Who cares about Inflation?

Endogenous Expectation Formation of Heterogeneous Households

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This Project: Inflation Expectations and Wealth

Household level inflation expectations are highly dispersed.

- 4pp interquartile range for US households. data
- Households make substantial errors.

Today: Focus on co-movement of these errors with wealth.

Key results:

1. Empirically: Wealthier households make less errors.
2. Rationalized by endogenous (costly) expectation formation.
3. Theoretical response of HHs' consumption to expected inflation depends on wealth.

$\Rightarrow$ Aggregate response determined by co-movement of expectations and wealth.

Literature

Empirical Observations

Empirical Setup

DNB Household Survey (CentERpanel)
Annual data on asset holdings and inflation expectations.
Individual level (household heads), waves 2010-2018.
$\sim 11,500$ observations in total.

Empirical Methodology:

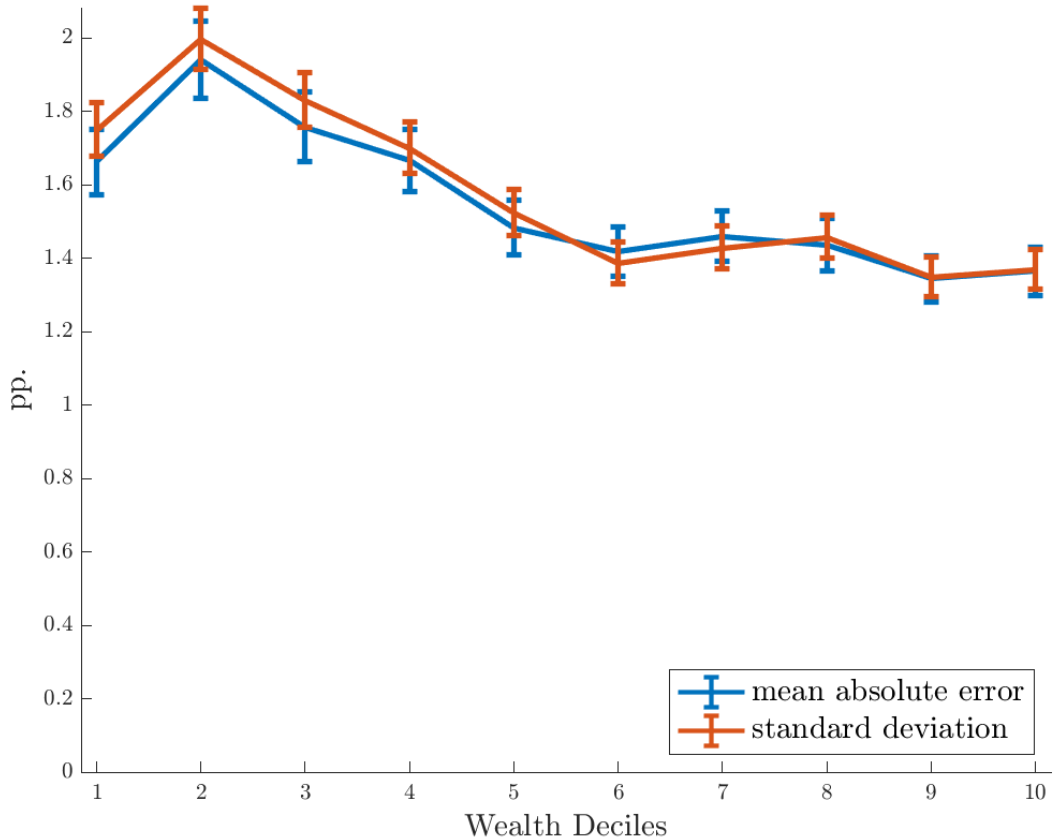
- Construct net financial wealth (NFW):
  Net wealth ex housing, vehicles and businesses.
- Sort HHs into wealth decile groups:
  Decile of NFW distribution in year of observation.
- Compute expectation errors:
  Ex-ante point forecast $-$ ex-post realized inflation rate.
- Compute "aggregate" statistics:
  Mean absolute errors and standard deviation of errors within each decile group.

deciles

Expectation Errors along the Wealth Distribution

Expectation errors co-move with wealth.

- Drop of 0.5 pp in standard deviation and mean absolute error from peak to bottom.
- Highest standard deviation and absolute errors around zero NFW (2nd decile).
- Robust to age / education controls.



Expectation Errors by Wealth Decile Groups

95% confidence bands. Data from DNB Household Survey waves 2010-2018.

mean table robustness

A Theory of Expectation Formation and Wealth

A Model of Inflation Expectations

Realized inflation (exogenous):

$$\pi_{t+1} = (1-\rho)\mu + \rho\pi_t + e_{t+1} \qquad e_{t+1} \sim \mathcal{N}(0, \sigma_e^2)$$

Households:

- Know underlying process, persistence ρ, long-run mean μ.
- Informed about current inflation π_t.
- Signal $\hat{e}$ with noise s, noise reduced by effort n.

$$\hat{e}^i_{t+1} = e_{t+1} + s^i_{t+1} \qquad s^i_{t+1} \sim \mathcal{N}(0, \sigma_s^2(n^i_t))$$

- Assume pure noise:
  $s^i_t \perp\!\!\!\perp s^j_t \; \forall i, j, t$, $e_t \perp\!\!\!\perp s^i_t \; \forall i, t$ and $s^i_t \perp\!\!\!\perp s^i_{t+1} \; \forall i, t$

A Model of Inflation Expectations - Errors

Bayesian updating with weight $\omega^i_{t+1}(n^i_t) = \frac{\sigma^2_e}{\sigma^2_e + \sigma^2_s(n^i_t)}$.

Posterior belief:

$$e_{t+1}|_{\hat{e}^i_{t+1}, n^i_t} \sim \mathcal{N}(\underbrace{\omega^i_{t+1}(n^i_t)\hat{e}^i_{t+1}}_{\text{point forecast}}, \underbrace{\omega^i_{t+1}(n^i_t)\sigma^2_s(n^i_t)}_{\text{subjective uncertainty}})$$

Expectation error:

$$err^i_{t+1} = \omega^i_{t+1}(n^i_t)s^i_{t+1} - (1 - \omega^i_{t+1}(n^i_t))e_{t+1}$$

Implications:

- Error = overreaction to noise + underreaction to news.
- Standard deviation and mean absolute error increase in subjective uncertainty ($\Rightarrow$ increase in noise).

formulas decomposition

HH Problem with Endogenous Expectations

- Infinitely lived households, Epstein-Zin preferences.
- Receive risky **real** income y.
- Save/borrow between periods at constant **nominal** rate r^n.

  $\Rightarrow$ Inflation is a risk to the real interest rate.
- Expectations as before.

- Each period:
  0. Wealth known, learn about π and y.
  1. Chose noise of signal (costly effort n).
  2. Receive signal and update beliefs.
  3. Decide on consumption and saving/borrowing.

HH Problem with Endogenous Expectations

Consumption-savings choice, conditional on n and $\hat{e}$:

$$V(a, y, \pi, n, \hat{\epsilon}) = \max_{c, a'} \left(c^{1-\gamma} + \beta \left(\mathop{\mathbb{E}}_{\pi', y'} [\tilde{V}(a', y', \pi')^{1-\alpha} | \hat{e}, n, \pi, y] \right)^{\frac{1-\gamma}{1-\alpha}} \right)^{\frac{1}{1-\gamma}}$$

$$s.t. \quad c + a' = \frac{1 + r^n}{1 + \pi} a + y - \mathcal{F}(n)$$

Information choice:

$$\tilde{V}(a, y, \pi) = \max_{n} \mathop{\mathbb{E}}_{\hat{e}} [V(a, y, \pi, n, \hat{e}) | n]$$

Functional Forms:

$$\sigma_s(n) = \frac{\chi}{1 + n} \qquad \mathcal{F}(n) = (\theta n)^{\phi}$$

calibration

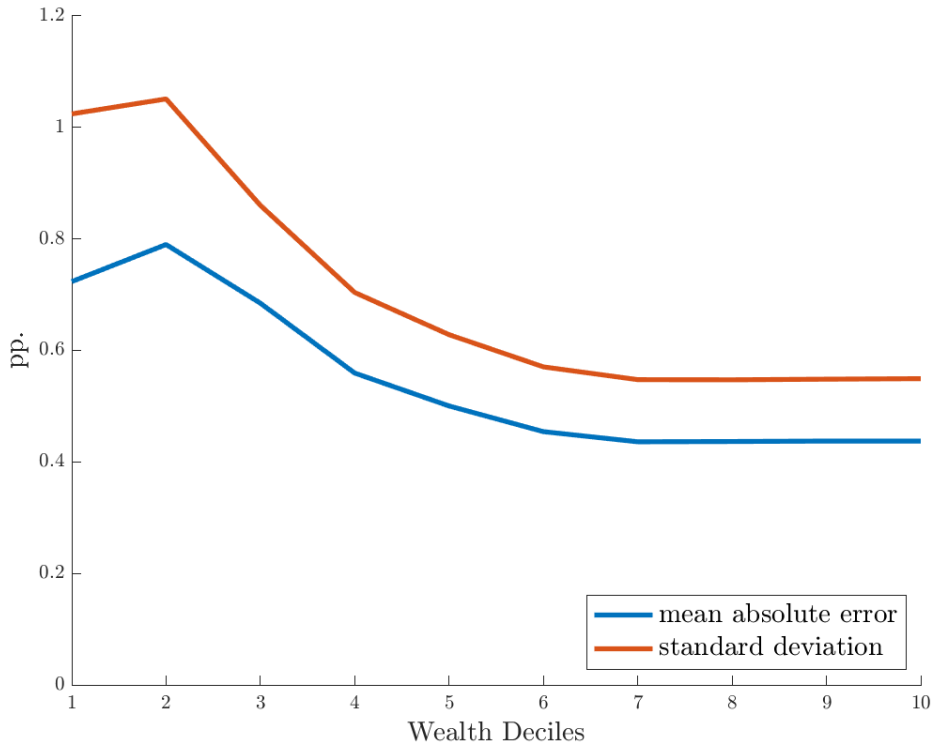
Expectation Errors along the Wealth Distribution

Model

Model matches decline of errors in wealth.

- Drop of 0.5 pp in standard deviation from peak to bottom.
- Highest standard deviation and absolute errors around zero wealth (2nd decile).

Expectation formation is driven by exposure to real interest rate risk.



Expectation Errors by Wealth Decile Groups

Simulated model implied statistics.

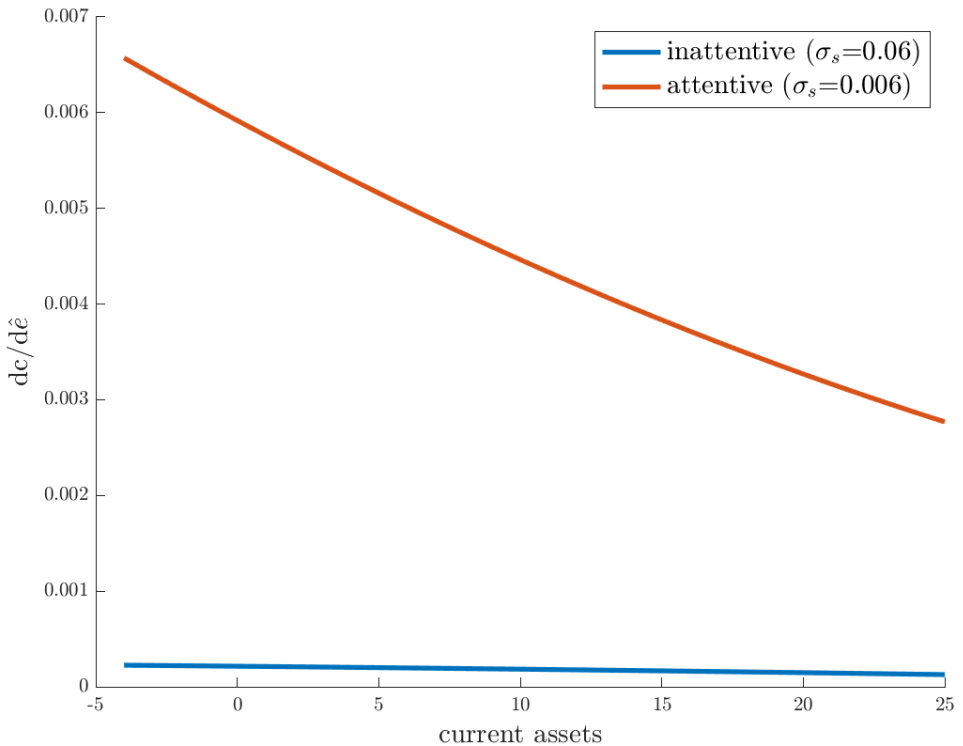
(Who cares?)^2

Co-movement of expectations and wealth important for aggregate consumption response.

- Noise reduces consumption response to signal.
- Inflationary signal has heterogeneous income effects.

  $\Rightarrow$ Consumption response declining in wealth.

Attentive low wealth HHs most responsive to expected inflation.



Marginal Propensity to Consume on Signal

Change in consumption policy if $\pi_t = 2$ and $\hat{e}_{t+1}$ changes from 0 to 1pp.

relative

Conclusion

Findings:

1. Dispersion and mean absolute error vary with wealth.
2. Rationalized in a model with endogenous expectations.
3. Response to expectations depends on noise and wealth.

$\Rightarrow$ Attentive low wealth HHs most responsive,
but low wealth HHs most likely inattentive.

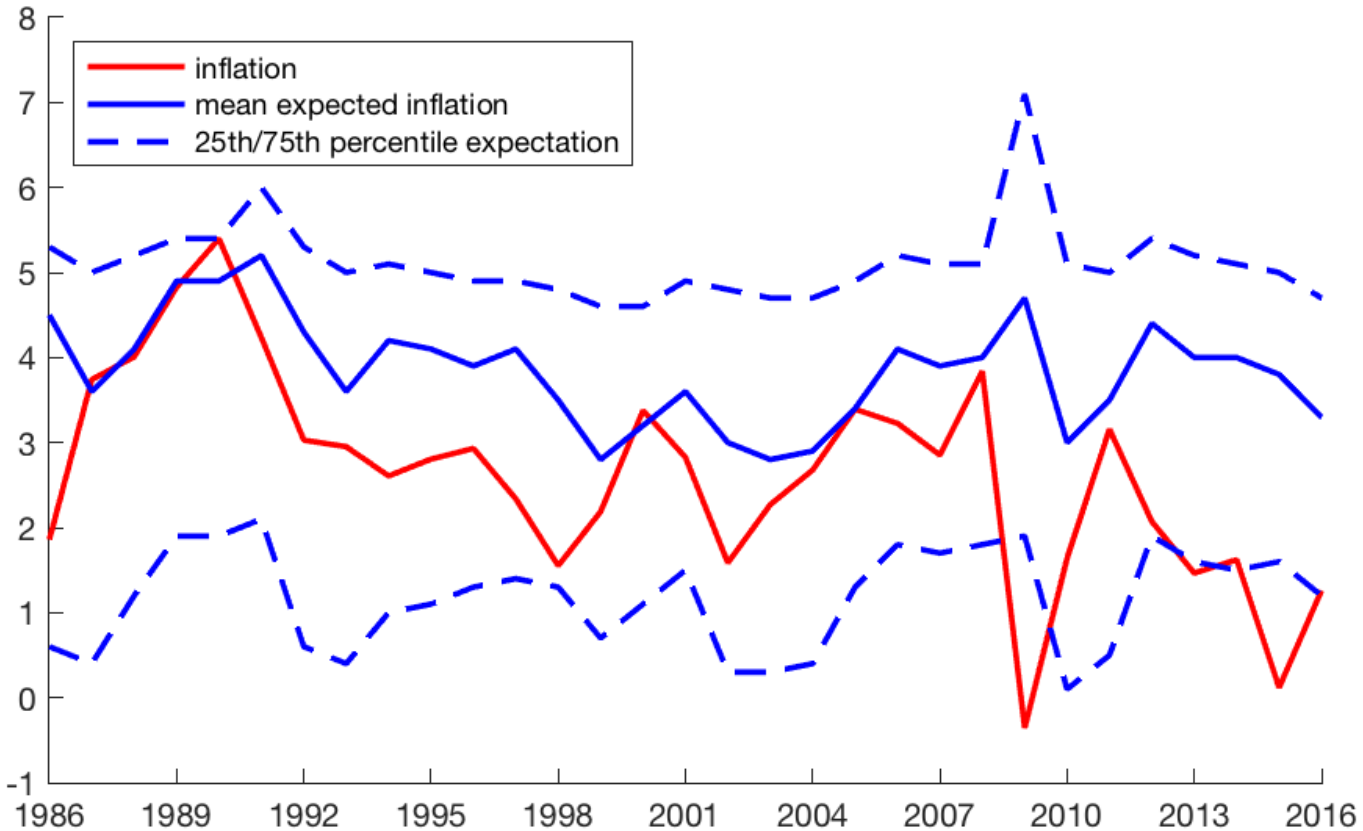
Co-movement of wealth and expectations could impact...

... effectiveness of forward guidance.

... intertemporal substitution channel in general.

Appendix

Dispersion of Inflation Expectations (US Data)



Time Series of Inflation Expectations

Data from Michigan Consumer Survey and FRED.

return

Related Literature

Expectation formation

- Models: Coibion and Gorodnichenko (2012), Mankiw et al. (2003), Patton and Timmermann (2010)...
- Empirics: D'Acunto et al. (2018), Arioli et al. (2017), Arrondel et al. (2014), Johannsen (2014), Malmendier and Nagel (2015), Axelrod et al. (2018), Ben-David et al. (2018), Fuster et al. (2018)...

$\Rightarrow$ **Here:** Precision/uncertainty and influence of wealth.

Inflation expectations and household choice:

- Armantier et al. (2015), Crump et al. (2015), Dräger and Nghiem (2018), Vellekoop and Wiederholt (2018), Coibion et al. (2019)...

$\Rightarrow$ **Here:** Reverse impact of choices on expectations.

Heterogeneous agent models with information frictions:

- Auclert et al. (2019), Broer et al. (2018), Carroll et al. (forthcoming), Lei (2019), Yin (2018)...

$\Rightarrow$ **Here:** Endogenous, disciplined by (expectation) data.

return

Net Financial Wealth Decile Groups - Summary

Net Financial Wealth Decile Groups - Summary

Decile	N	Min	Max	1pct	99pct	N err missing
1	1,270	-1,791,382	-135	-239,312	-375	149
2	1,269	-2,600	1,375	-1,875	1,072	167
3	1,262	361	4,921	450	4,588	123
4	1,263	2,350	10,375	2,486	9,710	130
5	1,263	6,005	18,480	6,250	17,300	117
6	1,264	11,100	27,730	11,625	26,750	114
7	1,265	19,525	44,037	19,850	42,584	92
8	1,265	30,500	75,750	31,375	73,000	91
9	1,265	52,360	140,465	55,095	131,447	68
10	1,259	105,646	3,940,520	111,379	2,227,178	58
Total	12,645	-1,791,382	3,940,520	-48,500	529,396	1,109

Data from DNB Household Survey waves 2010-2018. Net financial wealth refers to net wealth ex housing, mortgages, businesses and vehicles. Decile groups overlap due to differences in cut-offs across waves.

return

Expectation Error - Summary

Expectation Error by Decile Groups - Summary

Decile	Mean	Sd	Mean (abs)	N
1	1.42	1.75	1.66	1,121
2	1.71	2.00	1.94	1,102
3	1.56	1.83	1.76	1,139
4	1.43	1.70	1.67	1,133
5	1.24	1.52	1.48	1,146
6	1.19	1.39	1.42	1,150
7	1.25	1.43	1.46	1,173
8	1.22	1.46	1.44	1,174
9	1.10	1.35	1.34	1,197
10	1.14	1.37	1.36	1,201
Total	1.32	1.60	1.55	11,536

Data from DNB Household Survey waves 2010-2018. Summary statistics for expectation error by net financial wealth decile groups, computed as ex-ante point forecast for inflation minus ex-post realized inflation rate.

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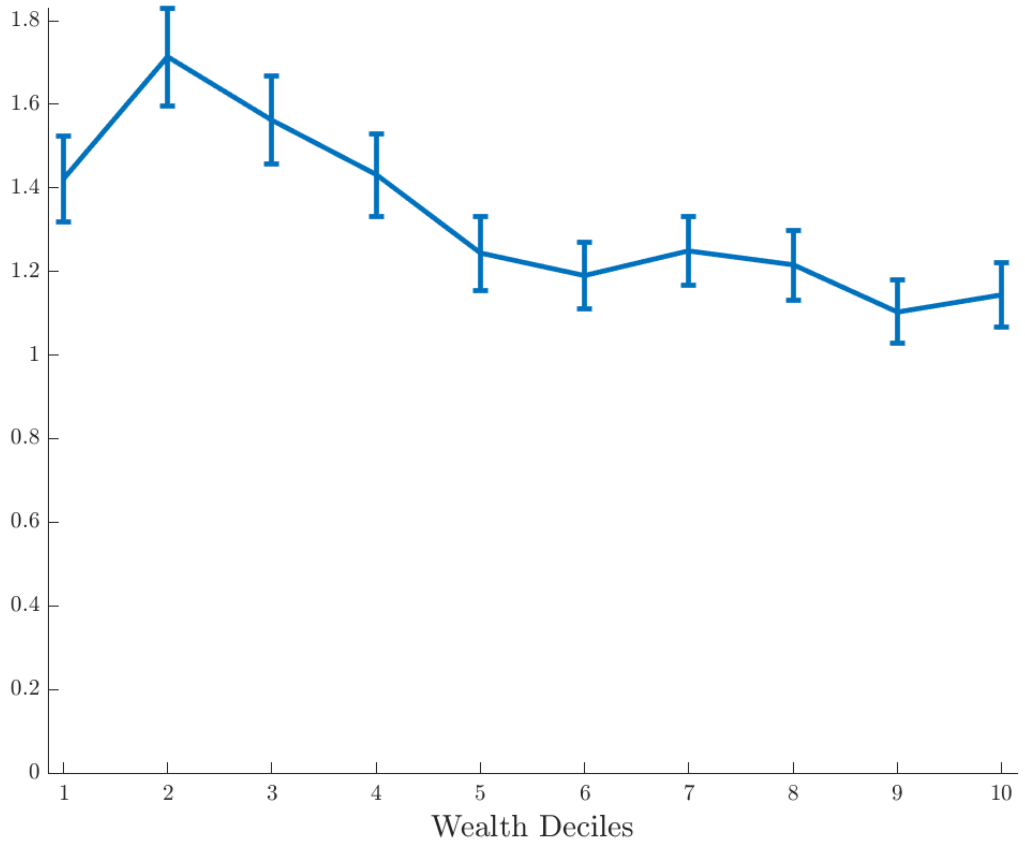
Mean Error by Wealth Deciles



Mean Expectation Error by Wealth Quintiles

95% confidence bands. Data from DNB Household Survey waves 2010-2018.

return

Empirical Observations - Robustness

Controls - Age and Education:

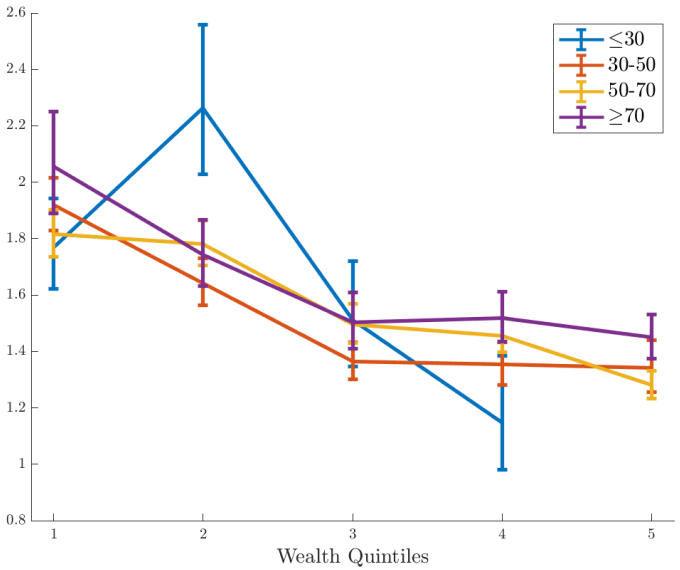
- Findings are robust by age / education groups.

Michigan Survey of Consumers:

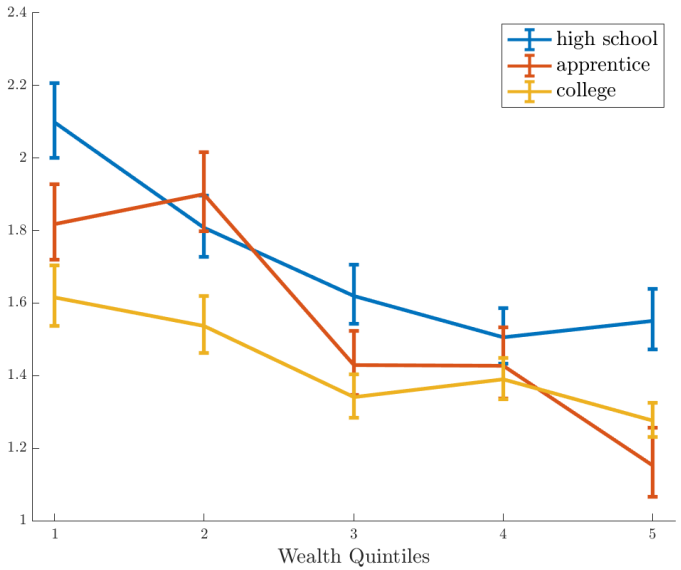
- No comprehensive wealth data, proxy by stock investment.
- Errors declining in stock investment.
- Robust to controlling for age / education.

controls Michigan return

Error Standard Deviation - Controls



(a) by age



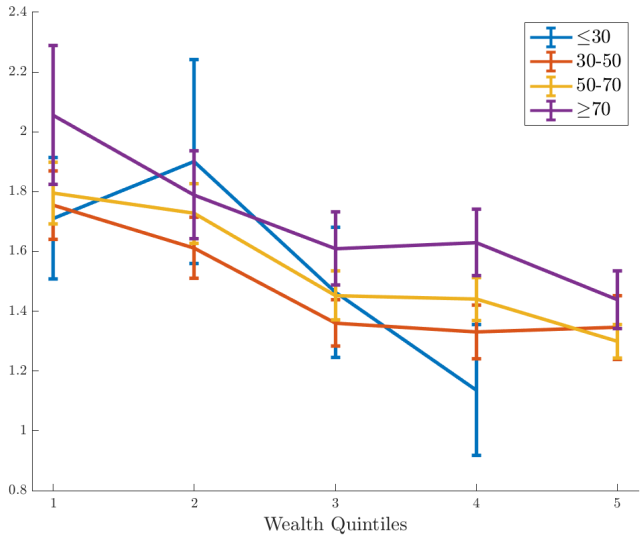
(b) by education

Standard Deviation of Errors by Wealth Quintile Groups

95% confidence bands. Data from DNB Household Survey waves 2010-2018. Combination of youngest age and highest wealth quintile omitted due to lack of observations.

return

Mean Absolute Error - Controls



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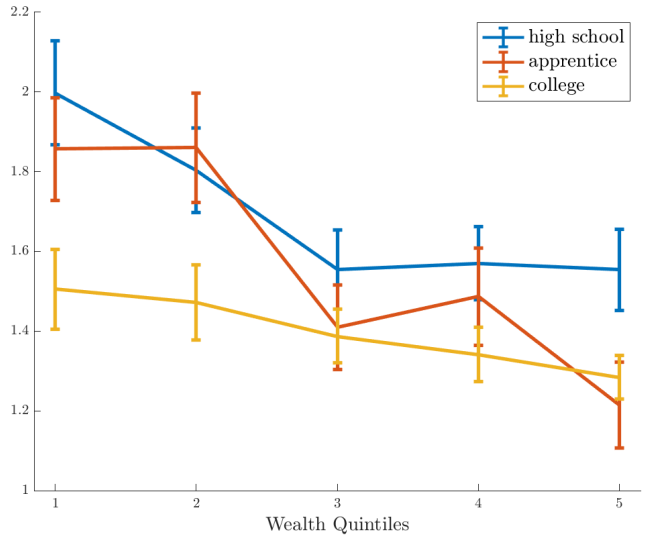

(b) by education

Mean Absolute Expectation Error by Wealth Quintile Groups

95% confidence bands. Data from DNB Household Survey waves 2010-2018. Combination of youngest age and highest wealth quintile omitted due to lack of observations.

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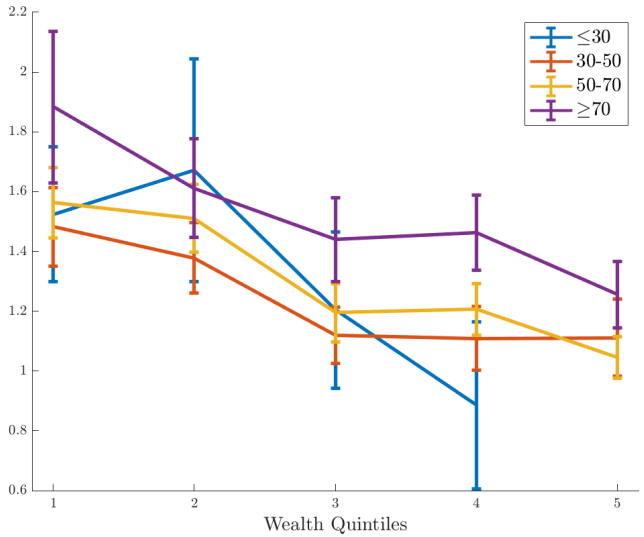
Mean Error - Controls



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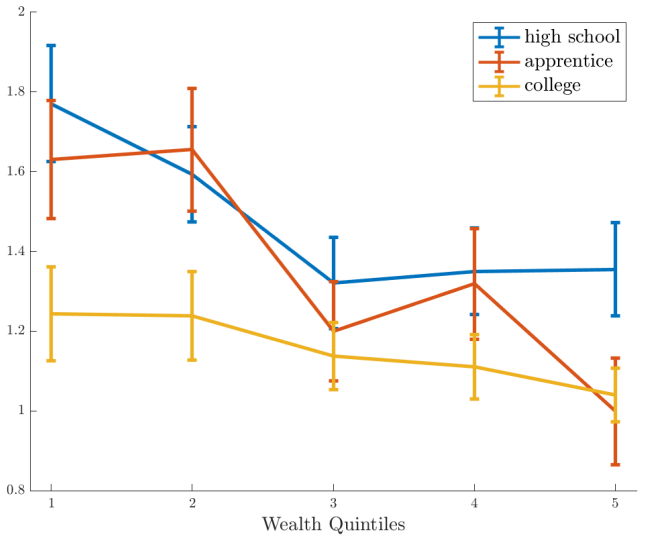

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Mean Expectation Error by Wealth Quintile groups

95% confidence bands. Data from DNB Household Survey waves 2010-2018. Combination of youngest age and highest wealth quintile omitted due to lack of observations.

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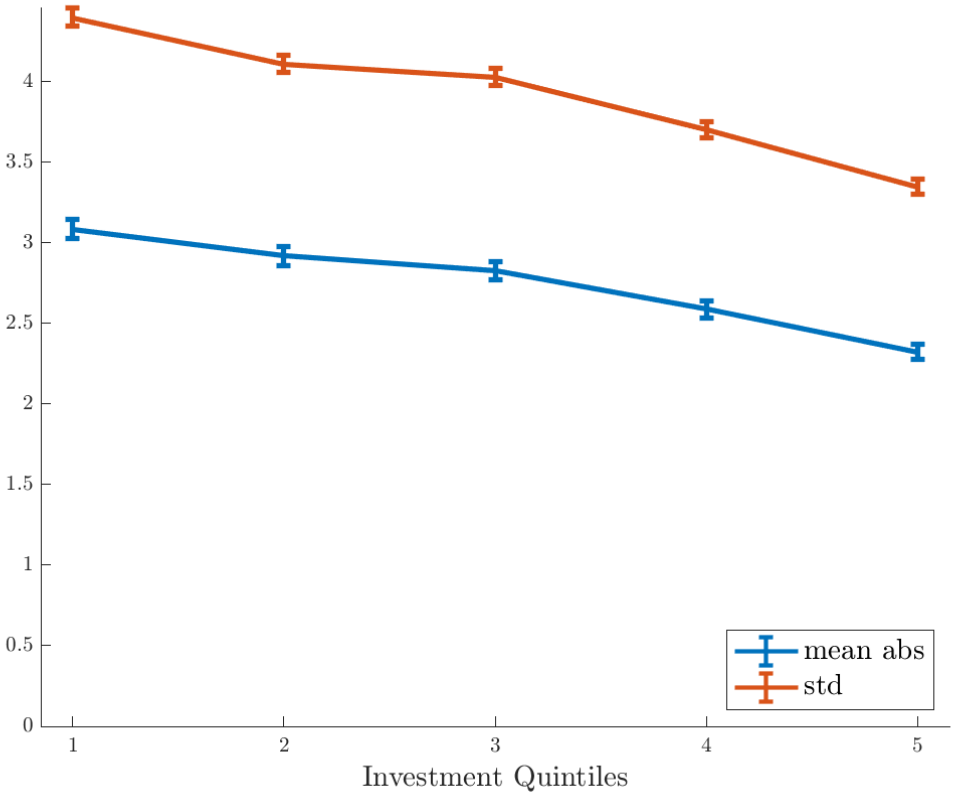
Expectation Errors along the Wealth Distribution

Michigan Data



Expectation Errors by Investment Quintile Groups

95% confidence bands. Data from Michigan Survey waves 09/1998-03/2019.

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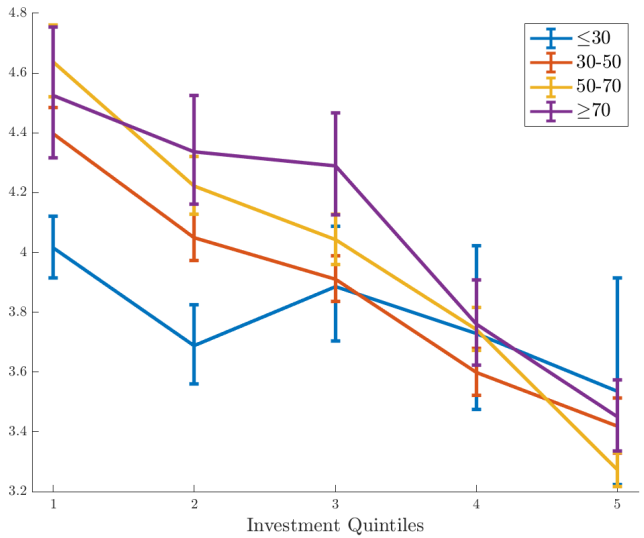
Error Standard Deviation - Controls

Michigan Data



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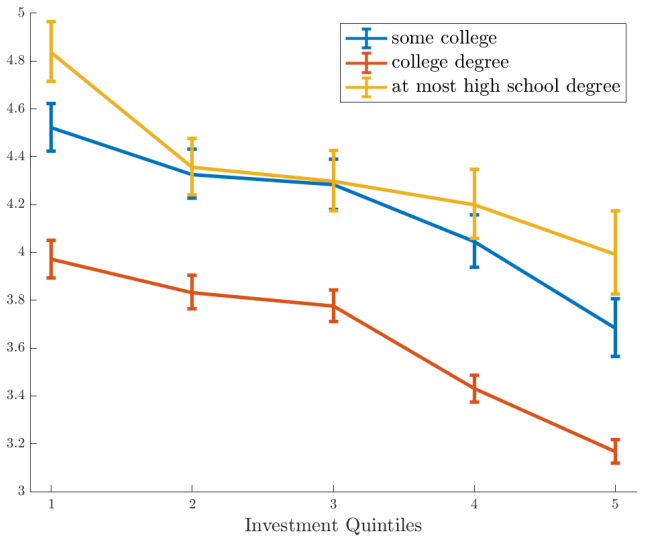


(b) by education

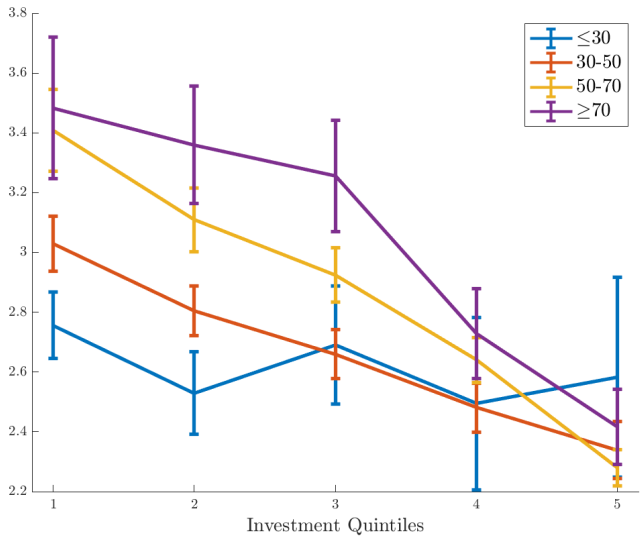
Standard Deviation of Errors by Investment Quintile Groups

95% confidence bands. Data from Michigan Survey waves 09/1998-03/2019.

return

Mean Absolute Error - Controls

Michigan Data



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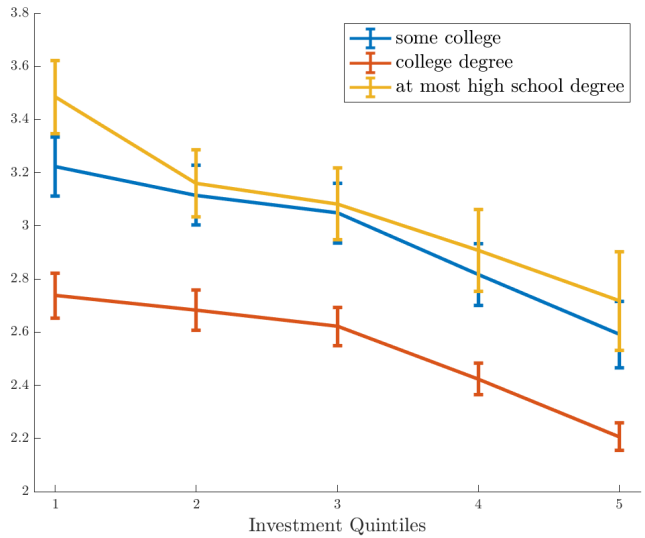


(b) by education

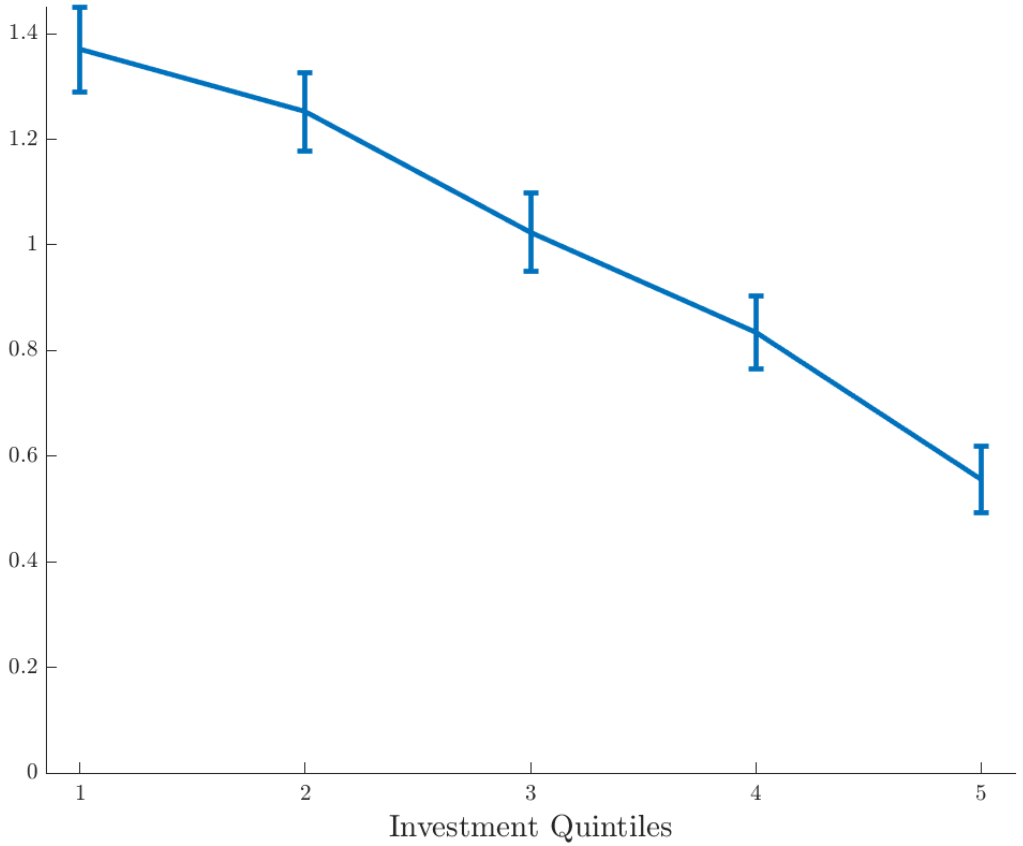
Mean Absolute Error by Investment Quintile Groups

95% confidence bands. Data from Michigan Survey waves 09/1998-03/2019.

return

Mean Error by Wealth Quintiles

Michigan Data



Mean Error by Investment Quintile Groups

95% confidence bands. Data from Michigan Survey waves 09/1998-03/2019.

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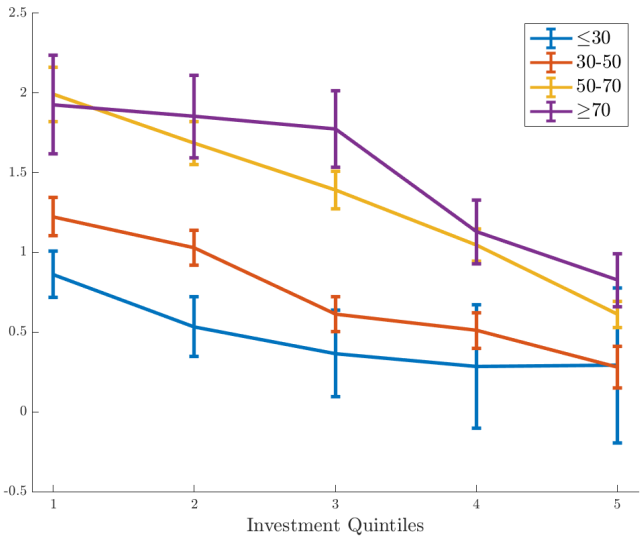
Mean Error - Controls

Michigan Data



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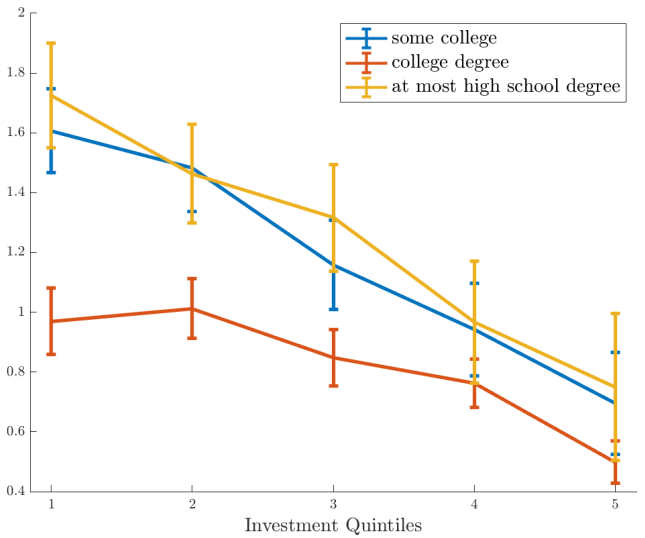


(b) by education

Mean Error by Investment Quintile Groups

95% confidence bands. Data from Michigan Survey waves 09/1998-03/2019.

return

Inflation Expectations - Model

Allow disagreement about long-run mean $\mu^i \sim \mathcal{N}(\bar{\mu}, \sigma_\mu^2)$, $\bar{\mu} \neq \mu$.

For a group g assuming that $n_t^i = \bar{n}_t^g \ \forall i \in g$ we get:

Variance of expectation errors:

$$\text{Var}(err_{t+1}^i | g) = (1-\rho)^2 \sigma_{\mu,g}^2 + \omega_{t+1}(\bar{n}_t^g)\sigma_s^2(\bar{n}_t^g)$$

Mean absolute error:

$$\mathbb{E}^g[|err^i|] = \sqrt{\text{Var}^g(err_{t+1}^i)\frac{2}{\pi}}\, e^{-\frac{\overline{err}^{g2}}{2\text{Var}^g(err_{t+1}^i)}} - \overline{err}^g \left(1 - 2\Phi\left(\frac{-\overline{err}^g}{\sqrt{\text{Var}^g(err_{t+1}^i)}}\right)\right)$$

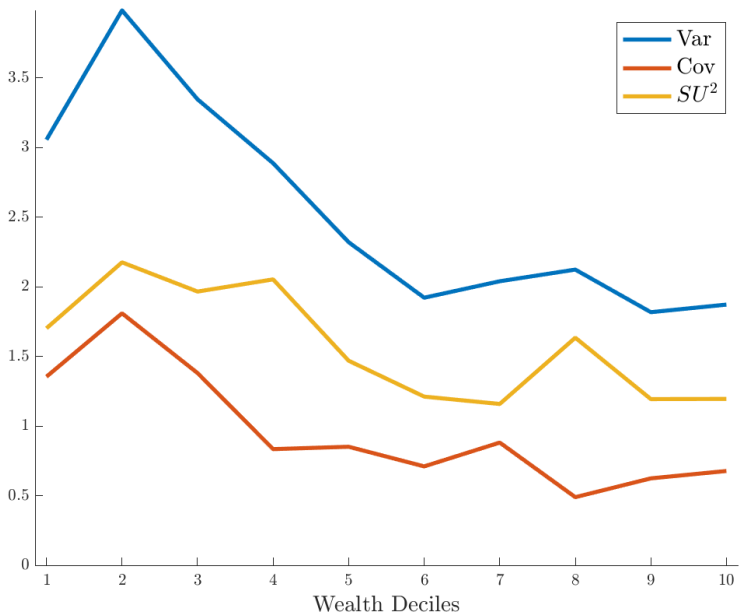
return

Expectation Error - Variance Decomposition

Covariance of expectation errors:

$$\text{Cov}(err^i_{t+1}, err^i_t | g) = (1-\rho)^2 \sigma^2_{\mu,g}$$

$\Rightarrow$ Variance = covariance + subjective uncertainty.



Expectation Error Variance - Decomposition

Decomposition of variance (Var) into covariance (Cov) and subjective uncertainty (SU). Data from DNB Household Survey waves 2010-2018.

return

Two Period Model - Calibration

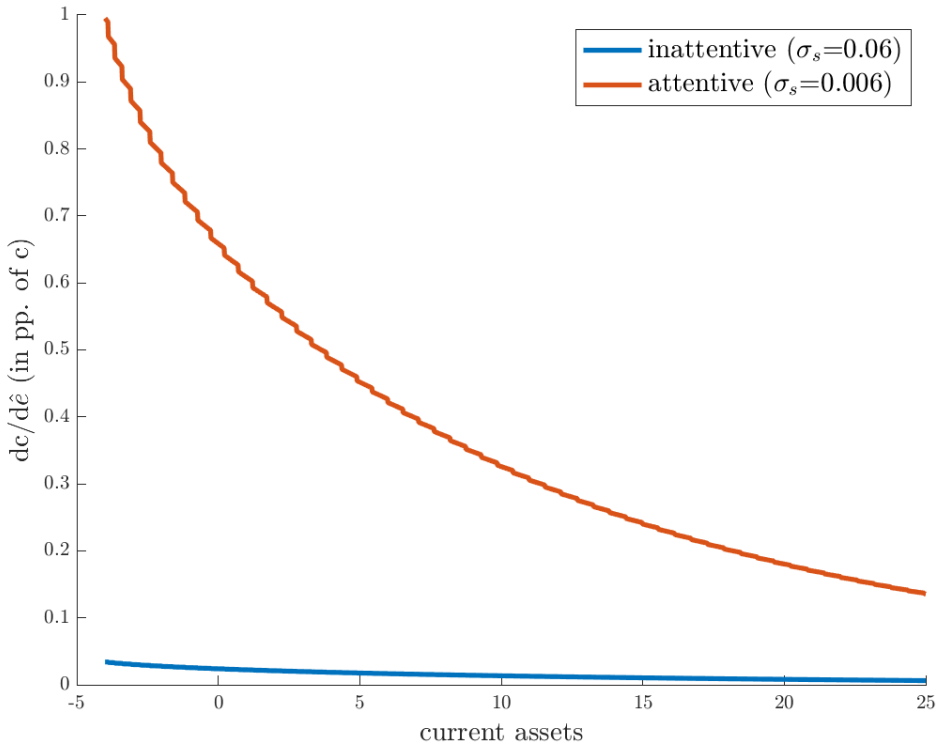
Two Period Model - Calibration

Parameter	Value
γ	1.5
α	9.0
β	0.965
ρ_y	0.94
σ_y	0.14
r^n	0.04
ρ	0.5
μ	0.02
σ_e	0.01
ϕ	2
θ	0.0017
χ	0.1

return

(Who cares?)^2 - Relative Response

Relative response is up to 1% of current consumption.



Relative Marginal Propensity to Consume on Signal

Percentage change in consumption policy if $\pi_t = 2$ and $\hat{e}_{t+1}$ changes from 0 to 1pp.

return

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