Myopia and Anchoring

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Forward-Looking Models and their Troubles

1. They are *excessively* forward looking
   - immense power of forward guidance puzzle at ZLB
   - indeterminacy, Neo-Fisherian effects ...
   - asset prices and news about earnings

2. They are *insufficiently* backward looking
   - no inertia or hump shapes, no momentum

3. Discomforting *gap* between macro and micro
   - fixes proposed by DSGE at odds with micro evidence
This Paper

\[ \text{info friction} = \text{myopia} + \text{anchoring} \]

plus: distortions larger at macro level due to GE
Theory

- **Starting point**: representative-agent model of the form

\[ a_t = \varphi \xi_t + \delta E_t [a_{t+1}] \]

- nests: Dynamic IS, NKPC, Q theory, AP
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- **Add**: informational friction
  - imperfect awareness of, or attention to, shocks (first-order uncertainty)
  - doubts about attention and responsiveness of others (higher-order uncertainty)
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- **Add**: informational friction
  - imperfect awareness of, or attention to, shocks (first-order uncertainty)
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- **Main result**: under conditions, observational equivalence with
  \[ a_t = \varphi \xi_t + \delta \omega_f E_t [a_{t+1}] + \omega_b a_{t-1} \]

- \( \omega_f < 1 \) (myopia) and \( \omega_b > 0 \) (anchoring)
**Applied Contribution**

- Justify backward-looking DSGE elements (habit, IAC, hybrid NKPC)
  
  But also make them endogenous to market structure and policy
  
  And blend them with a form of imperfect foresight

- Reduce gap between micro and macro

- Relate to emerging literature on bounded rationality / imperfect foresight

- Test and quantify in the context of inflation
Literature*

- **myopia**: Angeletos & Lian (2018)
- **anchoring**: Sims (2003), Woodford (2003), Mankiw & Reis (2003) ...
- **micro to macro**: Mackowiak & Wiederholt (2009) ...
- **inflation**: Nimark (2008) ...
- **evidence on expectations**: Coibion & Gorodnichenko (2012, 2015) ...
- **solution method**: Huo & Takayama (2018)

* in paper: more references plus connections to other strands of the literature
Roadmap

- Framework
- Equivalence Result
- Robustness
- Implications: DSGE, Micro to Macro, Bounded Rationality
- NKPC: Application and Empirical Evaluation
- Summary and Policy Implications
Framework
Framework

- Continuum of infinitely-lived agents with individual best responses

\[ a_{it} = \mathbb{E}_{it} [\varphi \xi_t + \beta a_{it+1} + \gamma a_{t+1}] \]

- \( \xi_t \): aggregate fundamental, exogenous \( \sim AR(1) \) or \( MA(\infty) \)
- \( a_t \): aggregate outcome, endogenous
- \( \beta \geq 0, \gamma \geq 0, \beta + \gamma < 1 \)
Framework

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- Equivalently, aggregate outcome satisfies

\[ a_t = \mathbb{E}_t \left[ \sum_{k \geq 0} \beta^k \varphi \xi_{t+k} \right] + \gamma \mathbb{E}_t \left[ \sum_{k \geq 0} \beta^k a_{t+k+1} \right] \]

- \( \beta \) controls PE response (direct effect)
- \( \gamma \) controls GE feedback (strategic complementarity)
Example: Aggregate Demand

- Consumption function (PIH) plus market clearing \((y = c)\) give

\[
c_t = - \sum_{k=0}^{\infty} \theta^k \mathbb{E}_t[r_{t+k}] + (1 - \theta) \sum_{k=0}^{\infty} \theta^k \mathbb{E}_t[c_{t+k+1}]
\]

where \(\theta\) is subjective discount factor

- Reduces to \(c_t = -r_t + \mathbb{E}_t[c_{t+1}]\) with complete info, but not without

- Nested here with \(\beta = \theta\) (PE) and \(\gamma = 1 - \theta\) (GE)

- Interpretation: \(\gamma = \text{strength of Keynesian income-spending multiplier}\)
Frictionless Benchmark

- Back to abstract framework:
  \[ a_{it} = \mathbb{E}_{it} [\varphi \xi_t + \beta a_{it+1} + \gamma a_t + 1] \]

- With complete (common) information \( \Rightarrow \) a representative agent with
  \[ a_t = \varphi \mathbb{E}_t [\xi_t] + (\beta + \gamma) \underbrace{\mathbb{E}_t [a_{t+1}]}_{\delta} \]

- Aggregate outcome given by
  \[ a_t = \varphi \mathbb{E}_t \left[ \sum_{k \geq 0} \delta^k \varphi \xi_{t+k} \right] \]

- Two key implications:
  - outcome pinned down by first-order beliefs
  - PE and GE do not play separate roles, only sum \( \delta \equiv \beta + \gamma \) matters
Adding Incomplete Information

○ Why incomplete information?
  ○ dispersed private information (Hayek, Lucas)
  ○ rational inattention and costly cognition (Sims)
  ○ plus, lack of CK = doubts about others’ awareness and response

○ Two key implications:
  ○ outcome depends on higher-order beliefs
  ○ PE and GE play distinct roles, $\gamma$ regulates relative importance of HOB
Higher-Order Beliefs and GE

- To illustrate, let $\beta = 0$, in which case

$$a_t = \varphi \overline{E}_t [\xi_t] + \gamma \overline{E}_t [a_{t+1}]$$

- Evaluating at $t + 1$ and taking the period-$t$ average expectation:

$$\overline{E}_t [a_{t+1}] = \varphi \overline{E}_t [\overline{E}_{t+1} [\xi_{t+1}]] + \gamma \overline{E}_t [\overline{E}_{t+1} [a_{t+2}]]$$

- Stronger GE ($\gamma$) → more weight on others → more weight on HOB
- Also: longer horizons ($h$) map to beliefs of higher order
Higher-Order Beliefs and GE

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- Iterating again and again → infinite belief hierarchy
  \[ a_t = \varphi \sum_{h=0}^{\infty} \gamma^h F_t^{h+1}[\xi_{t+h}] \]

  where $F_t^1[X] \equiv E_t[X]$ and $F_t^h[X] \equiv E_t[F_{t+1}^{h-1}[X]] \ \forall h \geq 2$.

- Stronger GE ($\gamma$) → more weight on others → more weight on HOB

- Also: longer horizons ($h$) map to beliefs of higher order
Challenge and Progress

○ Challenge: dynamics of HOB can be a computational nightmare

○ Baseline:
  o impose appropriate assumptions
  o bypass HOB and solve for RE using methods of Huo and Takayama (2015)
  o develop exact equivalence result

○ Robustness:
  o richer specification, alternate method
  o loose exact equivalence result, preserve essence
  o sharper understanding and additional insights
Equivalence Result
Specification

- Fundamental $\sim AR(1)$:

  \[ \xi_t = \rho \xi_{t+1} + \eta_t = \frac{1}{1 - \rho L} \eta_t \]

  where $\eta_t \sim \mathcal{N}(0,1)$ and $\rho \in (0, 1)$.

- Information given by history of private signals:

  \[ x_{it} = \xi_t + u_{it}, \]

  where $u_{it} \sim_{iid} \mathcal{N}(0, \sigma^2)$ and $\sigma \geq 0$ parameterizes the friction.
Solution of RE Fixed Point

- Frictionless benchmark corresponds to $\sigma = 0$ and is given by

\[ a_t^* = \sum_{k \geq 0} \delta^k \mathbb{E}_t [\xi_{t+k}] = \frac{\varphi}{1 - \delta \rho} \xi_t \]

i.e., follows same $AR(1)$ as the fundamental, rescaled

- What about $\sigma > 0$?
  - looks taunting: $h$-th order belief follows $ARMA(h + 1, h - 1)$, plus all $h$ matter
  - yet, some RE magic: the fixed point is merely an $AR(2)$!
**Solution of RE Fixed Point**

**Proposition**

The equilibrium exists, is unique, and follows an AR(2) given by

\[ a_t = \left(1 - \frac{\vartheta}{\rho}\right) \left(\frac{1}{1 - \vartheta L}\right) a_t^* \]

where \( a_t^* \) is the complete-information outcome and \( \vartheta \in (0, \rho) \) is the reciprocal of the largest root of the following cubic:

\[ C(z) \equiv -z^3 + \left(\rho + \frac{1}{\rho} + \frac{1}{\rho \sigma^2} + \beta\right) z^2 - \left(1 + \beta \left(\rho + \frac{1}{\rho}\right) + \frac{\beta + \gamma}{\rho \sigma^2}\right) z + \beta \]

- Deeper understanding requires working out HOB (later on)
- Useful, though, to note two properties of the solution:
  (i) \( \vartheta \) controls both impact and persistence
  (ii) \( \vartheta \) increasing in both \( \sigma \) (noise) and \( \gamma \) (GE)
Equivalence Result

Proposition (Observational Equivalence)

The incomplete-info economy is replicated by a complete-info economy with

$$a_t = \varphi \xi_t + \delta \omega_f E_t[a_{t+1}] + \omega_b a_{t-1}$$

for a unique pair of $\omega_f, \omega_b$ which is such that $\omega_f < 1$ and $\omega_b > 0$.

- myopia: $\omega_f < 1$
- anchoring: $\omega_b > 0$

Proposition (GE)

Holding $\sigma > 0$ constant, $\omega_f \downarrow$ and $\omega_b \uparrow$ as $\gamma \uparrow$

- both distortions are larger when GE is stronger
Robustness and Key Insights
Robustness

- General MA process for fundamental:
  \[ \xi_t = \sum \sum_k q_k \eta_{t-k} \]

- Each period, a series of private signals on current and past innovations:
  \[ x_{i,t}^k = \eta_{t-k} + v_{i,t}^k, \forall k \geq 0. \]

  where \( v_{i,t}^k \sim \mathcal{N}(0, \tau_k^2) \) is independent across \( i, t, k \) and \( \{\tau_k\} \) is arbitrary

  - cuts the Gordian of complicated signal-extraction problems
  - accommodates rich HOB dynamics
  - disentangles speed of learning from level of noise

- Exact equivalence breaks but essence remains, plus sharper understanding
Understanding Myopia ($\omega_f < 1$)

- To simplify, let $\beta = 0$, in which case

$$\bar{a}_t = \varphi \sum_{h=0}^{\infty} \gamma^h \bar{F}_{t}^{h+1} [\xi_{t+h}]$$

- Consider response of $a_t$ to a news about $\xi_{t+h}$:

$$x_{it} = \xi_{t+h} + \epsilon_{it};$$

let $\lambda \equiv \frac{\sigma_{\xi}^2}{\sigma_{\xi}^2 + \sigma_{\epsilon}^2} \in (0, 1)$; and assume no learning between $t$ and $t + h$.

- First and higher-order beliefs:

$$\bar{E}_{t+h}[\xi_{t+h}] = \lambda \xi_{t+h}$$
$$\bar{E}_{t+h-1}[\bar{E}_{t+h}[\xi_{t+h}]] = \lambda^2 \xi_{t+h}$$
$$\vdots$$
$$\bar{F}_{t}^{h+1}[\xi_{t+h}] = \lambda^{h+1} \xi_{t+h}$$

$\Rightarrow$ as if the news is discounted at a rate increasing with $h$
Parenthesis: Forward Guidance (Angeletos and Lian, AER 2018)

- Application: ZLB up to $t = T - 1$, response to news about $R_t$ at $t = T$
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\[
\frac{\phi}{\phi^*} = \begin{cases} 
\lambda_c = \lambda_f = 0.75 & \text{for } \lambda = 0.75, \, \lambda_f = 1 \\
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\end{cases}
\]
Parenthesis: Forward Guidance (Angeletos and Lian, AER 2018)

○ Application: ZLB up to $t = T - 1$, response to news about $R_t$ at $t = T$

○ Complementary intuition: lack of CK = attenuation of GE feedbacks
  ○ income-spending multiplier (Keynesian cross)
  ○ inflation-spending multiplier (inflationary spiral)

○ Added value here:
  ○ extend to stationary setting with recurrent and persistent shocks
  ○ allow for learning (crucial for $\omega_b > 0$, which comes next)
  ○ embed in observational-equivalence result
Understanding Anchoring \((\omega_b > 0)\)

- Anchoring, or momentum, hinges on learning

- Basic intuition: in Kalman filter, past belief shows up as a state variable

\[ \overline{E}_t[\xi_t] = (1 - G)\overline{E}_{t-1}[\xi_{t-1}] + G\xi_t \]

- Similar logic in our setting except that
  - anchoring reinforced by higher-order uncertainty
  - relevant state variable is \(a_{t-1}\) (magic: \(a_{t-1}\) is a summary statistic of HOB)
  - effective \(G\) decreases with \(\gamma\)
Understanding Anchoring ($\omega_b > 0$)

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- Versions of basic insight abound in the literature
  - Sims, Woodford, Mankiw-Reis, Nimark ...

- Added value here:
  - blend with insight about myopia
  - embed in observational-equivalence result
  - elaborate on interaction of learning with forward-looking behavior
Implications
Bridge to DSGE

- Our equivalence result offers a micro-foundation of DSGE add-ons
  - habit in consumption
  - adjustment cost to investment (IAC)
  - hybrid, backward-looking, NKPC

- But not a panacea: distortions endogenous to GE and thereby to
  - markets (e.g., liquidity constraints, IO structure)
  - policy (e.g., redistributive effects of FP, aggressiveness of MP)

- Plus: blend with myopia (also endogenous to GE and policy)
Macro vs Micro

- Pervasive gap between macro and micro
  - $C$: estimated habit much smaller in micro data (Havranek et al, 2017)
  - $I$: type of IAC used in DSGE inconsistent with standard Q theory as well as with literature that studies plant-level investment dynamics
  - $\pi$: menu-cost models that match price data (Golosov & Lucas etc) don't produce backward-looking feature of hybrid NKPC

- Our results help merge the gap
  - mechanism: GE and HOB
  - distinct from, but complementary to, Mackowiak and Wiederholt (2009)
Parenthesis I: Asset Pricing

- Basic asset pricing model, with OLG traders
  \[ p_t = d_t + \delta \mathbb{E}_t[p_{t+1}] \]

- Adding incomplete info and applying our result
  \[ p_t = d_t + \delta \omega_f \mathbb{E}_t[p_{t+1}] + \omega_b p_{t-1} \]

- \( \omega_b > 0 \) → momentum, predictability

- \( \omega_f < 1 \) → little response to long-term earnings (or long-run risk?)

- Distortions larger at aggregate level
  → Samuelson dictum (Jung and Shiller, 2005)
Relation to Bounded Rationality

○ Recent works that produce myopia by dropping REE
  ○ Garcia-Schmidt & Woodford (2018), Farhi & Werning (2017): with Level-k Thinking
  ○ Gabaix (2017): with “Cognitive Discounting”

○ They do not produce our second feature, anchoring or habit-like behavior
  ○ i.e., they let $\omega_f < 1$ but maintain $\omega_b = 0$

○ But: data appear to demand both, in line with our approach
  ○ $\omega_f < 1$ is focus of literature on forward-guidance puzzle
  ○ $\omega_b > 0$ is common message of SVAR and DSGE literatures
  ○ expectations data also support both $\omega_f < 1$ and $\omega_b > 0$
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- That said, interesting to combine incomplete info + bounded rationality
  - variant 1: level-k thinking
  - variant 2: fail to anticipate learning of others
  - both reduce $\omega_f$ but have opposite effects on $\omega_b$
Application to NKPC and Quantitative Evaluation
Application to NKPC

- Optimal price-setting decision:

\[ p^*_t = (1 - \delta \theta) \sum_{k=0}^{\infty} (\delta \theta)^k E_t[\xi_{t+k} + p_{t+k}] \]

- \( \xi_t \) = real marginal cost; \( \theta \) = Calvo parameter; \( \delta \) = discount factor

- NKPC with complete info:

\[ \pi_t = \kappa \xi_t + \delta E_t[\pi_{t+1}] \]
Application to NKPC

- Optimal price-setting decision:
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- NKPC with complete info: \(\pi_t = \kappa\xi_t + \delta E_t[\pi_{t+1}]\)

- NKPC with incomplete info:
  \[
  \pi_t = \kappa \sum_{k=0}^{\infty} (\delta\theta)^k E_t[\xi_{t+k}] + \delta(1 - \theta) \sum_{k=1}^{\infty} (\delta\theta)^k E_t[\pi_{t+k}]
  \]
Application to NKPC

- Optimal price-setting decision:

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- NKPC with complete info: \( \pi_t = \kappa \xi_t + \delta E_t [\pi_{t+1}] \)

- NKPC with incomplete info:

\[
\pi_t = \kappa \sum_{k=0}^{\infty} (\delta \theta)^k E_t [\xi_{t+k}] + \delta (1 - \theta) \sum_{k=1}^{\infty} (\delta \theta)^k E_t [\pi_{t+k}]
\]

- Our observational-equivalence result \( \Rightarrow \)

\[
\pi_t = \kappa \xi_t + \omega_f \delta E_t [\pi_{t+1}] + \omega_b \pi_{t-1}
\]

- invalid to use \( \pi_t = \kappa \xi_t + \delta E_t [\pi_{t+1}] \)

- \( \gamma \) increases with \( \theta \rightarrow \text{distortions increase with price flexibility!} \)
Test 1: Matching Estimates of Hybrid NKPC

- Both $\omega_f$ and $\omega_b$ functions of same parameter $\sigma \Rightarrow$ testable restriction

- Gali and Gertler (1999), Gali et al (2005) provide estimates of $(\omega_f, \omega_b)$

- Test whether these estimates satisfy our theory’s restriction
  - use standard value for $\delta$ and $\theta$, estimate $\rho$ from labor share data
Test 1: Matching Estimates of Hybrid NKPC

Ellipses are 90% confidence regions for various estimates in Gali et al (2005)
Test 2: Matching Evidence on Inflation Expectations

○ Coibion and Gorodnichenko (2015) use survey evidence to estimate

$$\pi_{t+k} - \mathbb{E}_t [\pi_{t+k}] = K \left( \mathbb{E}_t [\pi_{t+k}] - \mathbb{E}_{t-1} [\pi_{t+k}] \right) + v_{t+k,t}$$

  ○ $K = 0$ with complete information
  ○ $K > 0$ indicates correlated forecast errors

○ Results suggestive of info friction, but two key limitations
  ○ treat $\pi$ as exogenous $\Rightarrow$ could not quantify effect of info friction on $\pi$ dynamics
  ○ mapping from $K$ to $\sigma$ is endogenous to whole equilibrium

○ Our contribution
  ○ endogenize $\pi$, solve fixed point between $\mathbb{E}[\pi]$ and $\pi$, use theory to map $K$ to $\sigma$
  ○ quantify importance of info friction
  ○ connect to estimates of hybrid NKPC
Test 2: Matching Evidence on Inflation Expectations

Highlighted segment corresponds to 90% confidence interval in Coibion and Gorodnichenko (2015)

Parameters: \( \rho = 0.95, \theta = 0.6 \)
Quantitative Bite

Auxiliary economy: incomplete-info $\mathbb{E}[\xi]$ and complete-info $\mathbb{E}[\pi]$
Summary and Additional Policy Implications
Summary

- A new window to effects of informational frictions
- Rationalize both myopia and backward-looking behavior
- Justify DSGE add-ons, but also subject them to Lucas critique
- Ease disconnect between micro and macro
- Promising quantitative potential
Additional Policy Implications (Companion Research)

- Resolution to forward-guidance puzzle
- Rationale for back-loading fiscal stimuli
- Announcing instruments vs targets
- Policy rules that regulate strategic complementarity also regulate distortions