Myopia and Anchoring

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University of Cambridge / INET Conference  
May 4, 2018
Context

- Textbook version of forward-looking models

\[ a_t = \varphi \xi_t + \delta \mathbb{E}_t [a_{t+1}] \]

- NKPC:  \( \pi_t = \kappa x_t + \delta \mathbb{E}_t [\pi_{t+1}] \)

- DIS:  \( c_t = -\sigma r_t + \mathbb{E}_t [c_{t+1}] \)

- AP:  \( p_t = \mathbb{E}_t [d_{t+1}] + \delta \mathbb{E}_t [p_{t+1}] \)
**Motivation**

- **Empirical challenges:**
  - do not generate sluggish response to shocks
  - respond too strongly to news about distant feature fundamentals

- **DSGE literature** (*Christiano & Eichenbaum, Smets & Wouters*)
  - addresses first issue with hybrid NKPC, habit, IAC, etc
  - but is inconsistent with micro

- **Recent work on bound rationality** (*Gabaix, Farhi & Werning, Woodford*)
  - addresses second issue by dropping REE (a cost on its own right?)
  - but abstracts from first issue
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○ **This paper: simple resolution to both issues**
  ○ consistent with REE
  ○ consistent with evidence on expectations
  ○ explains why distortions more prevalent at macro level
What We Do: Theory

○ Take a model of the form

\[ a_t = \varphi \xi_t + \delta \mathbb{E}_t [a_{t+1}] \]

○ Add:
  o incomplete info (rational inattention)
  o higher-order uncertainty (doubts about others)
  o learning (gradual consensus)
What We Do: Theory

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  ○ incomplete info (rational inattention)
  ○ higher-order uncertainty (doubts about others)
  ○ learning (gradual consensus)

○ Main result: observational equivalence with

\[ a_t = \varphi \xi_t + \delta \omega f \mathbb{E}_t [a_{t+1}] + \omega_b a_{t-1} \]

○ \( \omega_f < 1 \) → myopia, additional discounting
○ \( \omega_b > 0 \) → anchoring, backward looking
○ distortions intensify with strength of GE feedback
○ distortions more prevalent at macro level
What We Do: Applications

- Evaluate quantitative performance in context of inflation/NKPC
  - rationalize evidence on hybrid NKPC (Gali and Gertler)
  - match evidence on inflation expectations (Coibion and Gorodnichenko)
  - quantify role of informational friction

- Other applications
  - habit in consumption
  - IAC
  - myopia and momentum in asset prices
Literature

○ Informational frictions and higher-order uncertainty
  o Sims (2003), Woodford (2003), Mankiw and Reis (2003, 2011)
  o Angeletos and Lian (2016), Huo and Takayama (2015b)

○ DSGE, Philips Curves, and Micro vs Macro
  o Havranek, Rusnak, and Sokolova (2017), Altissimo et al. (2010)

○ Bounded rationality
Framework

○ Continuum of infinitely-lived agents with Euler-like best responses given by

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

○ \( \xi_t \): persistent economic fundamental

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

○ \( a_t \): aggregate action

○ \( \beta \geq 0 \) parameterizes PE discounting

○ \( \gamma \geq 0 \) parameterizes GE feedback

○ Agents are forward-looking \( \rightarrow \) dynamic beauty contest
Frictionless Benchmark

- Assume $\xi_t$ perfectly and commonly known

- Model reduces to a representative agent with

  $$a_t = \varphi \xi_t + (\beta + \gamma) \mathbb{E}_t[a_{t+1}]$$

- PE and GE do not play separate roles, are “hidden” behind $\delta$
Frictionless Benchmark

- Equilibrium condition:
  \[ a_t = \varphi \xi_t + \delta \mathbb{E}_t[a_{t+1}] \]

- By forward iteration:
  \[ a_t = \varphi \sum_{k=0}^{\infty} \delta^k \mathbb{E}_t[\xi_{t+k}] \]

- By AR(1) assumption:
  \[ \mathbb{E}_t[\xi_{t+k}] = \rho^k \xi_t \]

- Result:
  \[ a_t = a_t^* \equiv \frac{\varphi}{1 - \rho \delta} \xi_t \]
  
  i.e., outcome follows same AR(1) as fundamental, up to rescaling
Adding Incomplete Information

- Why incomplete information?
  - dispersion of information (Hayek, Lucas)
  - rational inattention (Sims) and costly cognition (Tirole)
  - plus: lack of CK = doubts about others’ awareness and response
Adding Incomplete Information

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○ Main specification: sequence of private signals given by

\[ x_{it} = \xi_t + u_{it}, \quad u_{it} \sim \mathcal{N}(0, \sigma^2) \]

  ○ not only first-order uncertainty (imperfect knowledge of \( \xi_t \))
  ○ but also higher-order uncertainty (doubts about others)
Forward-Iteration Representation

- Recall that equilibrium behavior obeys:
  \[ a_{it} = \mathbb{E}_{it} [\varphi \xi_t + \beta a_{it+1} + \gamma a_{t+1}] \]

- By forward iteration and aggregation:
  \[ a_t = \varphi \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t [\xi_{t+k}] + \gamma \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t [a_{t+k+1}] \]

- Distinct role of \( \beta \) and \( \gamma \)
  - \( \beta \): PE discounting \( \rightarrow \) FOB
  - \( \gamma \): GE interaction \( \rightarrow \) HOB
Higher-Order Beliefs

○ To illustrate, consider the case where $\beta = 0$:

$$a_t = \varphi \bar{E}_t[\xi_t] + \gamma \bar{E}_t[a_{t+1}]$$
Higher-Order Beliefs

- To illustrate, consider the case where $\beta = 0$:
  \[ a_t = \varphi \mathbb{E}_t [\xi_t] + \gamma \mathbb{E}_t [a_{t+1}] \]

- Evaluating at $t + 1$ and taking the period-$t$ average expectation:
  \[ \mathbb{E}_t [a_{t+1}] = \varphi \mathbb{E}_t [ \mathbb{E}_{t+1} [\xi_{t+1}] ] + \gamma \mathbb{E}_t [ \mathbb{E}_{t+1} [a_{t+2}] ] \]
  2nd-order beliefs
Higher-Order Beliefs

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

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

2nd-order beliefs

○ Iterating again and again:

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

where $\overline{F}_t^h [X]$ is an $h$-th order, forward-looking belief defined by

$$\overline{F}_t^1 [X] \equiv \overline{E}_t [X] \quad \text{and} \quad \overline{F}_t^h [X] \equiv \overline{E}_t [\overline{F}_{t+1}^{h-1} [X]] \quad \forall h \geq 2.$$

○ Alert: with $\beta > 0$, structure of HOB more involved
Tractability and Solution

- Characterizing the dynamics of HOB can be a computational nightmare!

- This is where our signal specification and solution method come to rescue

- We bypass complexity of HOB and solve for RE fixed point in closed form
  - using methods of Huo and Takayama (2015b)
Tractability and Solution

Proposition

The equilibrium exists, is unique, and is such that

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

where \( a_t^* \equiv \frac{\varphi}{1 - \delta \rho} \xi_t \) is the complete-information outcome and \( \vartheta \in (0, \rho) \) is the reciprocal of the largest root of the following cubic:

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

- Key 1: \( \vartheta \) controls both impact effect and endogenous persistence
- Key 2: \( \vartheta \) increasing in both \( \sigma \) and \( \gamma \)
- Instrumental for observational equivalence, but insights more robust
Remark: HOB and Rational Expectations

○ For the analyst: understanding HOB = understanding RE

○ However, agents themselves need not engage in higher-order reasoning!
  ○ in Muth/Lucas tradition, agents can still be understood as “statisticians”
  ○ the literature often misses this elementary point

○ Plus: fixed point can be computationally/cognitively easier than iterating
  ○ our solution itself is an illustration of this point
**Proposition**

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

\[ a_t = \varphi \xi_t + \delta \omega_f \mathbb{E}_t [a_{t+1}] + \omega_b a_{t-1} \]

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 : \(\omega_b > 0\)
Equivalence Result

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Proposition

\(\omega_f \downarrow\) and \(\omega_b \uparrow\) as either \(\sigma \uparrow\) or \(\gamma \uparrow\)

- both distortions larger when GE is stronger
Understanding Myopia ($\omega_f < 1$)

- To simplify, let $\beta = 0$:

$$\bar{a}_t = \mathbb{E}_t[\xi_t] + \gamma \mathbb{E}_t[a_{t+1}]$$

$$= \varphi \sum_{h=0}^{\infty} \gamma^h \mathbb{E}_t^{h+1}[\xi_{t+h}]$$

- Consider response of $a_t$ to news about $\xi_{t+h}$, for some $h \geq 1$

- Response depends on $h$-th order beliefs
  - thinking about the future path of $a$ is the same as thinking about HOB

- HOB move much less than FOB $\Rightarrow$ as if the news is discounted
  - Indeed, in the absence of learning, effective discounting modified

$$\delta = \beta + \gamma \quad \rightarrow \quad \delta' = \beta + \lambda \gamma$$

for some $\lambda \in (0, 1)$ that is inversely related to $\sigma$. 
Understanding Anchoring ($\omega_b < 0$)

- Anchoring, or momentum, is a product of learning interacted with GE/HOB.

- Think of Kalman filter about $\xi$ (with $\rho = 1$)
  \[
  \mathbb{E}_t[\xi_t] = (1 - K)\mathbb{E}_{t-1}[\xi_{t-1}] + K\xi_t
  \]

- Past belief shows up as a state variable.

- Similar logic applies in our setting except that
  - relevant state variable is $a_{t-1}$ (summarizes HOB)
  - effective $K$ is smaller the stronger the GE effect.
Relations to the Literature

- Earlier versions of basic insights
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- Bridge to DSGE literature
  - DSGE: ad-hoc modifications on Euler, NKPC, Q-theory
  - this paper: a unified micro-foundation to these modifications
  - plus: relate distortions to GE effects and expectations

Connection to recent macro literature on bounded rationality
- Gabaix (2016), Farhi and Werning (2017): offer $\omega_f < 1$ but restrict $\omega_b = 0$.
- data want both $\omega_f < 1$ and $\omega_b > 0$.
- incomplete info (or RI): delivers both, plus maintains RE.
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Testable Predictions

- A hybrid economy can be replicated by an incomplete-info economy iff

\[ \omega_b = \Omega(\omega_f; \delta, \rho) \]

- Additional testable predictions regard dynamics of average forecast errors

- We return to these points in the NKPC application
Disentangling GE from PE

- Extend our previous model to

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

- \( \xi_{it} \) individual fundamental: \( \xi_{it} = \xi_t + \zeta_{it} \)
- \( \zeta_{it} \) idiosyncratic shock: \( \zeta_{it} = \rho \zeta_{it-1} + \epsilon_{it} \)

- Forward-iteration representation

\[ a_{it} = \sum_{k=0}^{\infty} \beta^k \mathbb{E}_{it} [\xi_{i,t+k}] + \gamma \sum_{k=0}^{\infty} \beta^k \mathbb{E}_{it} [a_{t+k+1}] \]

- GE is tied to higher-order beliefs, PE isolates first-order beliefs
Disentangling GE from PE

- Information
  - imperfect info about aggregate fundamental: \( x_{it} = \xi_t + u_{it} \)
  - perfect info about individual fundamental: \( z_{it} = \xi_{it} \)

- Consider limit \( \frac{\nabla(\zeta_{it})}{\nabla(\xi_t)} \approx \infty \)
  - consistent with fact that micro shocks much larger than macro shocks
  - shuts down inertia in FOB, isolates HOB
Disentangling GE from PE

○ Information
  ○ imperfect info about aggregate fundamental: \( x_{it} = \xi_t + u_{it} \)
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### Proposition

\begin{align*}
\text{Aggregate outcome given by } a_t & = \overline{PE}_t + \overline{GE}_t \\
\overline{PE}_t & \text{ is the same as with full information} \\
\overline{GE}_t & \text{ follows the same distorted law of motion as in the baseline model}
\end{align*}

○ Bottom line: GE is key, higher-order uncertainty suffices
Micro vs Macro

- Distortions are likely to be more pronounced at macro level
  - resolve disconnect between DSGE and micro evidence

- Robust to imperfect info at both individual and aggregate level

- Driven by GE and higher-order uncertainty

- Distinct from (complementary) point in Mackowiak and Wiederholt (2009)
  - first-order uncertainty about idiosyncratic < than that about aggregate
NKPC with Incomplete Information

- Firms’ optimal pricing decision, with probability $1 - \theta$ to reset price:
  \[
p^*_it = (1 - \delta\theta) \sum_{k=0}^{\infty} (\delta\theta)^k \mathbb{E}_{it}[\xi_{t+k} + p_{t+k}]
  \]

- real marginal cost: $\xi_t$
- observe $x_{it} = \xi_t + u_{it}$

- Equilibrium inflation dynamics:
  \[
  \pi_t = \frac{(1-\delta\theta)(1-\theta)}{\theta} \sum_{k=0}^{\infty} (\delta\theta)^k \mathbb{E}_t[\xi_{t+k}] + \delta(1 - \theta) \sum_{k=1}^{\infty} (\delta\theta)^k \mathbb{E}_t[\pi_{t+k}]
  \]

- Dynamic beauty contest representation:
  \[
a_{it} = \left[\frac{(1-\delta\theta)(1-\theta)}{\theta}\right] \mathbb{E}_{it}[\xi_{t}] + \left[\frac{\delta\theta}{\beta}\right] \mathbb{E}_{it}[a_{it+1}] + \left[\frac{\delta(1 - \theta)}{\gamma}\right] \mathbb{E}_{it}[a_{t+1}]
  \]
Test 1: Matching Estimates of Hybrid NKPC

- Our equivalence result: incomplete-info dynamics satisfies

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

where \((\omega_f, \omega_b)\) needs to satisfy the restriction

\[ \omega_b = \Omega(\omega_f; \delta, \rho) \]

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

- Test whether these estimates satisfy our theory’s restriction
**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

- Is the requisite informational friction empirically plausible?

- Match inflation survey evidence as in Coibion and Gorodnichenko (2015)

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

  - with complete information, \( K = 0 \)
  - a positive \( K \) indicates correlated forecast error, which helps to pins down \( \sigma \)

- Beyond Coibion and Gorodnichenko (2015)

  - their limitation: exogenous \( \pi \Rightarrow \) could not not quantify role info friction
  - our contribution: endogenous \( \pi \Rightarrow \) fill in the gap
Test 2: Matching Evidence on Inflation Expectations

Dashed part corresponds to 90% confidence interval in Coibion and Gorodnichenko (2015)

Parameters: $\rho = 0.95, \theta = 0.6$
Quantitative Role

![Graph showing inflation over quarters]

- **Perfect info**
- **Incomplete info**
- **90% confidence interval**

Angeletos & Huo
Other Applications

1. Consumption habit
   - reconcile DSGE with smaller micro estimates of habit (Havranek et al, 2017)

2. Investment adjustment cost
   - reconcile DSGE with standard Q theory
   - and micro literature on capital adjustment cost

3. Asset pricing
   - myopia towards earnings/fundamentals at longer horizons
   - challenges literature on long run risks
   - explains more momentum at aggregate level (Jung and Shiller, 2005)
Conclusion

- A theory of myopia and anchoring
  - recast RI and HOB as behavioral distortions
  - provide micro-foundation of ad hoc DSGE add-ons
  - ease disconnect between micro and macro
  - promising quantitative potential

- Rational Expectations (evil empire?) strikes back
  - emerging literature on bounded rationality