Experiences, Expectations, and Asset Prices

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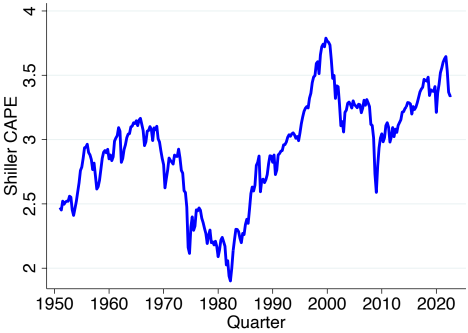
Asset pricing is all about expectations



Stock market index example:
Valuation level reflects investors' subjective expectations of future cash flows and returns

Campbell-Shiller PV identity under subjective expectations $\tilde{\mathbb{E}}_t[.]$

$$p_t - d_t \approx \text{const.} + \underbrace{\tilde{\mathbb{E}}_t \sum_{j=0}^{\infty} \rho^j \Delta d_{t+1+j}}_{\text{Cash flow expectations}} - \underbrace{\tilde{\mathbb{E}}_t \sum_{j=0}^{\infty} \rho^j r_{t+1+j}}_{\text{Return expectations}}$$

Expectations in asset pricing: Example

- Assumptions:
  - IID log dividend growth

$$\Delta d_t = \mu + \sigma\varepsilon_t, \qquad \varepsilon_t \sim \mathcal{N}(0,1)$$

  - Investors don't know μ, and estimate it to be $\tilde{\mu}_t$, i.e.,

$$\tilde{\mu}_t = \tilde{\mathbb{E}}_t \Delta d_{t+j} \quad \text{for} \quad j = 1, 2, \ldots$$

  - Investors require $\mathbb{E}_t r_{t+j} = \text{const.}$

- Valuation

$$p_t - d_t \approx \text{const.} + \underbrace{\frac{1}{1-\rho}\tilde{\mu}_t}_{\text{Cash flow expectations}}$$

- Key question in asset pricing: What is a good model for these subjective expectations $\tilde{\mathbb{E}}_t[.]$?

Outline

1. Subjective beliefs vs. full-information rational expectations
2. Subjective belief formation: Learning from experience
3. Asset pricing application #1: Stock market valuation cycles
4. Asset pricing application #2: Secular real interest rate dynamics

Talk draws on

1. Adam, K. and Nagel, S., 2023. Expectations Data in Asset Pricing. In *Handbook of Economic Expectations*, 477–506.
2. Malmendier, U., and S. Nagel, 2011. Depression Babies: Do Macroeconomic Experiences Affect Risk-Taking? *Quarterly Journal of Economics* 126, 373–416.
3. Malmendier, U., and S. Nagel, 2016. Learning from Inflation Experiences. *Quarterly Journal of Economics* 131, 53–87.
4. Nagel, S, 2024. Leaning Against Inflation Experiences. Working paper.
5. Nagel, S. and Z. Xu. 2022. Asset Pricing with Fading Memory. *Review of Financial Studies* 35 (5), 2190–2245.
6. Nagel, S. and Z. Xu. 2023. Dynamics of Subjective Risk Premia. *Journal of Financial Economics* 150 (2), 103713.

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Full information rational expectations (FIRE)

- FIRE: Investors are rational and they know DGP functional form and parameter values

$$\tilde{\mathbb{E}}_t[.] = \mathbb{E}_t[.]$$

where $\mathbb{E}_t[.]$ denotes objective expectations implied by true DGP parameters

- FIRE has long been the standard assumption in asset pricing, e.g.,
  - CAPM
  - Lucas asset pricing model
  - Campbell-Cochrane habit-formation model
  - Bansal-Yaron long-run risks model
  - ...

FIRE: Example

- FIRE applied to the earlier IID log dividend growth example

$$\tilde{\mathbb{E}}_t \Delta d_{t+j} = \mu \quad \text{for} \quad j = 1, 2, \ldots$$

  - Consistent with empirical evidence that Δd_{t+j} not predictable

- Then, valuation under FIRE

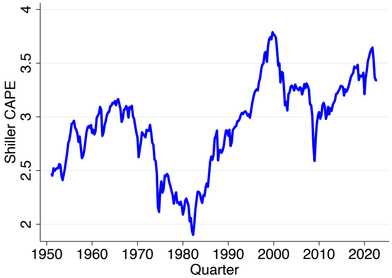
$$p_t - d_t \approx \text{const.} - \underbrace{\mathbb{E}_t \sum_{j=0}^{\infty} \rho^j r_{t+1+j}}_{\text{Return expectations}}$$

- Exact opposite of earlier subjective beliefs model
  - Cash flow expectations constant
  - $p_t - d_t$ varies only if expected return required by investors is time-varying

Subjective beliefs vs. FIRE perspective on asset pricing

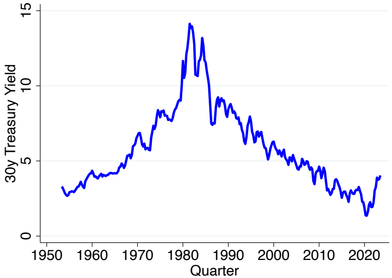
Stock market valuation cycles: e.g. high P/E ratio in late 1990s

- FIRE: Low risk aversion or low risk, low expected returns
- Subjective beliefs: High cash flow expectations?



Bond yields: e.g. high long-term interest rates in early 1980s

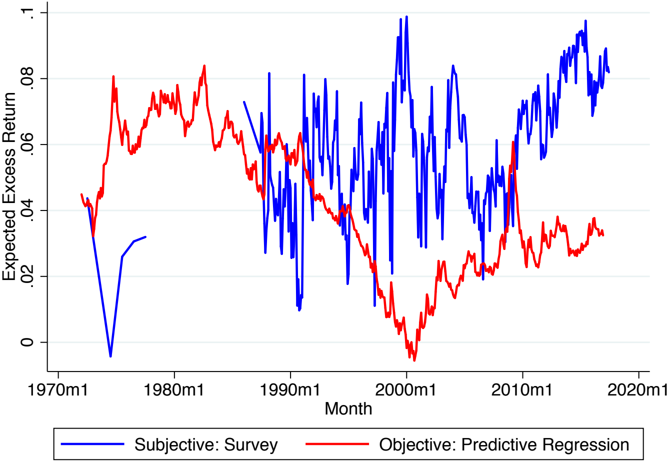
- FIRE: High term premium, high expected returns
- Subjective beliefs: High interest rate & long-run inflation expectations?



FIRE: Pros and cons

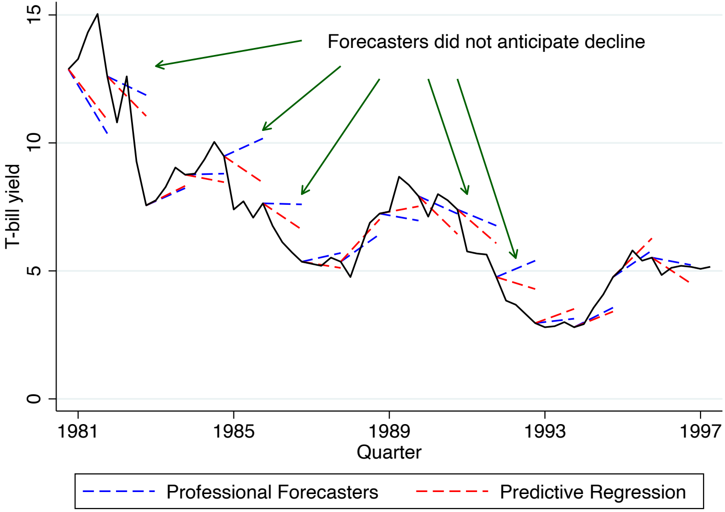
- Modeling convenience of FIRE
  - Removes need for modeling of belief formation: Beliefs reflect true DGP properties
    - In our example: $\tilde{\mathbb{E}}_t \Delta d_{t+j} = \mathbb{E}_t \Delta d_{t+j} = \mu$
  - Econometric estimates from ex-post, in-sample estimation asymptotically recover investor beliefs
    - In our example: $\lim_{T \to \infty} \frac{1}{T} \sum_{t=1}^{T} \Delta d_t = \mu$
- Issues with FIRE
  - How could investors possess perfect knowledge of DGP?
    - No learning, parameter uncertainty? Bounded rationality? ...
  - Evidence that subjective $\neq$ objective expectations
    - Survey data vs. econometric forecasts from in-sample regressions

Objective vs. subjective: Expected stock market excess returns



Source: Subjective = one-year expected stock market returns in excess of one-year Treasury yield from various individual investor surveys in Nagel and Xu (2022). Objective = Fitted value from predictive regression of stock market excess returns on log price-dividend ratio estimated on quarterly data 1927-2018.

Objective vs. subjective: Expected T-bill yields



Source: Subjective = four-quarter expected 3m T-bill yields from the BlueChip Survey of Professional Forecasters. Objective = Fitted value from predictive regression of T-bill yields on four-quarter lagged T-bill yields and 1y-3m term spread estimated on quarterly data 1961-2023.

Stepping away from FIRE: Asset pricing with subjective beliefs

- Need a model of how subjective beliefs are formed, e.g.,
  - Bayesian learning
  - Learning from experience
  - Diagnostic expectations

- Calibration or testing of belief formation mechanism with data other than asset prices
  - Expectations data from surveys
  - Microdata on portfolio choice

  Addresses concern that deviation from FIRE leads to lack of model "discipline"

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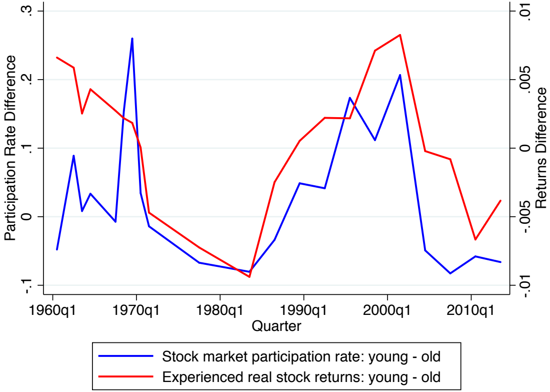
Subjective belief formation: Bayesian learning?

- Bayesian uses "all available data" – but what is that in practice? Important for quantitative predictions of model.
  - Since 1925 when CRSP starts? 19th century? 16th century stock market in Amsterdam?
- Bayesian learning in stationary environment implies deterministic decline in risk premia over time.
  - Hard to square with data
  - Are investors today really less uncertain about long-run growth than, say, 30 years ago?
- Empirical evidence suggests reliance by individuals and professionals on life-time experience
  - Malmendier and Nagel (2011, 2016), Malmendier, Nagel, and Yan (2021)

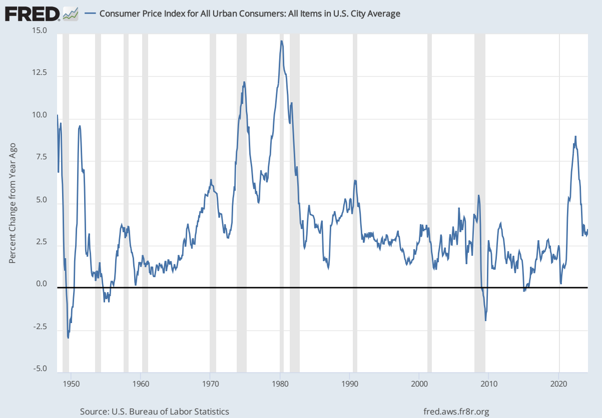
Learning from experience: Stock market participation



Based on Malmendier and Nagel (2011). **Stock market participation**: Survey of Consumer Finances, proportion of households owning stocks and stock mutual funds. **Experienced returns**: Weighted average of life-time real stock market returns for each survey respondent. Figure shows **differences**: average for individuals of age < 40 minus average for individuals of age > 60.

Examining belief formation: Inflation expectations

- Decades of expectations data available
  - households
  - professional forecasters
- Relevant for bond pricing and monetary policy
- Interesting variation over time in inflation process properties



Least-squares learning

- Perceived law of motion of inflation: AR(1)

$$\pi_{t+1} = a + \rho\pi_t + \varepsilon_{t+1},$$

- Least-squares regression written as an recursive updating rule for estimates of parameters $\boldsymbol{b} \equiv (a, \rho)'$:

$$\begin{aligned} \boldsymbol{b}_t &= \boldsymbol{b}_{t-1} + \phi_t \boldsymbol{R}_t^{-1} \boldsymbol{x}_{t-1}(\pi_t - \boldsymbol{b}'_{t-1}\boldsymbol{x}_{t-1}), \\ \boldsymbol{R}_t &= \boldsymbol{R}_{t-1} + \phi_t(\boldsymbol{x}_{t-1}\boldsymbol{x}'_{t-1} - \boldsymbol{R}_{t-1}), \end{aligned}$$

  where $\boldsymbol{x}_t \equiv (1, \pi_t)'$.

- Variants with different gain specifications
  - OLS regression: $\phi_t = \frac{1}{t}$ (equally weighted data)
  - Constant gain learning: $\phi_t = \phi$ (exponentially weighted data)

Learning-from-experience variant of least-squares learning

- Perceived law of motion of inflation: AR(1)

$$\pi_{t+1} = a + \rho\pi_t + \varepsilon_{t+1},$$

- Individual in cohort born at time s uses $\boldsymbol{x}_t \equiv (1, \pi_t)'$ to update estimate of parameters $\boldsymbol{b} \equiv (a, \rho)'$:

$$\begin{aligned} \boldsymbol{b}_{t,s} &= \boldsymbol{b}_{t-1,s} + \phi_{t,s}\boldsymbol{R}_{t,s}^{-1}\boldsymbol{x}_{t-1}(\pi_t - \boldsymbol{b}'_{t-1,s}\boldsymbol{x}_{t-1}), \\ \boldsymbol{R}_{t,s} &= \boldsymbol{R}_{t-1,s} + \phi_{t,s}(\boldsymbol{x}_{t-1}\boldsymbol{x}'_{t-1} - \boldsymbol{R}_{t-1,s}), \end{aligned}$$

- Gain decreasing with age $= t - s$

$$\phi_{t,s} = \begin{cases} \frac{\theta}{age} & \text{if } age \geq \theta \\ 1 & \text{if } age < \theta, \end{cases}$$

where $\theta = 1$ would yield OLS regression on life-time data

Data and approach

- Data:
  - Michigan Survey of Consumers 1953-2023
    - $\tilde{\mathbb{E}}_{t,s}\pi_{t:t+4}$: 1-year inflation expectations aggregated at birth-year cohort level
  - Inflation: Quarterly CPI inflation 1871-2023
- Construct experience-based forecast for each cohort s each t

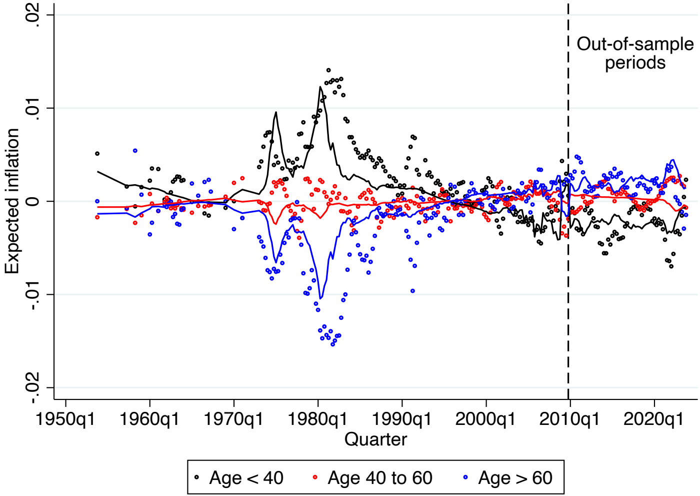
$$\tau_{t,s} = \boldsymbol{x}_t' \boldsymbol{b}_{t,s}(\theta)$$

- Regression in cohort panel

$$\tilde{\mathbb{E}}_{t,s}\pi_{t:t+4} = \beta_{0,t} + \beta_1 \tau_{t,s}(\theta) + \varepsilon_{t,s}$$

- MN (2016) estimate: $\theta = 3.044$ and $\beta_1 = 0.67$

Explaining 1-year inflation expectations with learning from experience: Update of MN (2016)



Four-quarter moving averages, shown as deviations from the cross-sectional mean expectation. Solid lines show fitted value based on learning-from-experience model.

Learning from experience: Dynamics of the average belief

- Cohort-level heterogeneity allows identification of learning-from-experience effects and the gain parameter θ
- But for asset pricing & macro issues, the dynamics of the cross-sectional average of cohort-level beliefs likely to be more important than beliefs heterogeneity between cohorts
- From now on: Use cross-sectional average of cohort-level beliefs as approximation of representative agent beliefs
- What are the dynamics of the average of cohort-level beliefs under learning from experience?

Learning from experience: Dynamics of the average belief

- Under learning from experience, cohort-level gain decreases over life time: With $\theta = 3.044$,
  - Gain for 30-year old $= \frac{\theta}{120} \approx 0.025$
  - Gain for 60-year old $= \frac{\theta}{240} \approx 0.013$

  for quarterly data.

- MN (2016): Average of cohort-level beliefs with $\theta = 3.044$ is well approximated by learning with constant gain of

$$\nu \approx 0.018$$

- Constant gain learning captures fading memory aspect of learning from experience
  - downweighting of earlier within-life experiences
  - generational turnover

Asset pricing applications of learning from experience

- Application #1: Subjective expectations about long-run growth (Nagel and Xu 2022)
  - Learning from experience explains stock market valuation cycles and return predictability
- Application #2: Subjective expectations about long-run inflation (Nagel 2024)
  - Learning from experience explains why long-term inflation expectations are sticky, making it hard for monetary policy to control them
  - Consequences for secular dynamics of real interest rates

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Application #1: Asset pricing with fading memory

- Representative investor perceives stock market index payout growth as IID:

$$\Delta d_t = \mu + \sigma\varepsilon_t, \qquad \varepsilon_t \sim \mathcal{N}(0,1)$$

- Learns about μ with constant gain

$$\tilde{\mu}_{t+1} = \tilde{\mu}_t + \nu(\Delta d_{t+1} - \tilde{\mu}_t)$$

- Fix $\nu = 0.018$ based on MN (2016), i.e., not tweaked to fit asset prices

- Assume: Investor's required rate of expected return constant
    - constant subjective risk premium
    - constant risk-free rate r_f

Asset pricing with fading memory

- Present value identity under subjective expectations

$$p_t - d_t \approx \text{const.} + \underbrace{\frac{1}{1-\rho}\tilde{\mu}_t}_{\text{Cash flow expectations}}$$

- Present value identity under objective expectations

$$p_t - d_t \approx \text{const.} - \underbrace{\mathbb{E}_t \sum_{j=0}^{\infty} \rho^j r_{t+1+j}}_{\text{Return expectations}}$$

- Taking both together, one can show

$$\mathbb{E}_t r_{t+1} - r_f = \text{const.} + \left(1 + \frac{\rho\nu}{1-\rho}\right)(\mu - \tilde{\mu}_t)$$

i.e., econometrician will find returns predictable with $\tilde{\mu}_t$.

Measuring experienced payout growth

- Iterating on constant-gain learning scheme yields

$$\tilde{\mu}_t = \nu \sum_{j=0}^{\infty} (1-\nu)^j \Delta d_{t-j}$$

which we label experienced payout growth

- Need long sample to compute Δd, back to 19th century
  - CRSP value-weighted index dividends and repurchases 1926-2016
  - Piketty et al. tax return data on aggregate household dividends 1913-1926
  - Aggregate nonfinancial dividends from Wright (2004) for 1900-1913
  - GDP growth 1871-1900

expressed as real per-capita growth.

Return predictability based on experienced payout growth

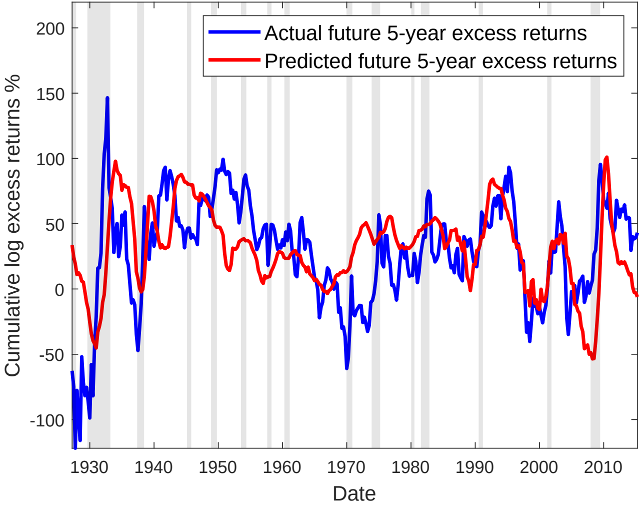
- Model prediction

$$\mathbb{E}_t r_{t+1} - r_f = \text{const.} + \left(1 + \frac{\rho\nu}{1-\rho}\right)(\mu - \tilde{\mu}_t)$$
$$= \text{const.} - 2.78 \times \tilde{\mu}_t$$

- Empirical results for predicting excess returns (1927-2019, quarterly):

bias-adj. coeff.	-5.50
[bootstrap p-value]	[0.03]

Predicted five-year excess returns and subsequent actual cumulative five-year excess returns



From Nagel and Xu (2022).

Equilibrium asset pricing with fading memory

- Nagel and Xu (2022) further explore equilibrium in an endowment economy
- Representative agent learns about expected growth rate of endowment
- Model reconciles return predictability in ex-post predictive regressions with lack of countercyclical risk premium in survey data
  - Strongly countercyclical objective equity risk premium
  - Virtually constant subjective equity risk premium
- Fading memory raises subjective uncertainty, which raises unconditional level of risk premia

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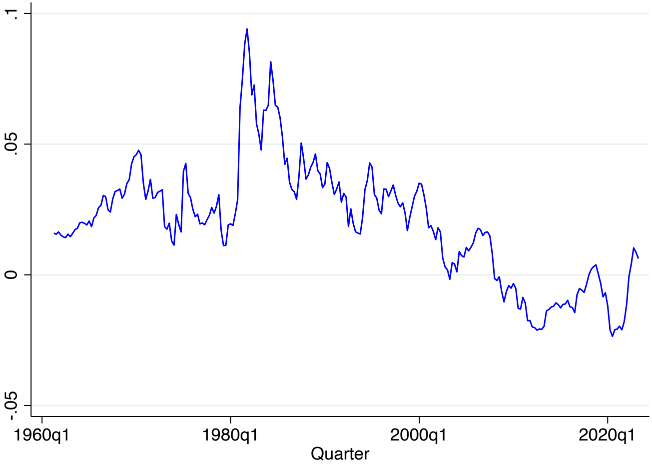
Application #2: Experience-based inflation expectations and secular real interest rate dynamics

- How inflation expectations are formed is crucial for monetary policy questions
  - When/if/how are long-run inflation expectations anchored?
  - Can monetary policy communication influence expectations about long-run inflation, e.g., by commitment to numerical inflation target?
- Answers to these questions in turn are important for bond pricing
- Here: Examine how learning from experience & monetary policy jointly generate secular real interest rate dynamics

Secular variation in real interest rates: Ex-ante 5-year real rate



Ex-ante real interest rate: 5y Treasury yield - 5y Michigan Survey expected inflation

Secular variation in real interest rates: Natural rate of interest variation leaves much unexplained

Ex-ante real interest rate: 5y Treasury yield - 5y Michigan Survey expected inflation; Laubach-Williams natural interest rate estimate

Experience-based long-run inflation expectations

- Focus on long-run inflation expectations

$$\tilde{\pi}_t = \tilde{\mathbb{E}}_t \pi_{t+\infty}$$

which can be interpreted as perceived inflation target of CB

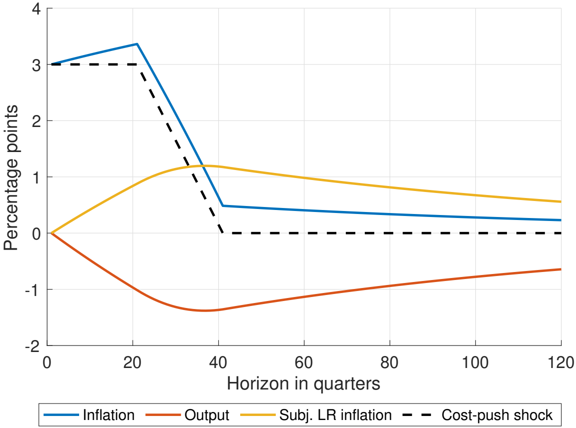
- Again focus on representative agent beliefs approximated by constant gain learning about long-run mean of inflation

$$\tilde{\pi}_t = \tilde{\pi}_{t-1} + \nu(\pi_t - \tilde{\pi}_{t-1})$$

  - Estimate of gain based on updated Michigan survey inflation expectations data: $\nu = 0.016$ (MN 2016: 0.018)

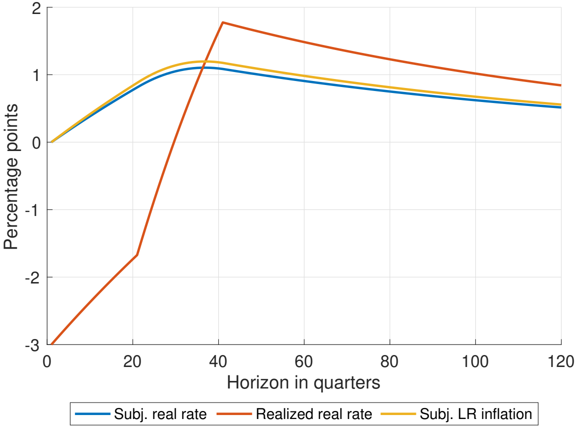
- New Keynesian (NK) macroeconomic model
  - Inflation experiences determine expectations via constant gain learning, not the "words" of central bankers
  - Monetary policy leans against these experience-based long-run inflation expectations: Persistent real interest rate effect

NK model applied to rise of inflation in 1970s and subsequent fall



Inflation experiences affect inflation expectations (learning), and inflation expectations generate inflation (Philipps curve)

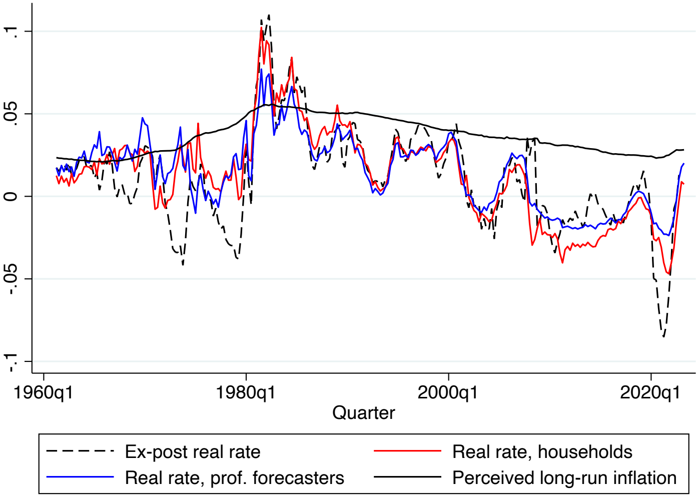
NK model prediction: Real interest rates rise with long-run inflation expectations



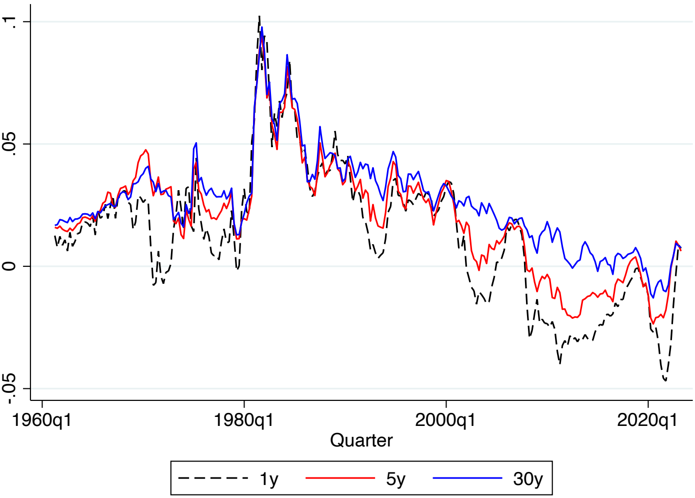
CB persistently leans against long-run inflation expectations via a Taylor rule to bring them towards target $\bar{\pi}$

$$i_t = r^* + \tilde{\pi}_{t-1} + \gamma_\pi(\tilde{\pi}_{t-1} - \bar{\pi}) + \text{other terms}$$

Data: Real interest rates at one-year horizon



Data: Term-structure of ex-ante real interest rates (households)



Econometric approach

- Interested in estimating something like

$$\text{real interest rate} = \beta_0 + \beta\tilde{\pi}_t + e_t$$

- Issue: Persistence, possibly unit roots, possibly cointegration
- Descriptive: OLS with HAC s.e.
- Main approach: Inference with unknown order of intergration
  - Estimate β as long-run coefficients from error correction model (ECM)
  - Pesaran, Shin, and Smith (2001) (PSS) bounds test for long-run relationship between real rates and $\tilde{\pi}_t$

Econometric approach

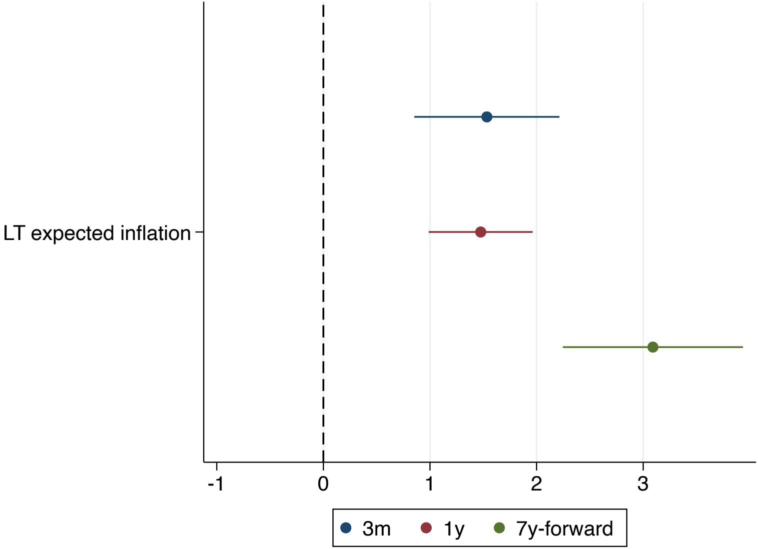
- Error correction model: real yield variable y_t, $\boldsymbol{x}_t = (\tilde{\pi}_t, r_t^*)'$

$$\Delta y_t = c - a(y_{t-1} - \boldsymbol{\beta}'\boldsymbol{x}_{t-1}) + \sum_{j=1}^{p-1} \psi_{yj} \Delta y_{t-j} + \omega' \Delta \boldsymbol{x}_t + \sum_{j=1}^{q-1} \psi_{xj} \Delta \boldsymbol{x}_{t-j} + \xi_t.$$

  with optimal lag length choice via BIC.

- PSS bounds test rejection = rejection of all three nulls
  1. $H_0 : (a = 0) \cap (\boldsymbol{\beta} = 0)$
  2. $H_0 : a = 0$, i.e., y_t is $I(1)$ but not cointegrated with any variable in $\boldsymbol{x}_t$
  3. $H_0 : \boldsymbol{\beta} = 0$

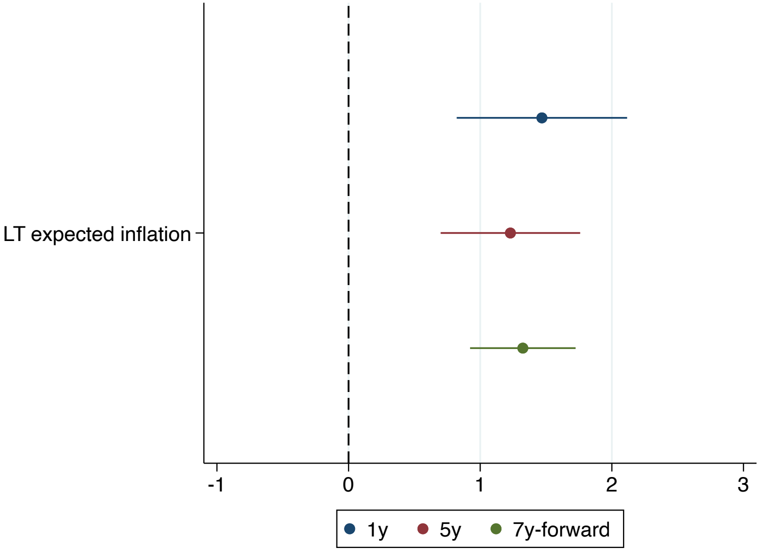
Ex-post realized real rates: loading on experience-based long-run inflation expectations



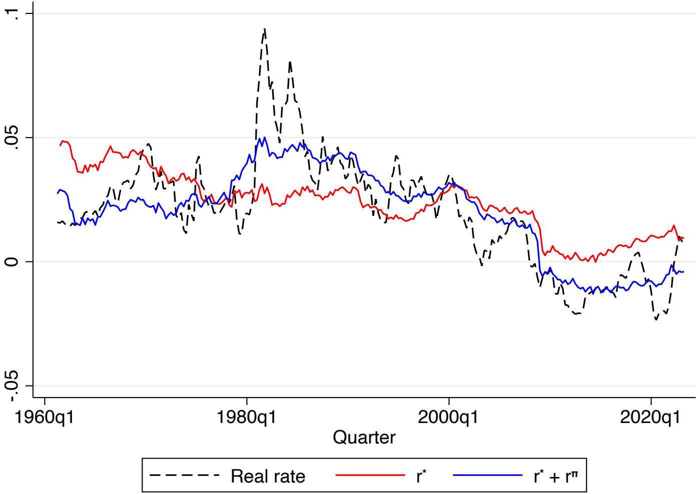
Ex-ante subjective real rates, households

- 1-year horizon: 1-year zero-coupon yield - 1-year Michigan Survey median
- 5-year horizon: 5-year zero-coupon yield - 5-year Michigan Survey median
- 7-year forward: 7-year forward rate - 5-year Michigan Survey median

Ex-ante subjective real rates, households: loading on experience-based long-run inflation expectations

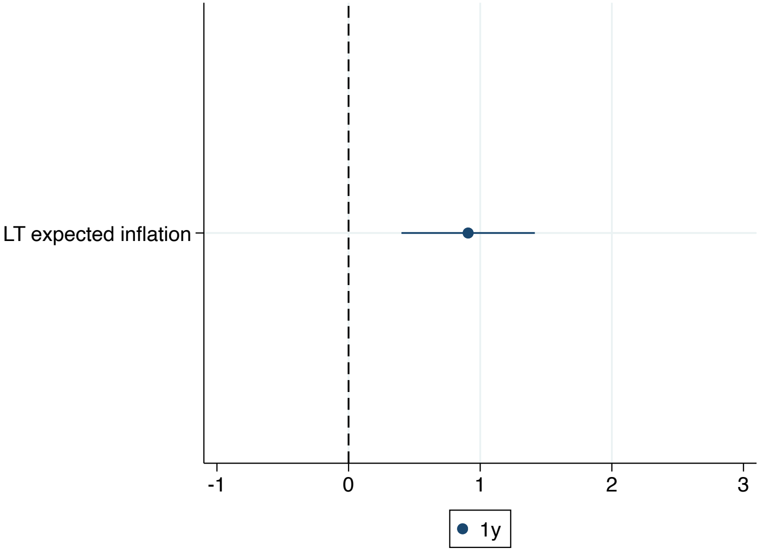


Ex-ante subjective real rates (households), r^*, and r^π



Real interest rates are measured as 5-year zero coupon yields minus 1-year inflation expectations from the Michigan Survey of Consumers, r^* shows LW estimates adjusted for the average CPI-Core PCE inflation spread.

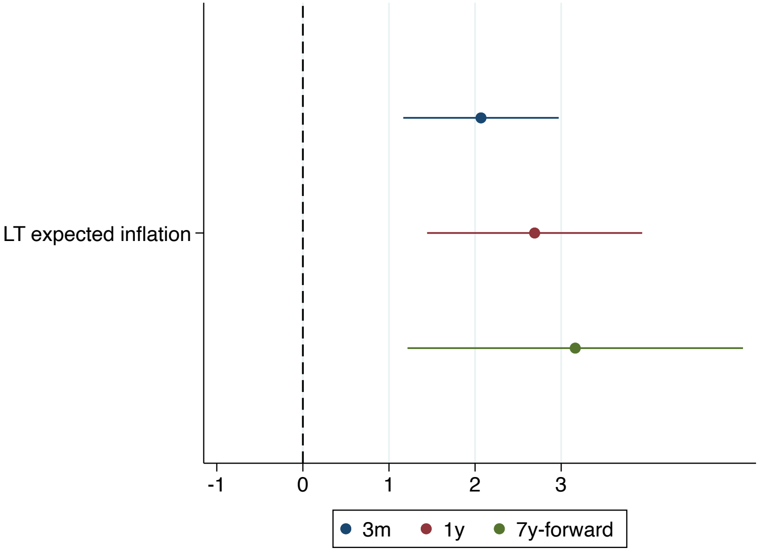
Ex-ante subjective real rates, professional forecasters: loading on experience-based long-run inflation expectations



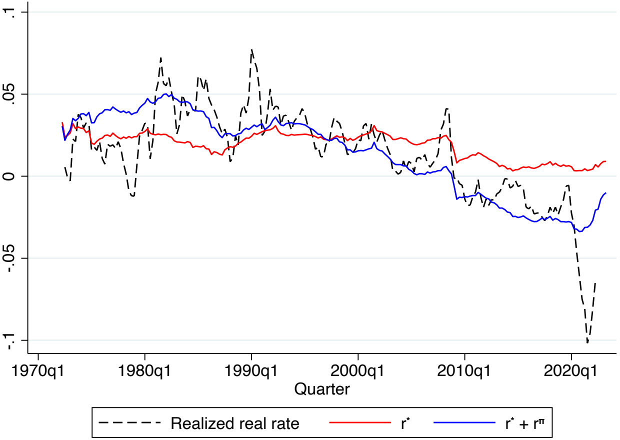
International evidence

- Germany (1972-2023), U.K. (1972-2019), and Japan (1979-2017)
- Natural rate of interest estimates:
  - Holston, Laubach, Williams (2023) for Euro area
  - Holston, Laubach, Williams (2017) U.K.
  - Wynne and Zhang (2018) for Japan
- Sufficiently long data sets of survey data not available, so focus on ex-post realized real interest rates

Ex-post realized real rates in Germany: loading on experience-based long-run inflation expectations

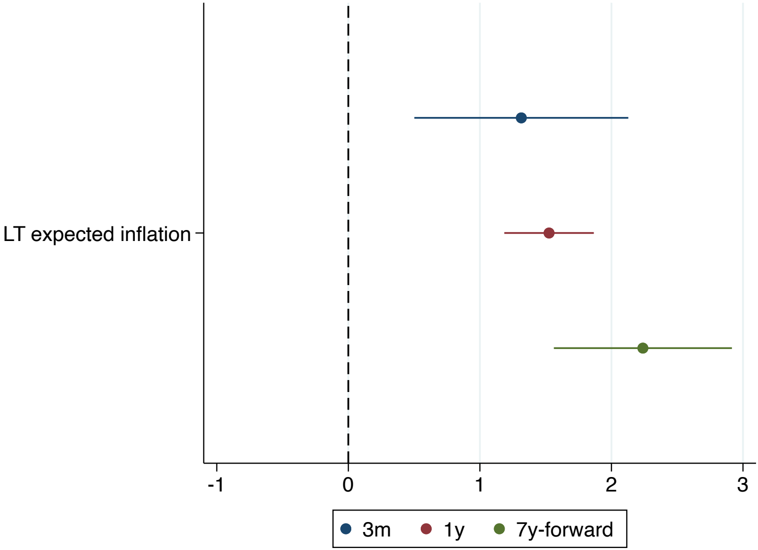


Ex-post realized real interest rates in Germany, r^*, and r^π

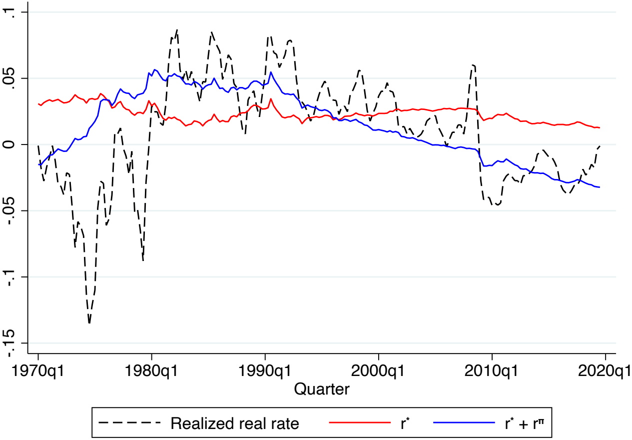


Real interest rates are measured as 1-year zero coupon yields minus inflation over the next four quarters, r^* shows HLW estimates for the Euro area.

Ex-post realized real rates in the U.K.: loading on experience-based long-run inflation expectations.

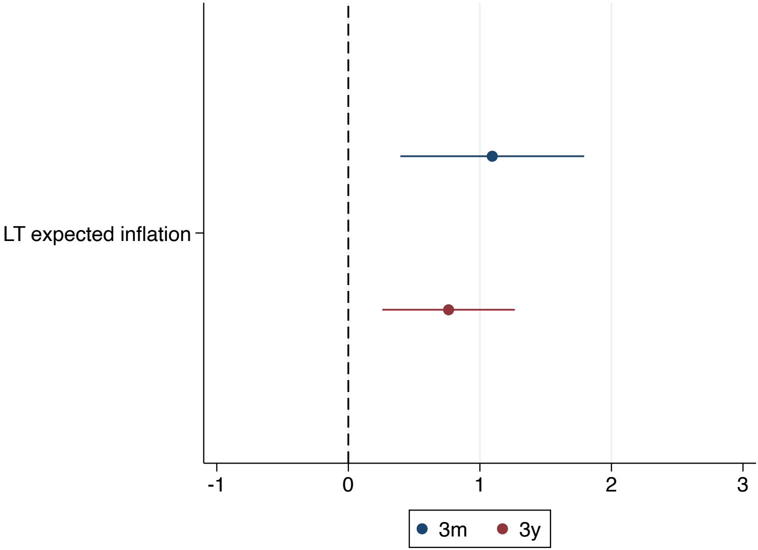


Ex-post realized real interest rates in the U.K., r^*, and r^π

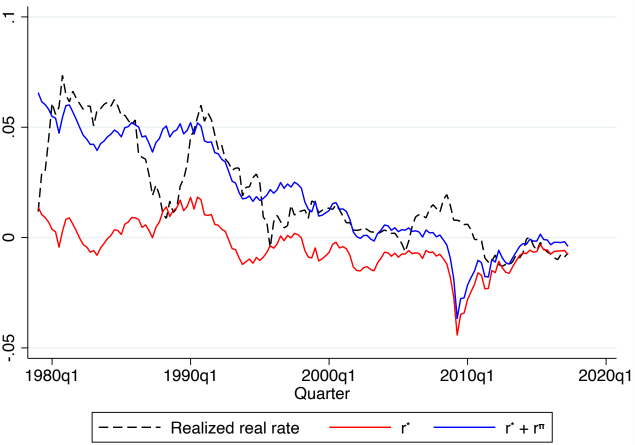


Real interest rates are measured as 1-year zero coupon yields minus inflation over the next four quarters, r^* shows HLW estimates for the U.K.

Ex-post realized real rates in Japan: loading on experience-based long-run inflation expectations



Ex-post realized real interest rates in Japan, r^*, and r^π



Real interest rates are measured as 1-year zero coupon yields minus inflation over the next four quarters, r^* shows estimates from Wynne and Zhang (2018).

Conclusion

- Modeling of subjective beliefs of investors is an important challenge for asset pricing research
- Learning from experience model has empirical support from
  - Survey data on expectations
  - Survey data on portfolio choice
- Learning from experience model helps explain major asset pricing facts
  - Stock market valuation cycles
  - Secular real interest rate dynamics
- But still many open questions, e.g.,
  - Subjective risk perceptions?
  - Where/when/how does belief heterogeneity between investor types (individuals, professionals) matter?