaussian_t$$

Fundamental anchor

- Want to forecast inflation over long horizon: $\pi = \pi_{t,T}$

- Fundamental rational expectation is π^e

- Properties:

$$\mathbb{E}_t(\pi_{t,T}) = \pi^e_{t,T} \quad \text{and} \quad \mathbb{E}_t(\pi^e_{t,T}(\pi_{t,T} - \pi^e_{t,T})) = 0$$

- Household expectation: v^h

First property: incomplete information

- People do not know π^e. They have a (dynamic) prior with mean π^*

- Receive idiosyncratic noisy signal(s) with error:

$$\mathbb{E}^h(\pi^e + e^h|\pi^e) = \pi^e \quad \text{and} \quad Var(e^h|\pi^e) = \sigma^2$$

- *Empirically:* match dispersion of expectations, under-reaction of average inflation expectations to news

- *Simplification:* distribution of signals is normal

Second property: over-confidence

- Agents behave as if their signals were more precise than they really are

- Responsiveness may be higher than what precision would entail (and >1):

$$\frac{\partial v^h}{\partial(\pi^e + e^h)} = \theta$$

- *Empirically:* over-reaction to news in the cross-section

- *Simplification:* linear relation

Third property: learn from experience

- Bias in beliefs. Type-specific scars.

- Added constant to expectation

$$z_c$$

- *Empirically:* evidence of long scars of high inflation times, systematic biases

- *Simplification:* the bias is linear in group ***c* = *0,1,2,…***

$$z_c = c\pi^z$$

Fourth property: sticky information

- Groups infrequently update, transitions across biases is a ladder over which a small share updates

- Fraction of individuals in group ***c***:

$$\lambda(1-\lambda)^c$$

- *Empirically:* slow dissemination of news, endogenous disagreement

- *Simplification:* exponential distribution

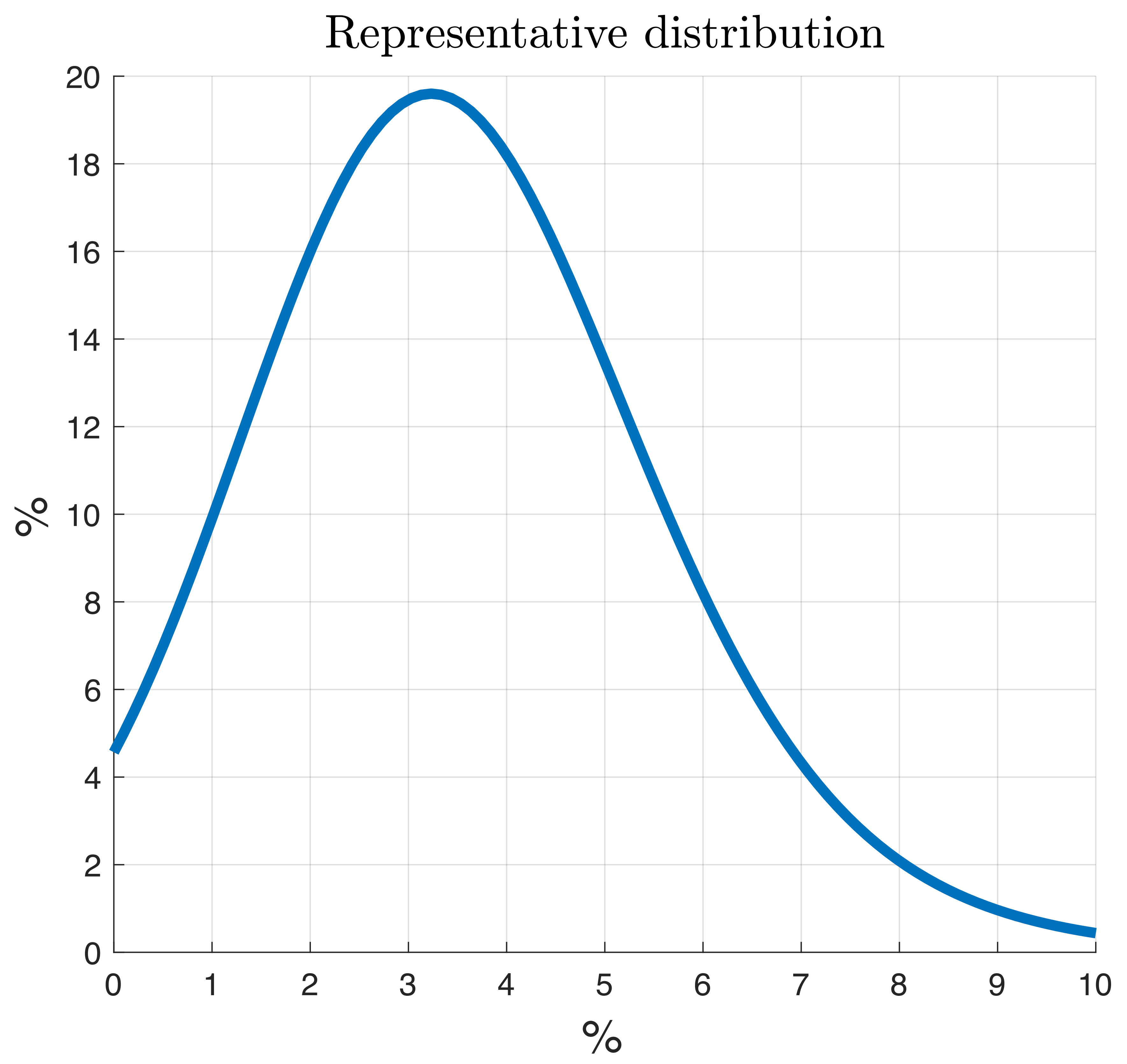
Parsimonious model of expectations

- Full model, conditional on (π*, πe),

$$v_t^h = c_t \pi_t^z + \pi_t^* + \theta_t (e_t^h + \pi_t^e - \pi_t^*)$$

$$e_t^h | \pi_t^e \sim N(0, \sigma_t^2) \text{ and } c_t \sim Exp(\lambda_t)$$

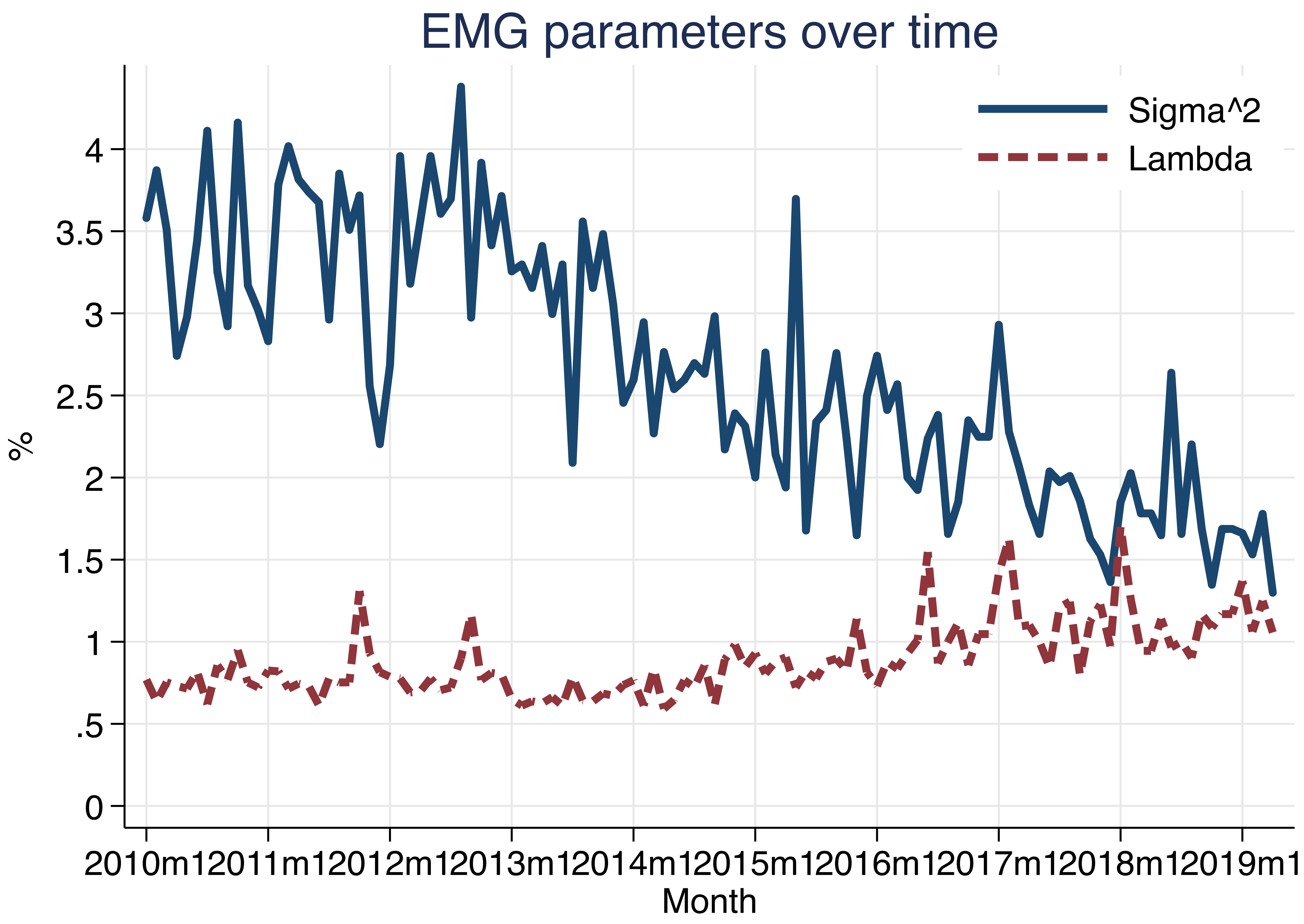
follow an EMG distribution ***F$_t$(.)***



- 3 identified parameters, 3 non-zero moments

$$\theta, \sigma^2, \lambda / \pi^z$$

Identification and over-identification



Checks on the model:

1. Both positive always
2. Kurtosis and higher-order moments are zero
3. Adjusted mean

$$\mu_t \equiv Mean_t - StDev_t(0.5Skew_t)^{1/3}$$

$$\lim_{T\to\infty} \frac{\sum_t \mu_t}{T} = \pi^*$$

2.3% full sample 1.9% since 2010

4. A parsimonious model of traders' beliefs and market prices

$$\mathbb{E}^b(.) = \mathbb{E}(.|v^{median}, q)$$

$$\mathbb{E}^m(.) = \mathbb{E}(.|v^*, q)$$

$$\mathbb{E}^*(.) = 1/q(\pi^e, \sigma)$$

The traders' information and beliefs

- Continuum in ***[0,1]***, indexed by ***i***, drawn from household prior v^i from ***F(.)***

- Trade nominal bond, costs ***q*** today, gives ***1*** next period, Bayesian update:

$$p(\pi^e|v^i, q) \propto g(q|\pi^e) f(\pi^e|v^i)$$

- Goal is to choose b^i given an sdf ***m(.)***

$$\max \int \left[m(\pi)e^{-\pi} - q\right] b^i p(\pi^e|v^i, q) d\pi^e$$

Optimal trading

- Simplifications
    - Start with some wealth, cannot short: $b^i \in [0,w_i]$
    - SDf is common across all, given by representative agent, so risk aversion does not depend on choices, payoff $y(\pi^e) = E(m(\pi)e^{-\pi} \mid \pi^e)$.

- MLRP of $F_t(.)$: those with high signal, choose $b_i=0$; those with low signal, choose $b_i=w_i$, marginal trader is indifferent, has signal v^*:

$$\int y(\pi^e)p(\pi^e|v^*, q)d\pi^e = q$$

Market clearing and noise

- Market clearing

$$F(v^*|\pi^e) = B/w \equiv \omega$$

- Noise from behavioral biases, noise, liquidity frictions, supply of bonds, habitats. Contaminates signal from price, prevents revelation, produces high volatility

- Simplification: Symmetric Beta distribution, mode 1/2, parameter $\boldsymbol{\beta}$

- Two parameters: $\boldsymbol{\pi}^*$ shift price $\boldsymbol{q}$ one-to-one, $\boldsymbol{\beta}$ how informative prices are

Market prices and the discrepancy

- Property: the threshold ***v**** is a sufficient statistic for ($\boldsymbol{\pi}^e$,$\boldsymbol{\omega}$). Equilibrium price:

$$q(\pi^e, \omega) = Q(v^*) = \frac{\int y(\pi^e) g(v^* - \pi^e) f(v^* - \pi^e) d\pi^e}{\int g(v^* - \pi^e) f(v^* - \pi^e) d\pi^e}$$

- Monotonic in ($\boldsymbol{\pi}^e$,$\boldsymbol{\omega}$) spans real line, so can fit data.
- Parameters: $\boldsymbol{\pi}^*$ shifts $\boldsymbol{q}$ 1-to-1, $\boldsymbol{\beta}$ informativeness of market prices

- Model justifies a decomposition of the discrepancy

$$\phi_t = \underbrace{\mathbb{E}_t^b(\pi_{t,T}) - \mathbb{E}_t^p(\pi_{t,T})}_{\text{disagreement across}} + \underbrace{\mathbb{E}_t^m(\pi_{t,T}) - \mathbb{E}_t^b(\pi_{t,T})}_{\text{disagreement within}} + \underbrace{\mathbb{E}_t^*(\pi_{t,T}) - \mathbb{E}_t^m(\pi_{t,T})}_{\text{risk compensation}}$$

A model to combine data into fundamental RE

$$v_t^h = \pi_t^* + c_t^h + \theta_t(e_t^h + \pi_t^e - \pi_t^*)$$

$$\text{with} \quad c_t^h \sim E(\lambda_t), \quad e_t^h|\pi_t^e \sim N(0, \sigma_t^2)$$

$$\text{cross-sectional distribution} \quad v_t^h \sim F_t(\pi_t^e)$$

$$q_t = \frac{\int y_t(\pi_t^e) g_t(F_t^{-1}(\omega_t)) f_t(F_t^{-1}(\omega_t)) d\pi_t^e}{\int g_t(F_t^{-1}(\omega_t) f_t(F_t^{-1}(\omega_t)) d\pi_t^e}$$

$$\text{with:} \quad \omega_t \sim B(\beta), \quad \pi_t^e|q_t \sim G(\pi_t^e)$$

$$E_t^b = \mathbb{E}_t(\pi_t|v_t^{\text{median}}, q_t)$$

Households: biased from experiences, sluggish average, over-react individually

Markets: more information, sensitive to news, filled with noise

Professionals: median is misleading, not marginal traders.

Data inputs: three moments from household survey distribution, one market price, median professional

Model outputs: reaction, dispersion and bias (θ, σ, λ), market noise (ω), fundamental expected inflation (π^e)

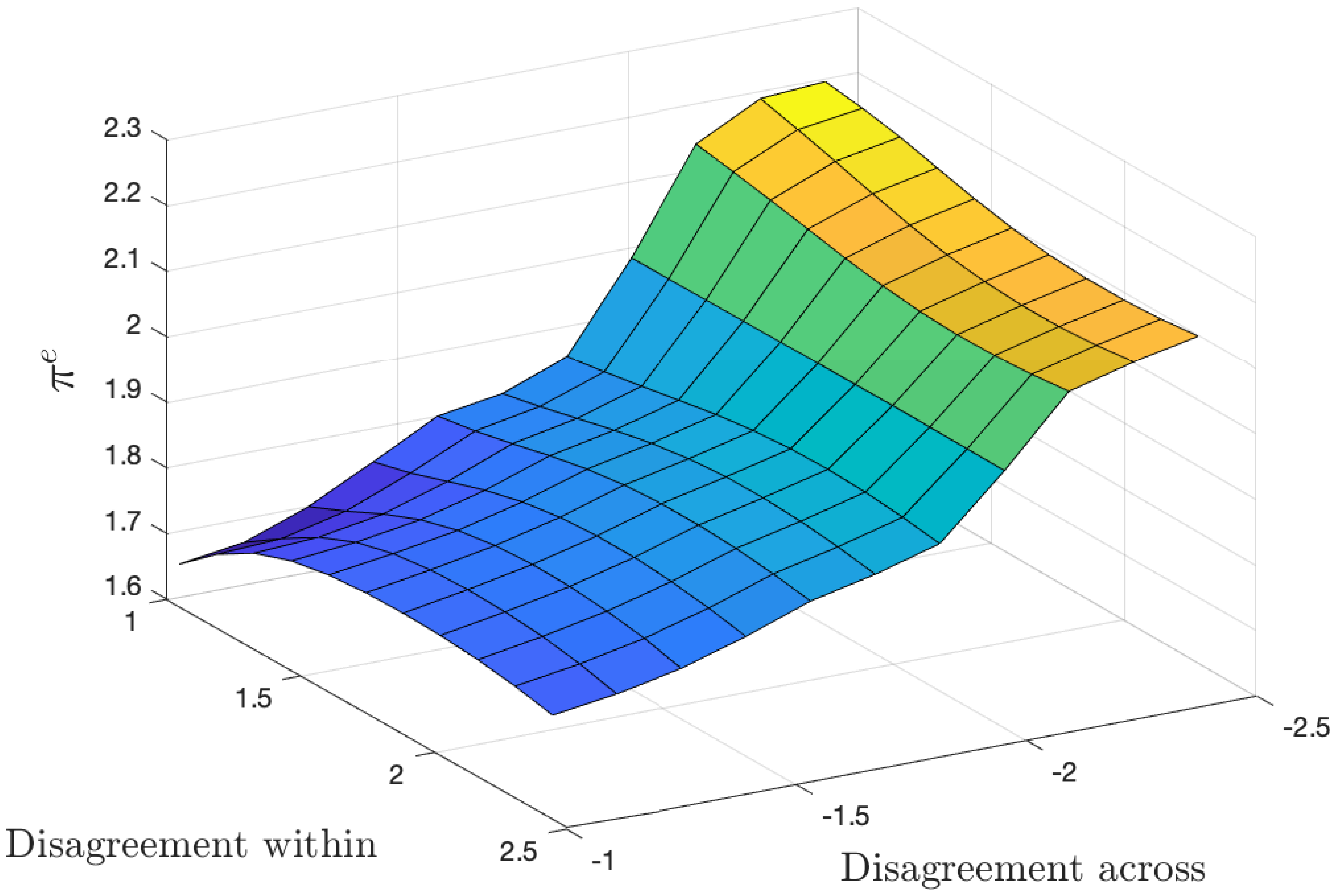
5. Measuring US and EZ long-run inflation expectations

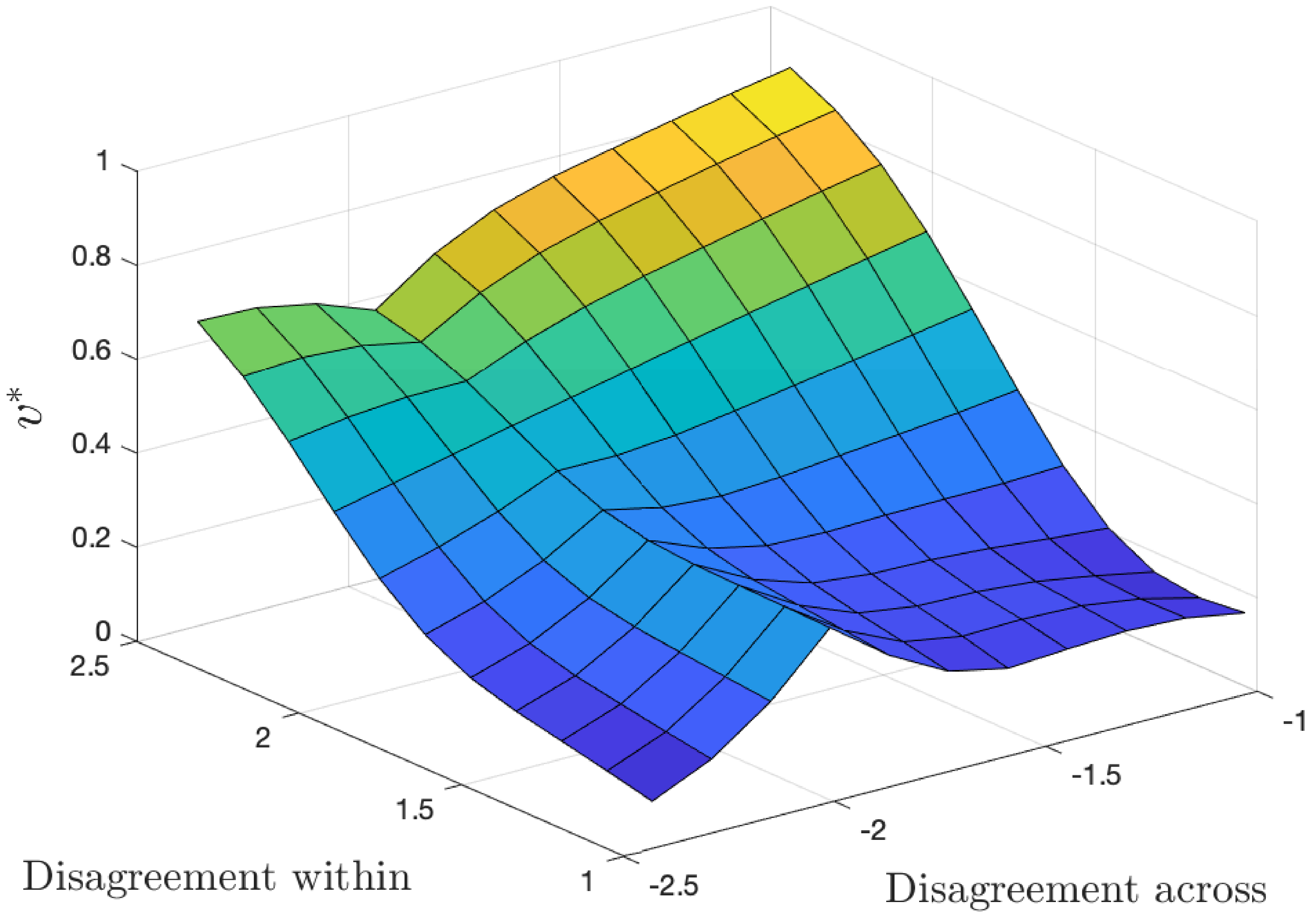
Model's mechanics

Parameters: only two $\pi^* = 2\%$, and $\beta = 2$

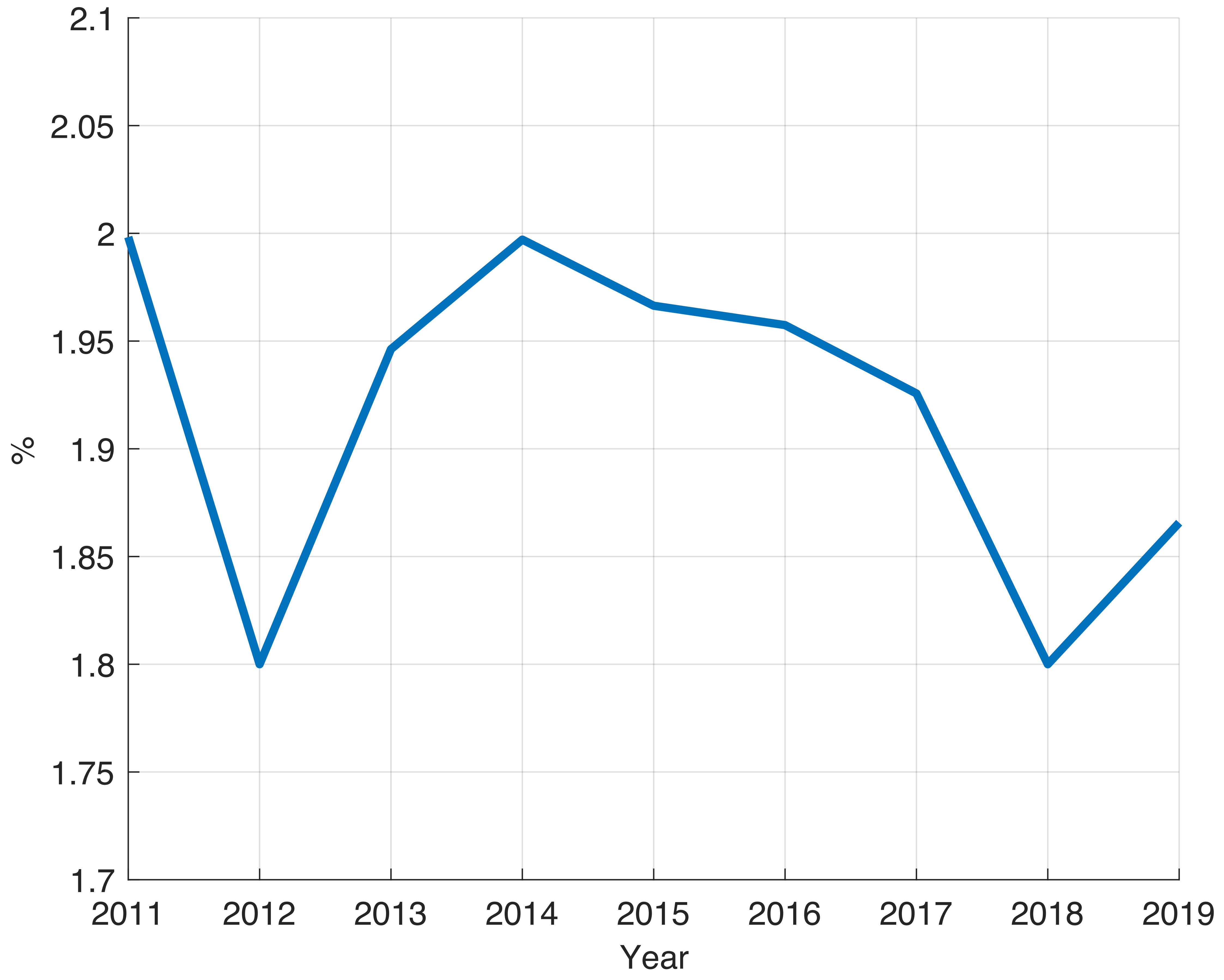
Inputs: Five series in introduction.

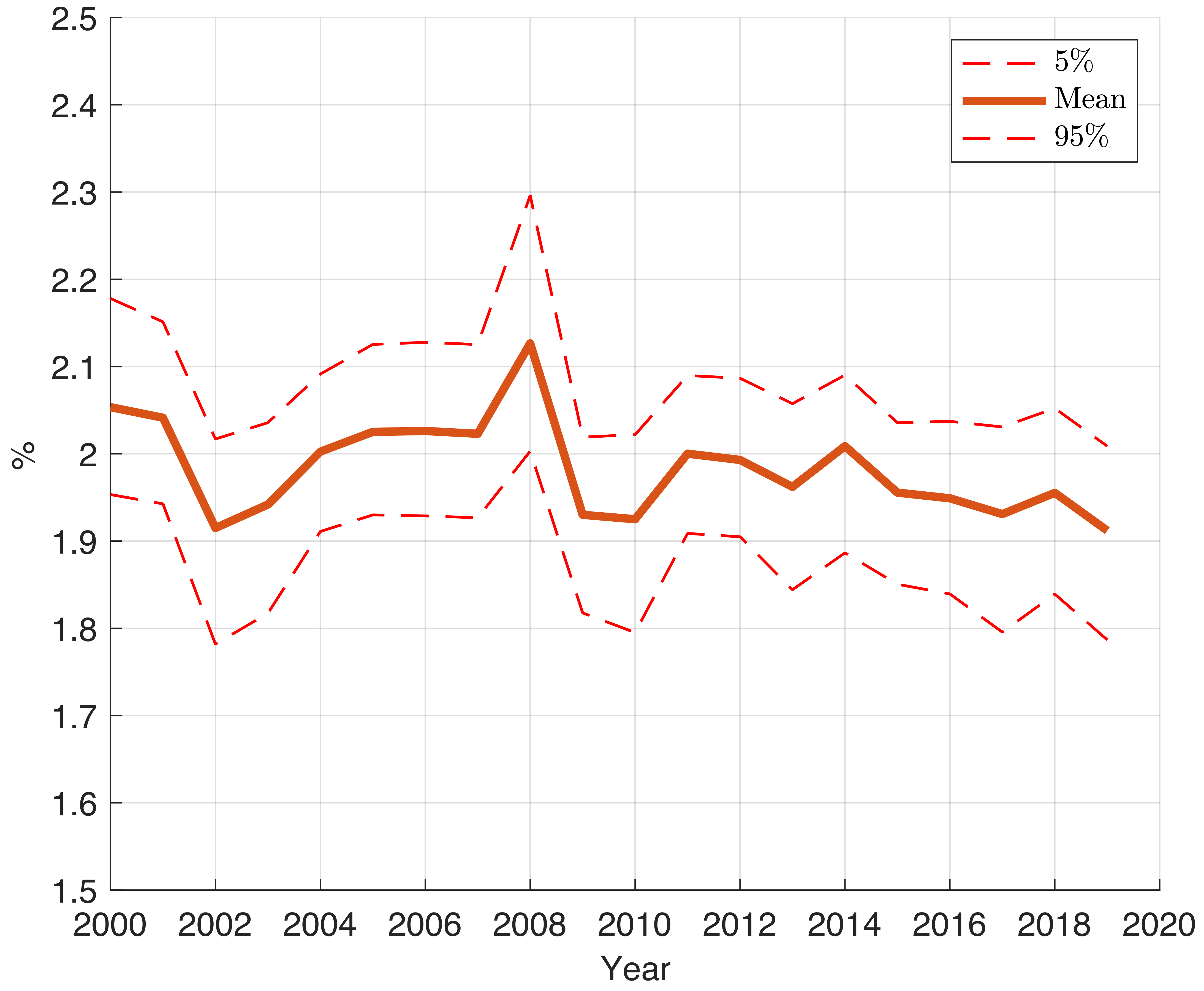
Outputs: fundamental π^e_t, marginal trader v^* , decomposition of discrepancy



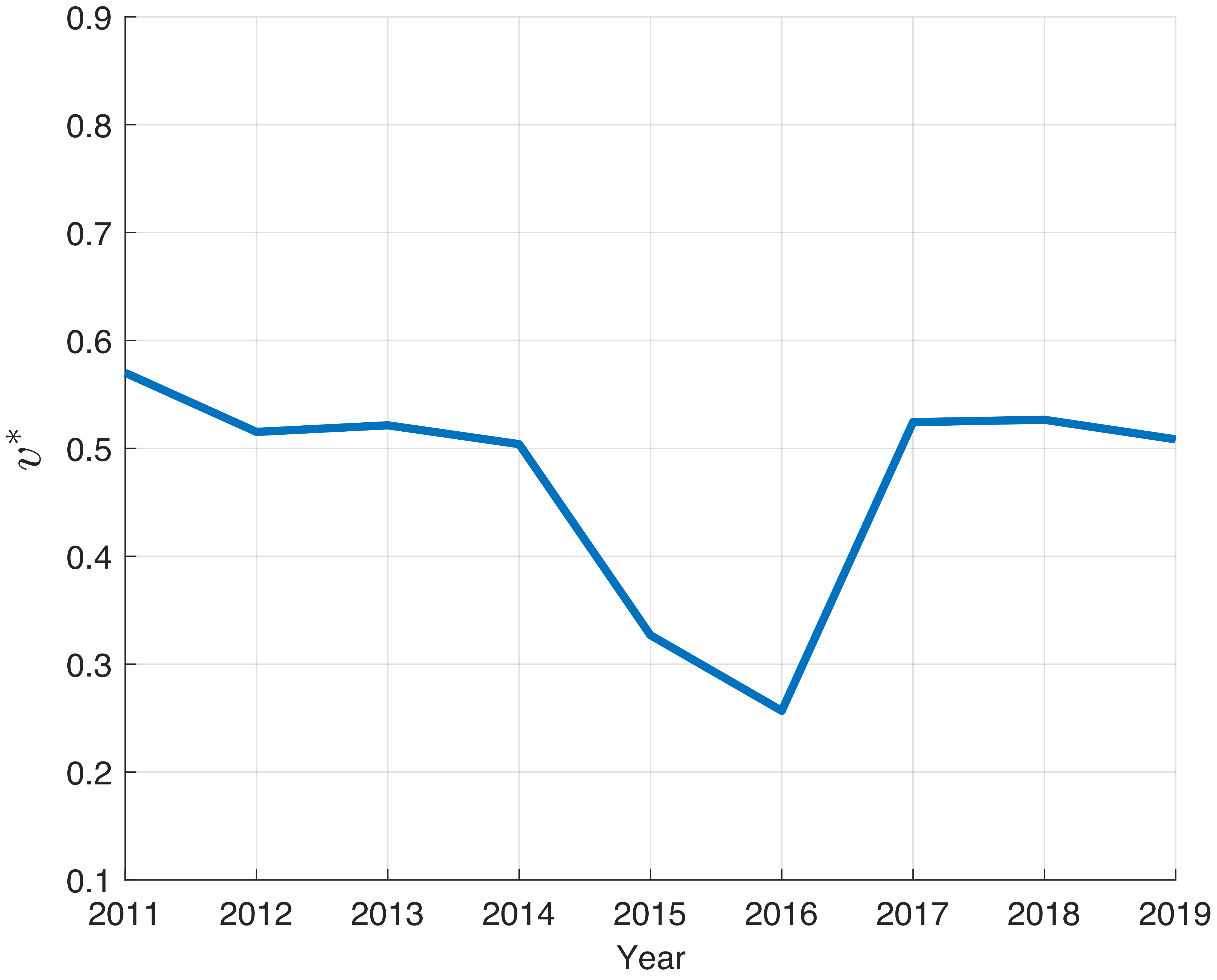


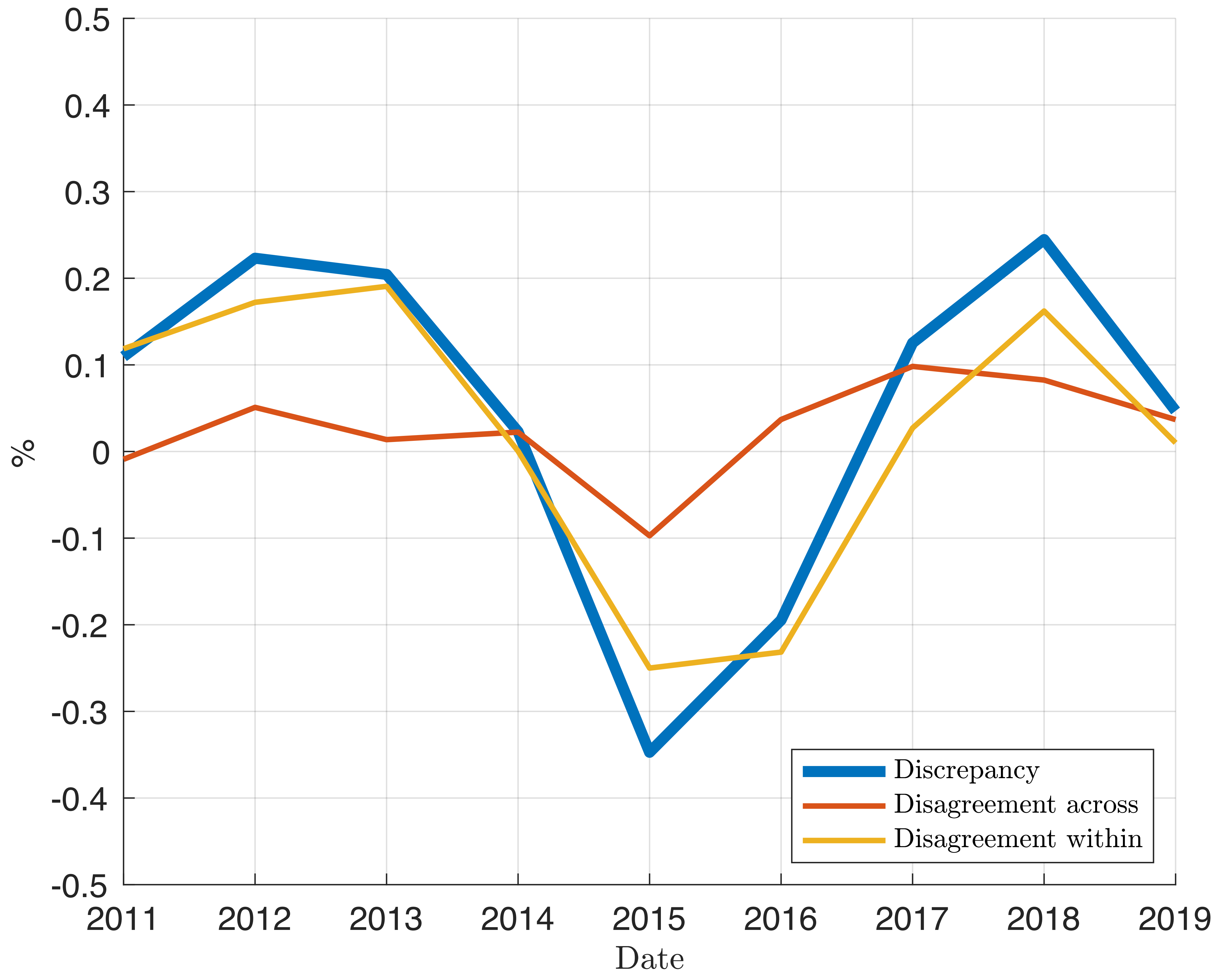
Expected inflation post-2011 and post-2000



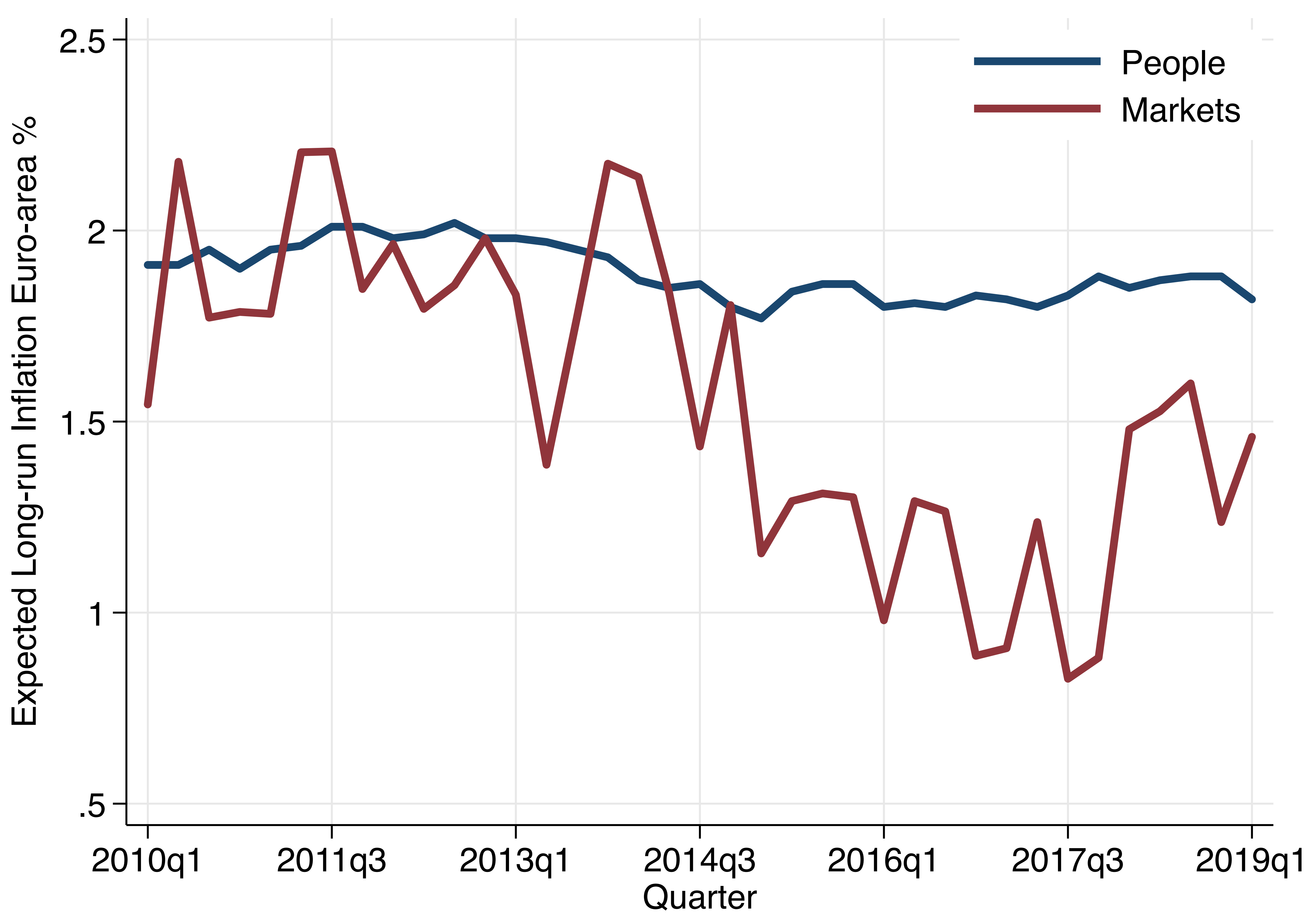


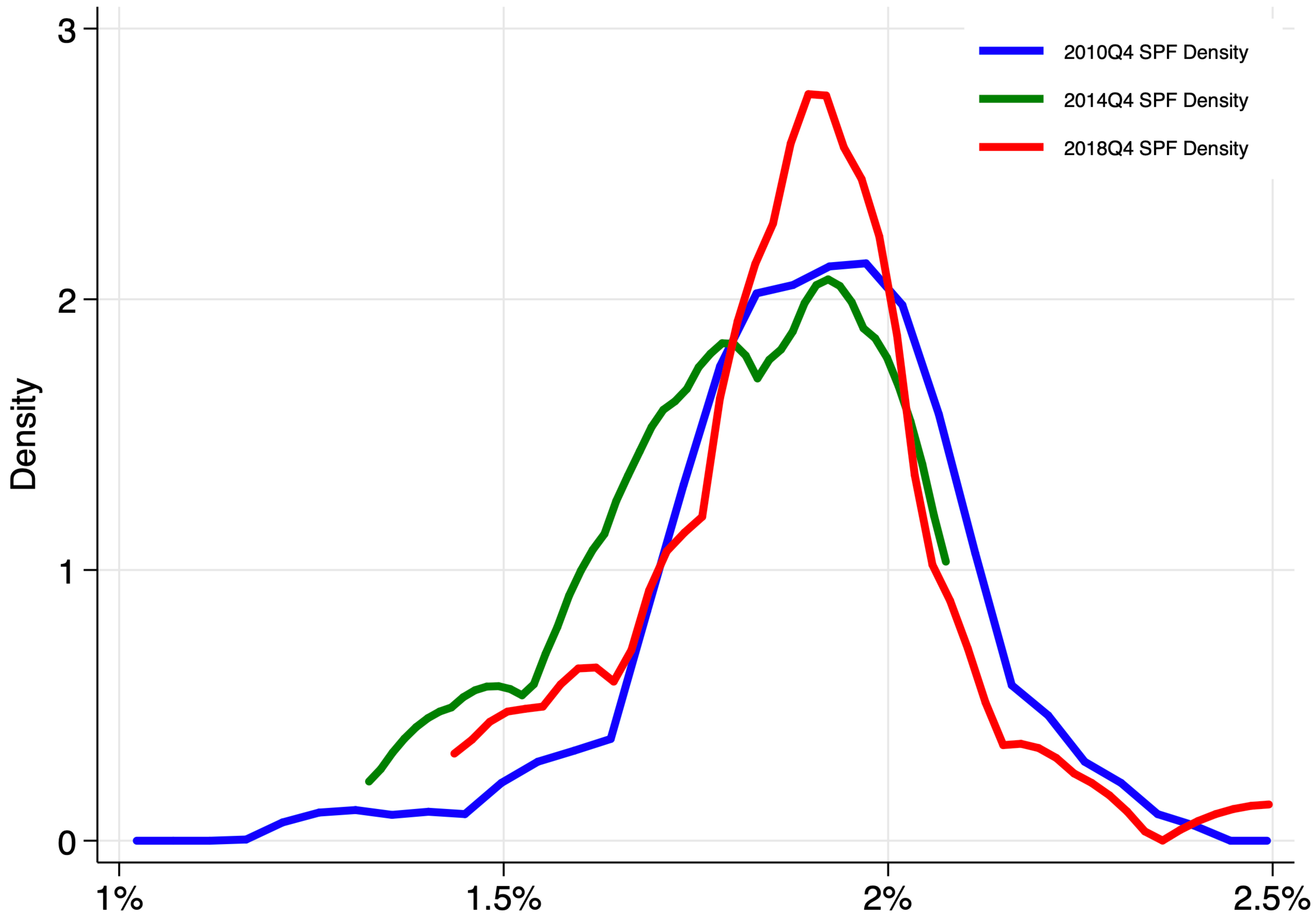
Marginal trader and decomposition



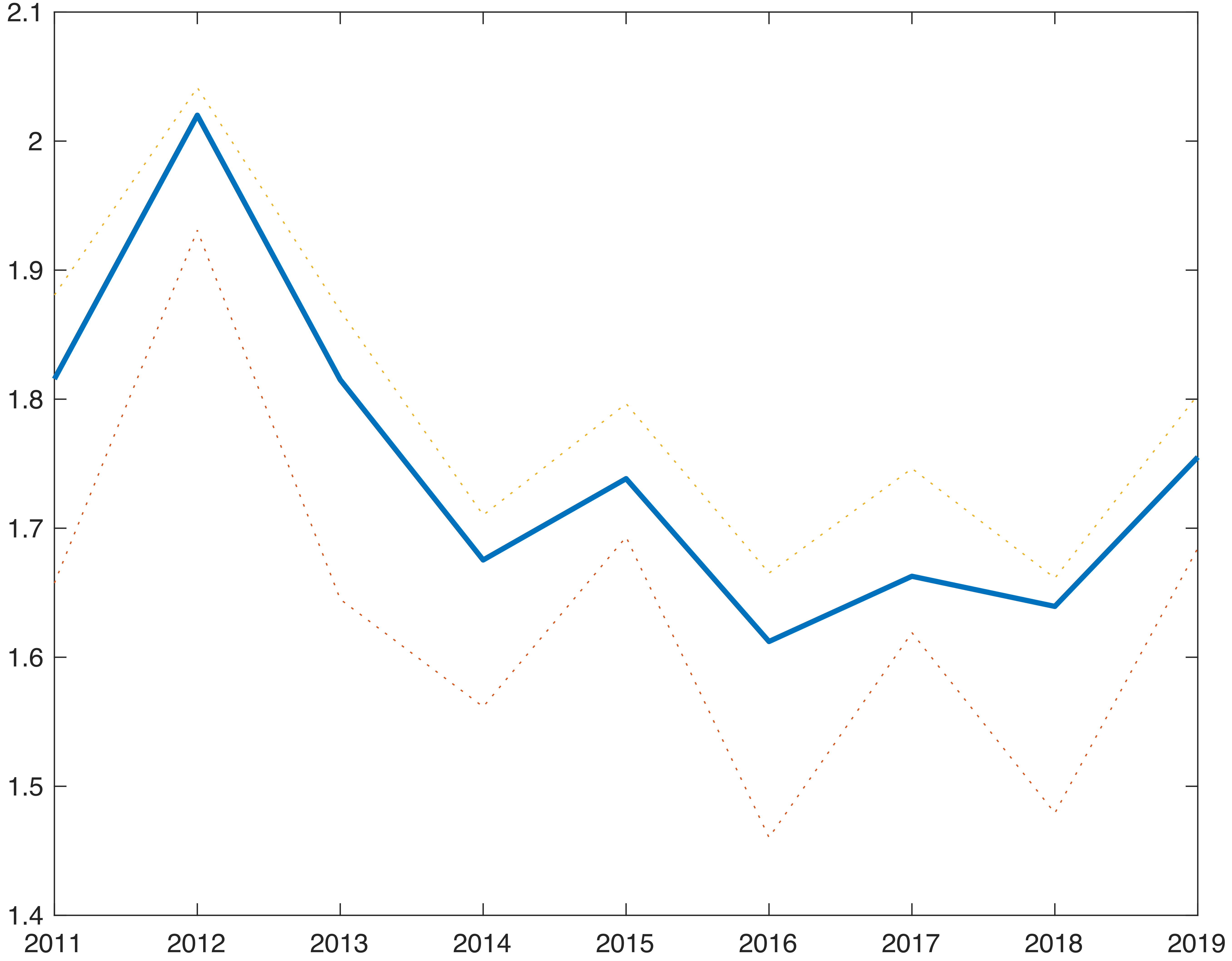


Application to the Euro-area: inputs

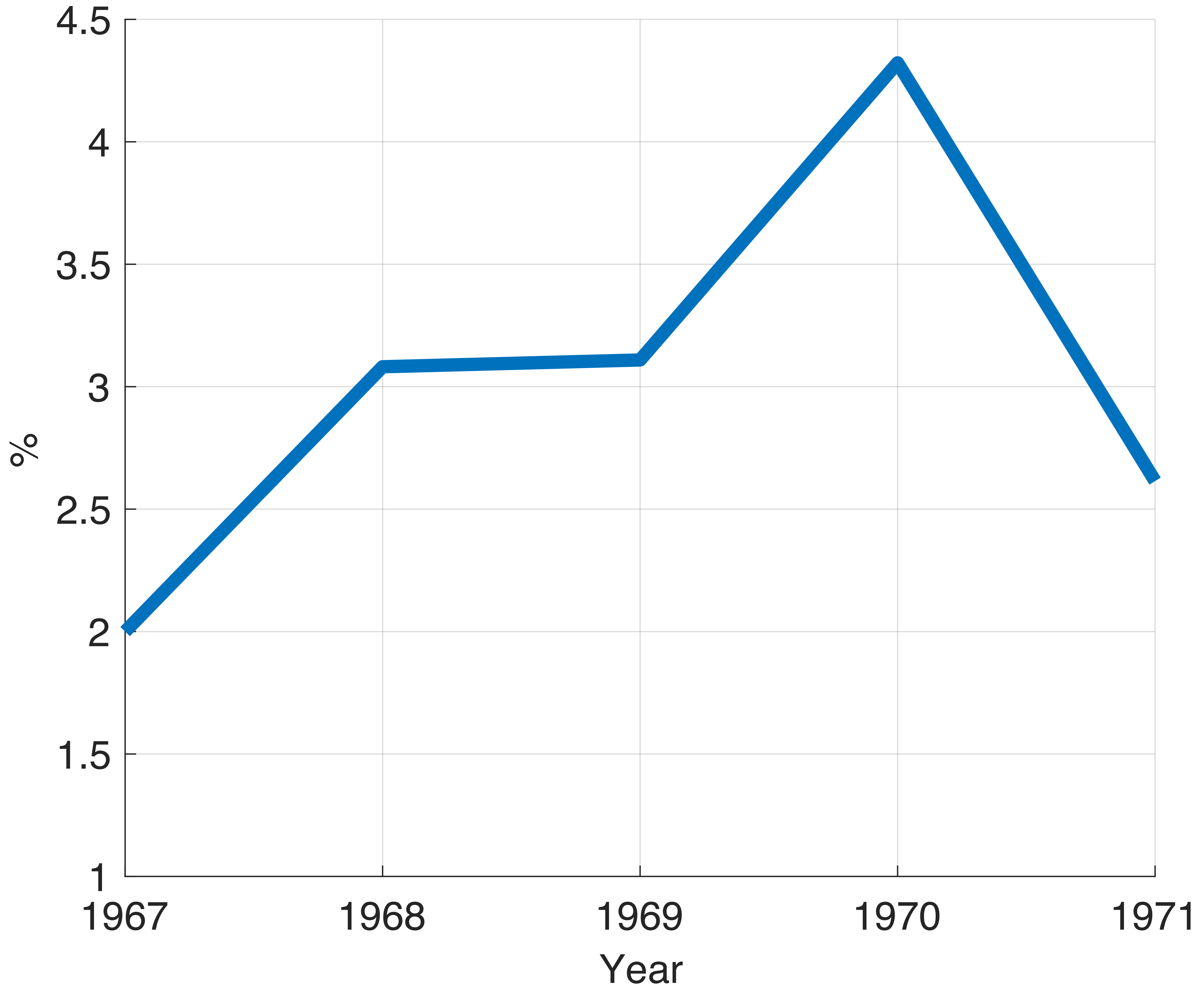




Application to the Euro-area: anchor



United States 1967-71

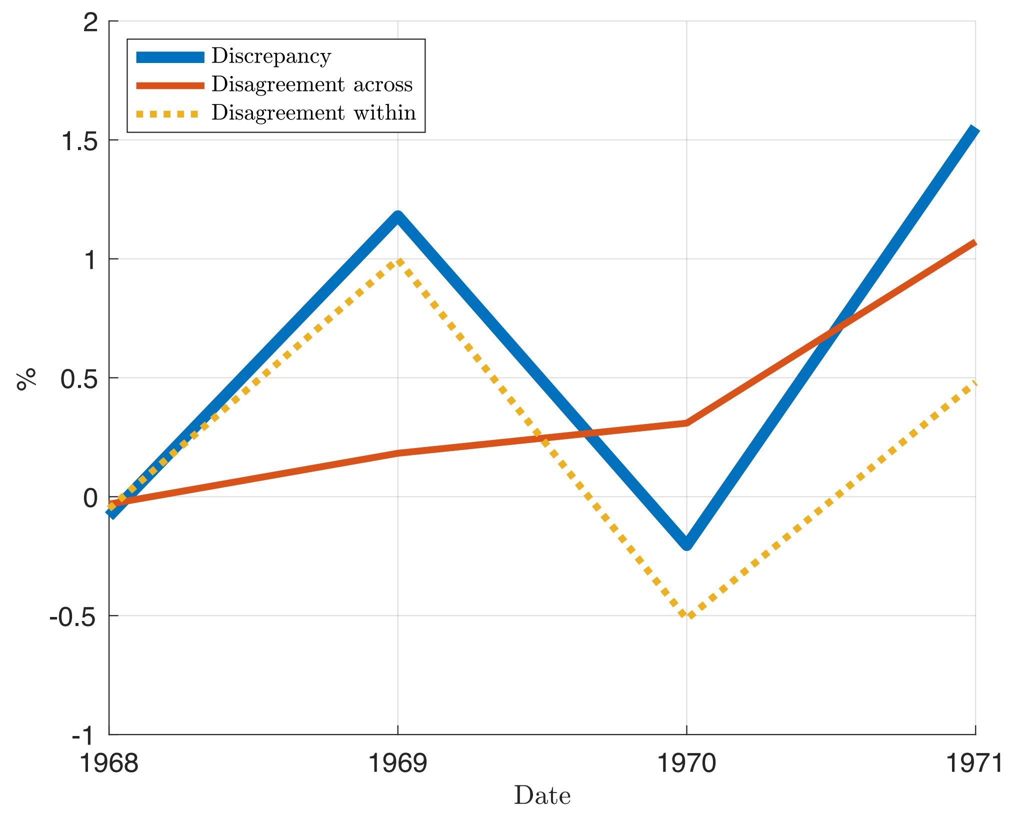


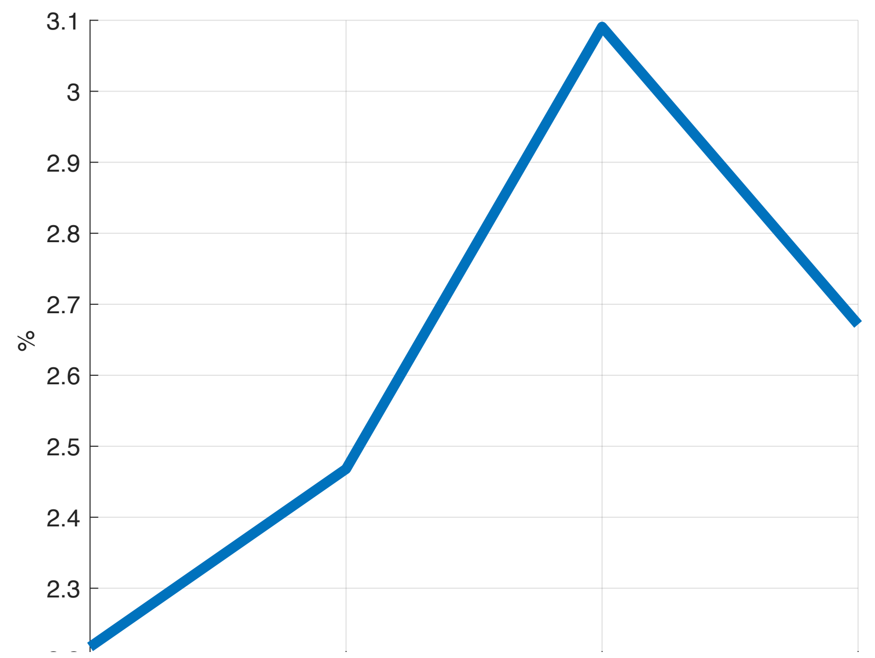
The drifting anchor

At first, markets seen as maybe reflecting noise

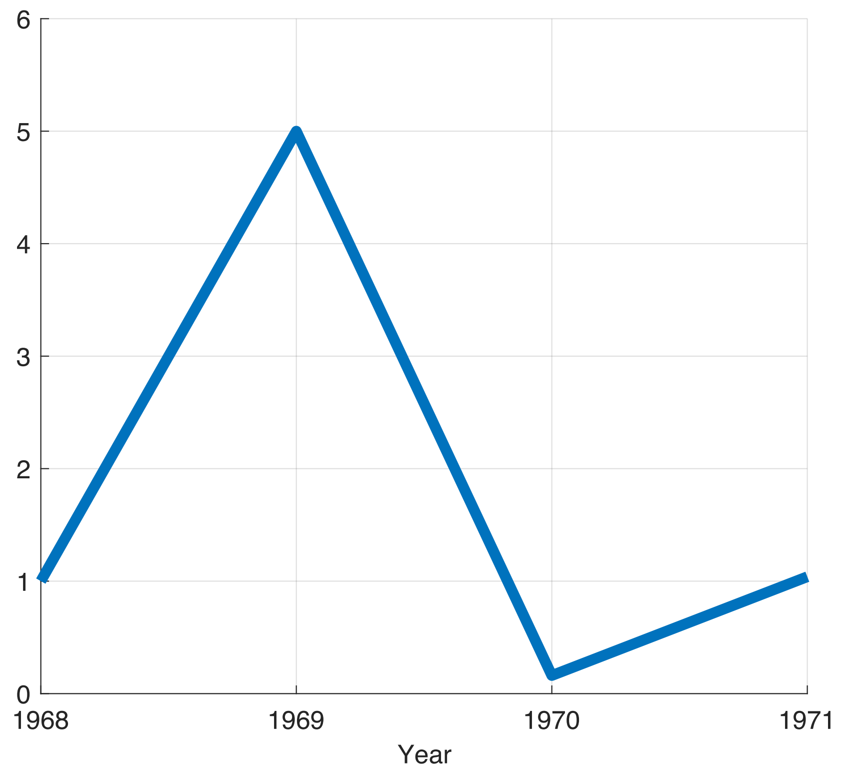
But, disagreement across households showed the fund. expectation shifting

Later, sluggish response of medians of professionals confirms it



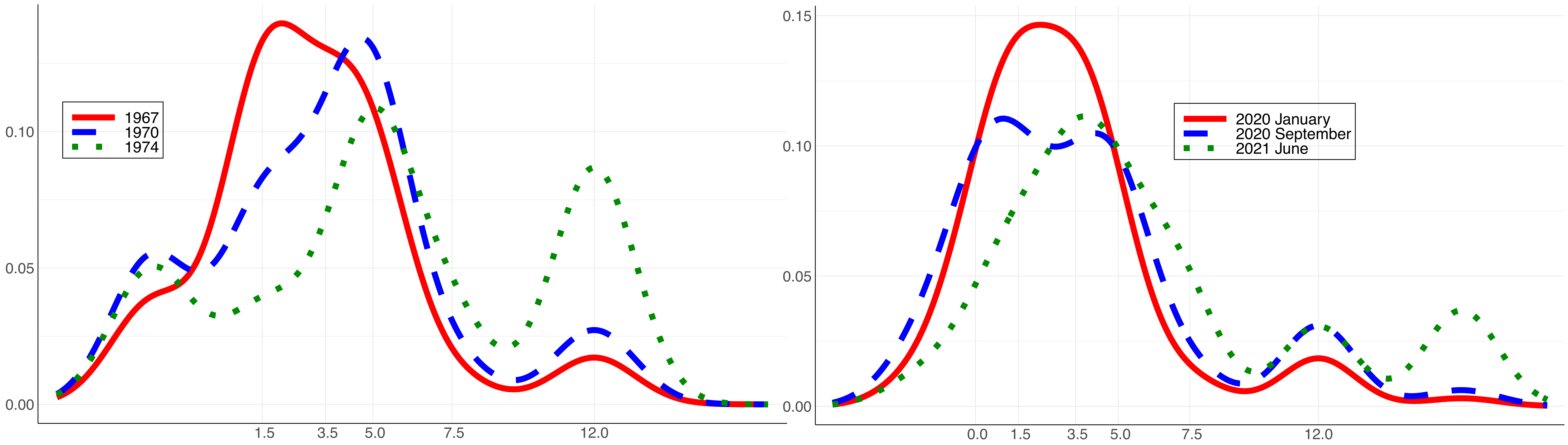


σ



θ

Late 1960s and 2021



Source: Reis (2021)

6. Monetary policy, inflation, and the discrepancy

Inflation GE: policy, expectations, outcomes

- Solve for expected and actual inflation, given log-linear model

$$\frac{dp_t}{p_t} = \pi_t^e dt + \alpha' dZ_t \qquad \phi_t = -\alpha'\alpha + \chi_\pi(\pi_t^e - \pi^*) + \chi_\omega \hat{\omega}_t$$

- Transmission mechanism on natural rate

$$g_t = \ln(\zeta) + i_t^{CB} - \pi_t^e - \delta\phi_t$$

- Monetary policy response

$$di_t^{CB} = -\rho(i_t^{CB} - i^*)dt + \eta\left(\frac{dp_t}{dt} - \pi^*\right) + \gamma d\phi_t$$

- Natural rate and financial shocks both OU processes.

Basics of anchoring: determinacy

Proposition: *Inflation is determinate as long as:*

$$\eta/\rho > 1 + \delta\chi_\pi \qquad \text{and} \qquad \chi_\pi(\gamma - \delta) < 1$$

- Stronger than Taylor condition if higher expectation of inflation lowers discrepancy (markets think higher inflation).

- This lowers market real rates, pushes inflation up. Need extra tightening to keep anchoring.

Trade-off in volatility of expected inflation

Proposition: *Expected inflation is given by:*

$$\pi^e = \pi^* + \frac{(\rho - \kappa_g)(g_t - g^*)}{\eta - \rho - \rho\delta\chi_\pi + \kappa_g(1 - \chi_\pi(\gamma - \delta))}$$
$$+ \frac{\chi_\omega[\kappa_\omega(\gamma - \delta) + \rho\delta]\hat{\omega}_t}{\eta - \rho - \rho\delta\chi_\pi + \kappa_\omega(1 - \chi_\pi(\gamma - \delta))}$$

- Benefit: offset transmission of markets, exploit the extra signal. Cost: transmits financial shocks
- Optimal policy response to discrepancy γ higher if
  - higher direct effect of discrepancy on economy δ
  - less responsiveness of discrepancy to financial shocks χ_ω
  - less volatility of financial shocks σ_ω
  - stronger signal of expected inflation χ_π
  - more volatility of natural rate shocks σ_g

Who is right: the people or the markets?

- Traders observe prices: more information, but also noise.

- GE effect of dovish monetary policy
  - η low, π^e more volatile, people worse forecasters. But markets more informative, better forecasters.

- Back to policymaker: wants to respond more to discrepancy.

7. Conclusion

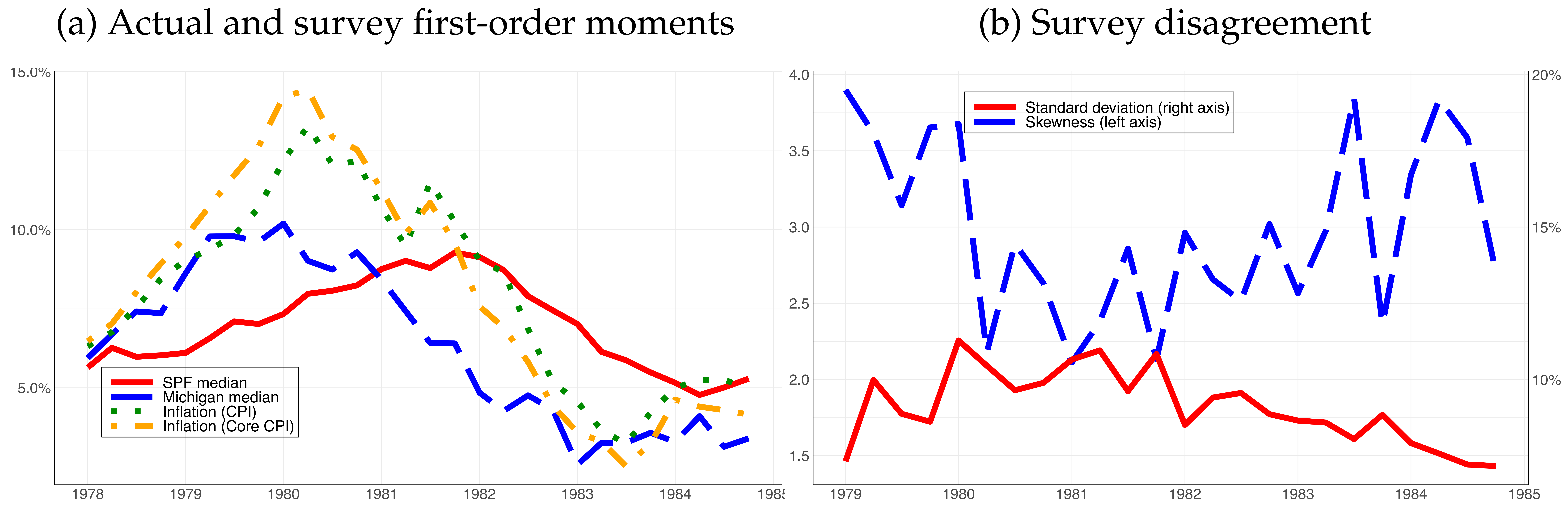
How are expectations of macro variables formed?

1. Parsimonious model of subjective expectations and market prices for business-cycle fluctuations of long-horizon expectations

2. US un-anchoring of inflation expectations, with a drift down 2014-19, revealed by skewness and discrepancy. EZ more pronounced.

3. Policy tradeoff in reacting to different measures of expectations, as both financial and fundamental shocks

1980s…



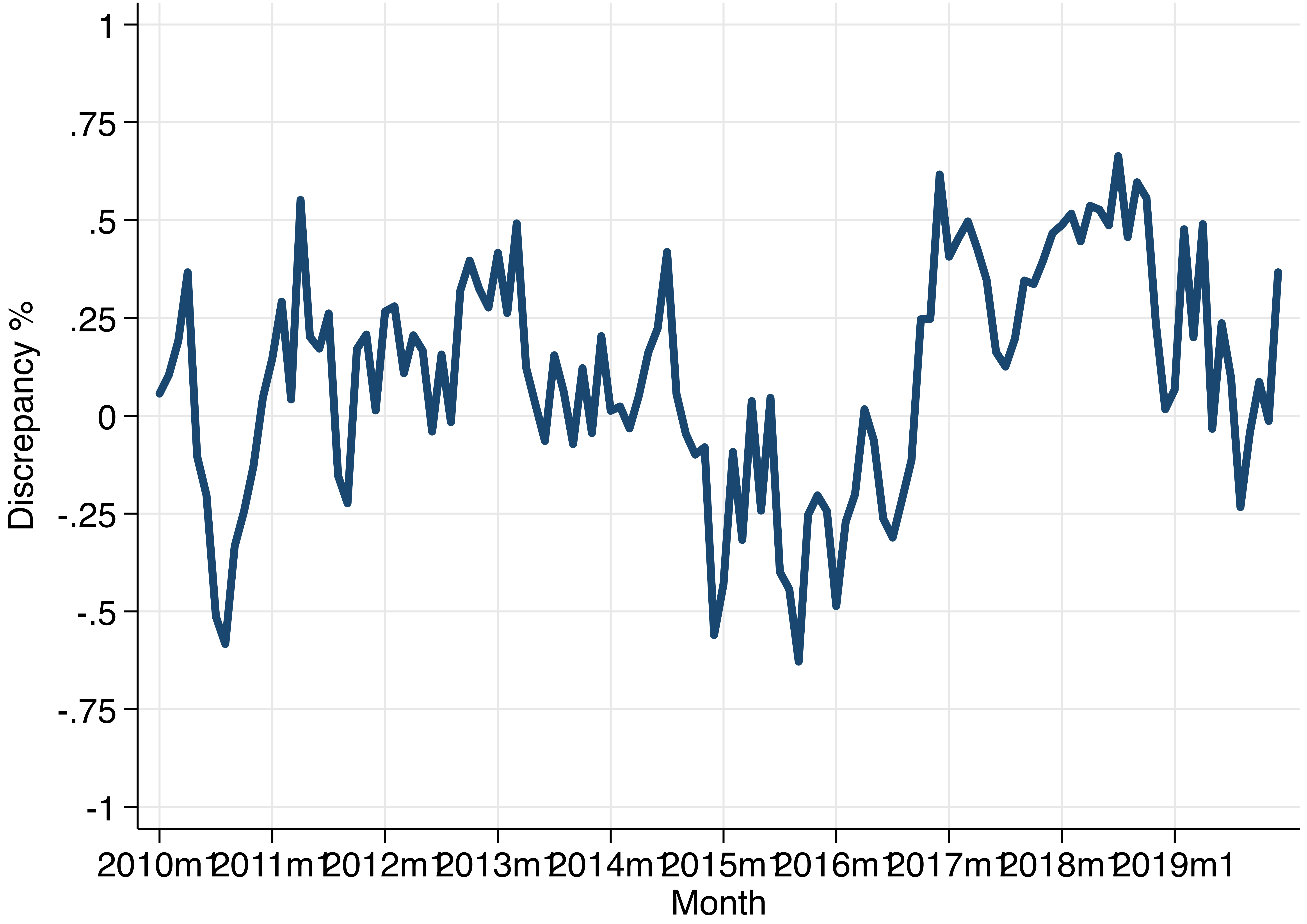
Source: Reis (2021)

The discrepancy

$$\phi_t = \mathbb{E}_t^*(\pi_{t,T}) - \mathbb{E}_t^p(\pi_{t,T})$$

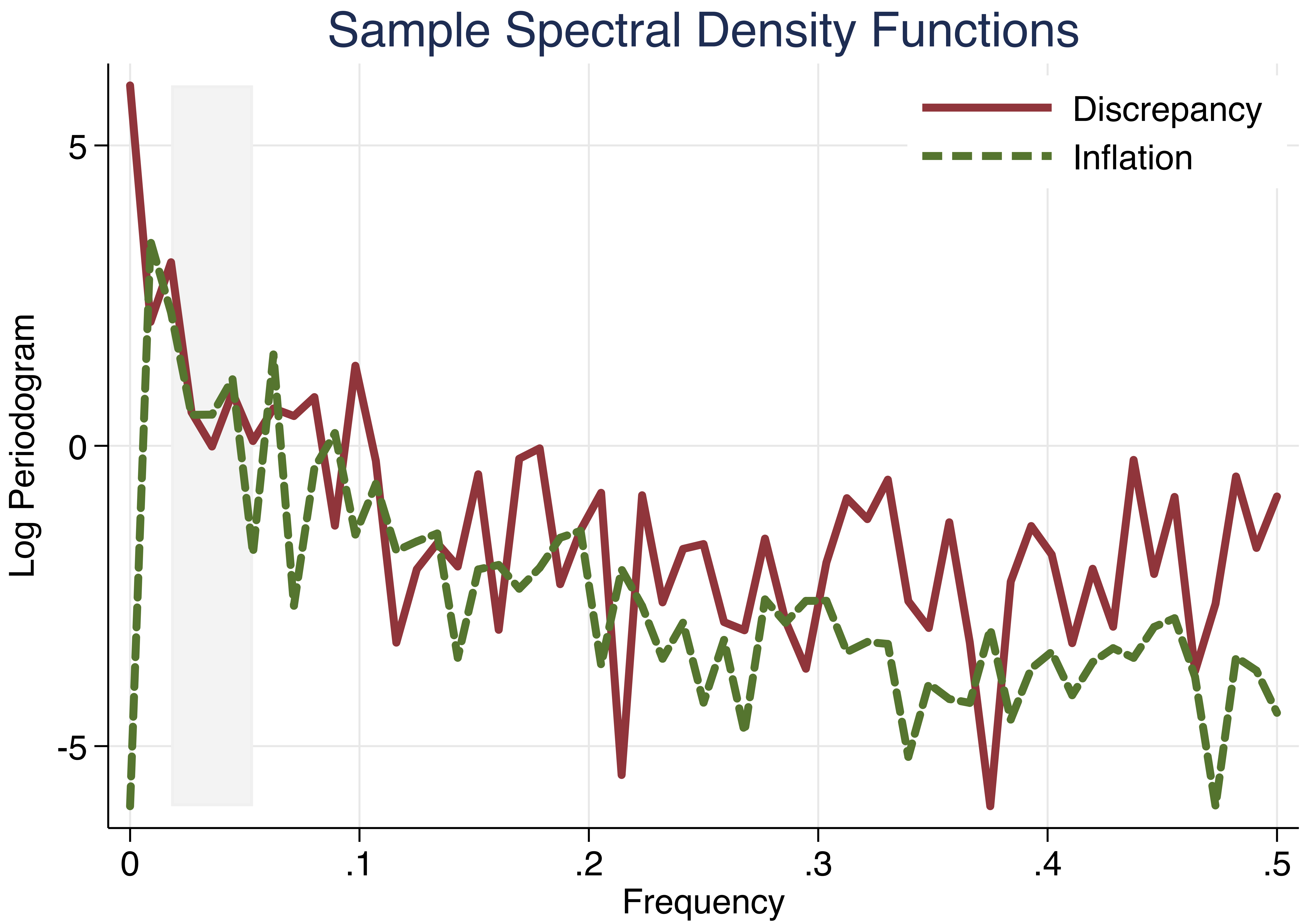
- **Choices:**
  - Country (US)
  - Frequency, ***t*** (monthly)
  - Horizon, ***T*** (5 years)
  - Market for * (swaps)
  - Population for ***p*** (Michigan survey of households)
- Alternatives: countries, quarterly, 10 years, TIPS, SPF

Fact 1: large business cycle fluctuations



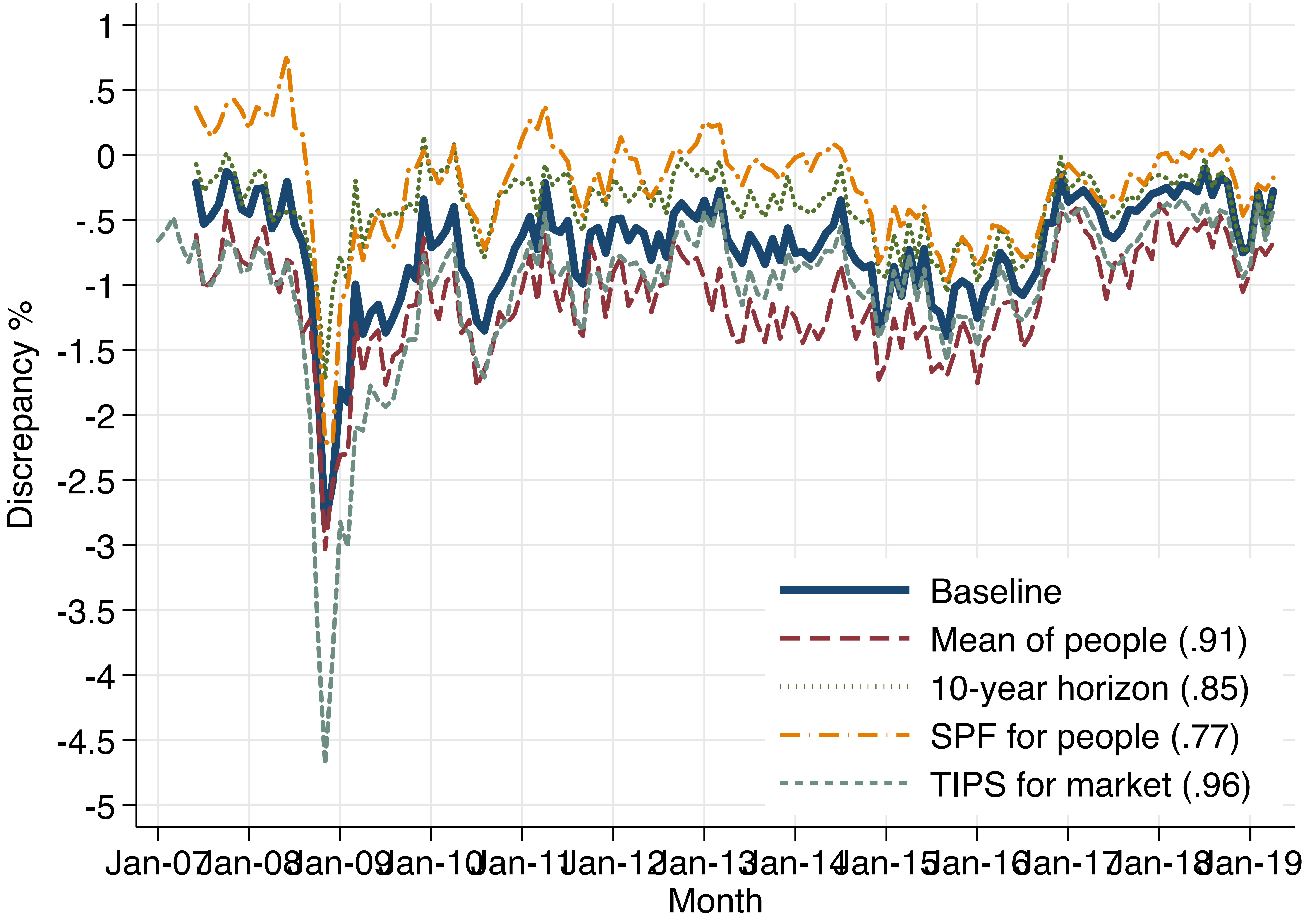
StDev = 0.50%
(vs. 0.57%)

Fact 1: large business cycle fluctuations

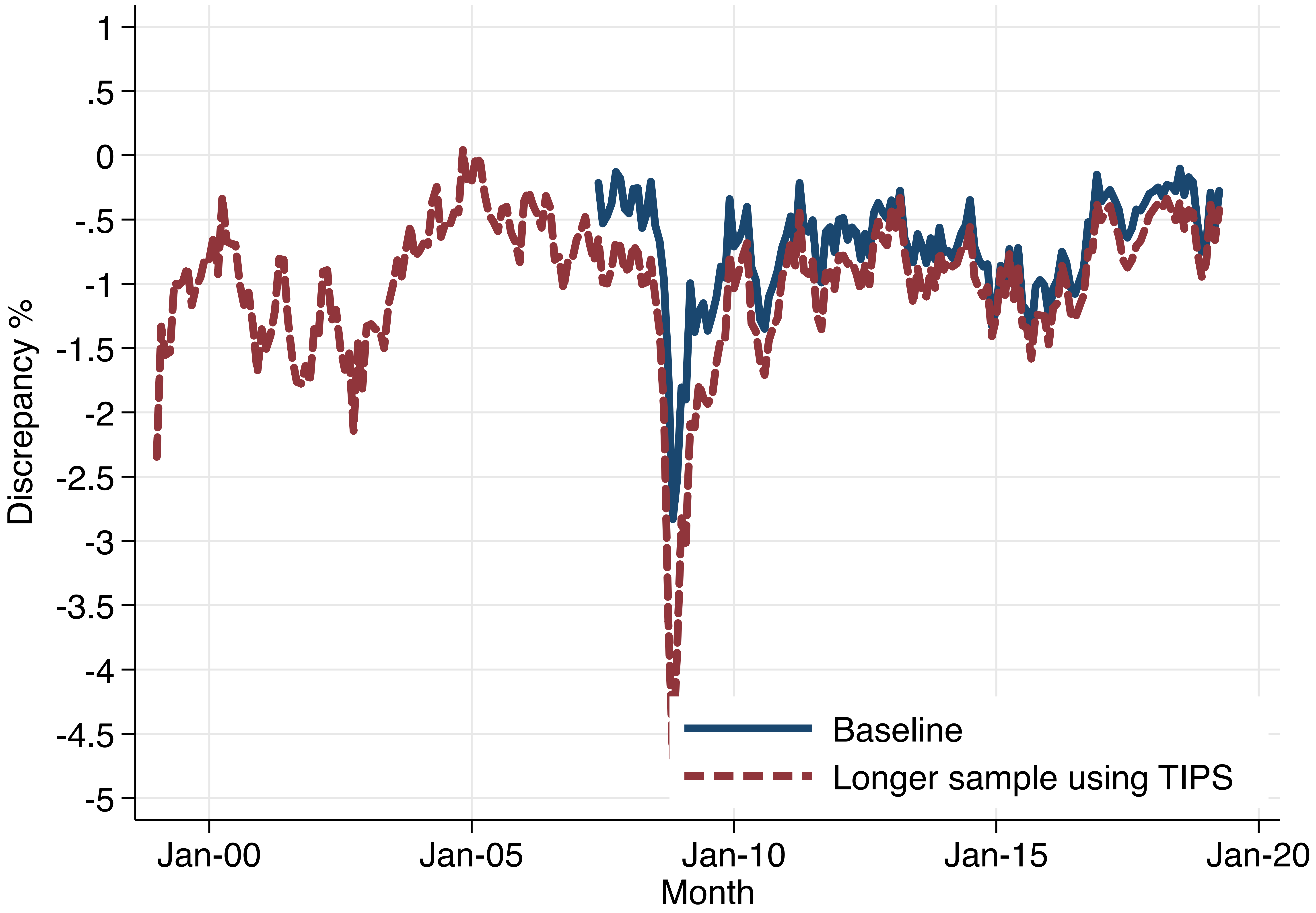


Power fraction: 44%

Fact 1: large business cycle (robustness)



Fact 1: large business cycle (longer sample)



Fact 2: related to monetary policy

Table 1: The proximate determinants of the discrepancy

	Determinants	Policy shocks
	(1)	(2)
2-year yield	0.149***	
	(0.0273)	
Inflation	0.177***	
	(0.0233)	
Squared change inflation	-0.200	
	(0.159)	
Monetary shocks		6.717
		(3.884)
Observations	111	43
R-squared	0.512	0.068

Standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Fact 2: related to monetary policy