Acquisition, (Mis)use and Dissemination of Information: The Blessings of Cursedness and Transparency

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Aggregate Information and Transparency

- Many economic situations feature
  - **Fundamental and strategic uncertainty**: value of a company, state of the economy, risk of infection
  - *Learning based on (statistics of) others' actions*: stock price, inflation, contagion

- Backing out **information about the state based on statistics of actions**
  - Information Dissemination: Piggybacks on information others acquire and use
  - Understand how the actions of others reflect their information
- This type of **inference is challenging** and agents often fail to perform it
  - Winner's curse in auctions, underinference in social learning and market games,...

Questions

- **How does this bias affect the use, acquisition and dissemination of information?**
  - Increases the use and acquisition of private information
  - Does not decrease the informativeness of the aggregative action
- **What is the impact on welfare?**
  - Mitigates the dissemination inefficiency, but introduces inefficient use
  - Cursedness is bliss
- **How does it affect the impact of transparency and other policies?**
  - Fundamental information can backfire
  - Transparency is always beneficial but not fully appropriated by cursed agents

Cursed Inference in LQN game

Workhorse LQN game, with Private Information Acquisition and

- **Aggregative Signal**
  - Information generation and dissemination
  - Transparency (policy instrument): precision of the aggregative signal
- **Cursedness (Eyster&Rabin '05)**
  - Failure to understand the link between others' private information and actions
  - Here: updating bias enabled by transparency
  - Cursed agents assess the value of information: CEE with information acquisition
- **Novel Notion of Value of Information for Biased Agents**

Related Literature

- **Use and Value of Information in LQN games**
  - Morris&Shin 02; Angeletos&Pavan 07; Colombo, Femminis&Pavan 14; Bayona 18; Vives 17
- **Misuse of Information, Mispecified Learning, Cursed Equilibrium**
  - Eyster&Rabin 05; Eyster, Rabin&Vayanos 19; Cohen&Li 23; Fong et al. 23; Bohren&Hauser 23
- **Transparency in Financial Markets**
  - Grossman&Stiglitz 80; Pagano&Roell 96; Vives 14

Model Primitives

Payoffs

- Simple beauty contest:

$$u\left(a_i, \overline{a}, \theta\right) = -\left[\left(1-r\right)\left(a_i-\theta\right)^2 + r\left(a_i-\overline{a}\right)^2\right]$$

- Unit mass of players choosing action $a_i \in \mathbb{R}$ to match an average of
    - unknown state $\theta \in \mathbb{R}$, prior $\mathcal{N}\left(0, \tau_\theta^{-1}\right)$
    - average action $\overline{a} = \int_0^1 a_i \mathrm{d}i$
    - parameter $r \in (-\infty, 1)$ parametrizes action complementarity
        - complements for $r > 0$, substitutes for $r < 0$

Information Structure

- Private signal about fundamental $s_i \sim \mathcal{N}\left(\theta, \tau_S^{-1}\right)$, τ_S later endogenous
- Public signal about fundamental $y \sim \mathcal{N}\left(\theta, \tau_y^{-1}\right)$.
- Public signal about aggregate action $p \sim \mathcal{N}\left(\bar{a}, \tau_p^{-1}\right)$
    - τ_p: *transparency parameter*
    - p is public: government statistic, news story, not private observation

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- In a linear equilibrium

$$\bar{a} = \delta_0 + \delta_1 \theta + \delta_2 y + \delta_3 p$$

- The aggregative signal p: information of *endogenous precision about θ*:

$$\widehat{\mathbf{p}} = \text{Linear Combination of Signals} \sim \mathcal{N}\left(\boldsymbol{\theta}, \frac{\mathbf{1}}{\boldsymbol{\delta_1^2 \tau_p}}\right)$$

Cursed Expectations

- **Fully cursed agents**
  - perceives no connection between other agents' actions and their information
  - Hence p is not informative about θ (conditional on (s_i, y)), so updates

$$\mathbb{E}[\theta] = \frac{\tau_y y + \tau_s s_i}{\tau_\theta + \tau_y + \tau_s}$$

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- **Partially cursed agents**
  - interior level of cursedness $\chi \in (0, 1)$
  - convex combination of **rational** and **fully cursed**

$$\mathbb{E}_\chi[\theta] = (1-\chi)\,\frac{\tau_y y + \tau_s s_i + \delta_1^2 \tau_p \hat{p}}{\tau_\theta + \tau_y + \tau_s + \delta_1^2 \tau_p} + \chi \frac{\tau_y y + \tau_s s_i}{\tau_\theta + \tau_y + \tau_s}$$

Information Acquisition

Why is Modeling Information Acquisition Tricky in this Setting?

- Endogenize τ_s: Agents acquire private information in the first stage.
- Key challenge: Discipline acquisition in setting with incorrect use.
    - *How does a cursed agent think about his welfare as a function of τ_s ex-ante?*

Information Acquisition: Desiderata

- **Understand equilibrium**: Hold aggregate variables fixed, no magical thinking
  - rules out quasi-Bayesian approach
- **Systematic mistake**: Correct beliefs about your future actions
  - rules out naive approach
- **No meta-rationality**: Do not fix your bias via information acquisition
  - rules out sophisticated approach

Subjective Envelope Condition

- True ex-ante welfare buying precision τ_s, playing $\boldsymbol{\alpha}$ against equilibrium $\boldsymbol{\delta}$ is

$$W(\boldsymbol{\alpha}, \boldsymbol{\delta}, \tau_s) = \mathbb{E}_{\boldsymbol{\alpha}, \boldsymbol{\delta}, \tau_s}\left[-\left(1-r\right)\left(a_i - \theta\right)^2 - r\left(a_i - \bar{a}\right)^2\right] - c\tau_s$$

  - Holding fixed equilibrium loading $\boldsymbol{\delta}$ (and the precision of public signals): (1)
  - Using the actual action rule $\boldsymbol{\alpha}$: (2)

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- What about (3)?
  - In the rational case, we have the envelope theorem

$$\frac{d}{d\tau_s} W(\boldsymbol{\alpha}(\tau_s), \boldsymbol{\delta}, \tau_s) = \frac{\partial}{\partial\tau_s} W(\boldsymbol{\alpha}(\tau_s), \boldsymbol{\delta}, \tau_s)$$

  - LHS: includes the influence of information acquisition on information use, which is negligible because information is used optimally

- Operationalize (3) by using

$$\frac{\partial}{\partial\tau_s} W(\boldsymbol{\alpha}(\tau_s), \boldsymbol{\delta}, \tau_s) = 0 \tag{SE}$$

Subjective Envelope: Learning Foundation

- Consider a decision maker trying to learn the optimal τ_s by an iterative process

Subjective Envelope: Learning Foundation

- Consider a decision maker trying to learn the optimal τ_s by an iterative process
- Infinitely many periods (discrete): $t \in \mathbb{N}$
  - agent picks a target precision $\bar{\tau}_t$
  - realized level of precision is given by $\tau_t = \bar{\tau}_t + \sigma\epsilon_t$
    - implementation errors $\epsilon_t \sim F([-1,1])$, symmetric, iid
- Gradient ascent towards optimal $\bar{\tau}$ using the realizations of welfare and precision

Filling in the Square

- By varying the assumptions about how the agent reacts to trembles and records welfare, we also get the classic notions

	reoptimize: $a^*(\cdot\|\tau_t)$	don't reoptimize: $a^*(\cdot\|\bar{\tau}_t)$
interim expected payoff	quasi-Bayesian	quasi-Bayesian
realized payoff	sophisticated	subjective envelope

- Our notion is arguably the simplest
  - Doesn't require recalculating the action rule
  - Doesn't even require a well-specified interim belief
- Generalizes to situations where action rule comes from black-box algorithm
  - Assumption: Agent believes that it is approximately optimal

χ-CEE-IA

Definition (χ-Cursed Expectations Equilibrium with Information Acquisition)

A tuple $(\boldsymbol{\delta}, \tau_s)$ constitutes a $\chi-$*CEE-IA* if

1. $\boldsymbol{\delta}$ is a best response under expectations $\mathbb{E}_\chi$ given $\boldsymbol{\delta}$, and
2. $(\boldsymbol{\delta}, \boldsymbol{\delta}, \tau_s)$ satisfy (SE).

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Theorem

For all χ, a $\chi-$CEE-IA exists and is unique; non-degeneracy requires $\sqrt{c} < \frac{1-r}{\tau_\theta+\tau_y}$.

Positive Results

Information Acquisition and Use

- **Increased cursedness:** use more private and public fundamental information and less aggregative information.

$$\boldsymbol{\frac{\partial \delta_1}{\partial \chi} > 0}, \qquad \frac{\partial \delta_2}{\partial \chi} > 0, \qquad \frac{\partial \delta_3}{\partial \chi} < 0, \qquad \frac{\partial \tau_s}{\partial \chi} > 0$$

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- **Endogenous precision** of aggregative signal: increasing in χ and τ_p

$$\frac{\partial \delta_1^2 \tau_p}{\partial \tau_p} > 0, \qquad \frac{\partial \delta_1^2 \tau_p}{\partial \chi} > 0,$$

Informational Efficiency

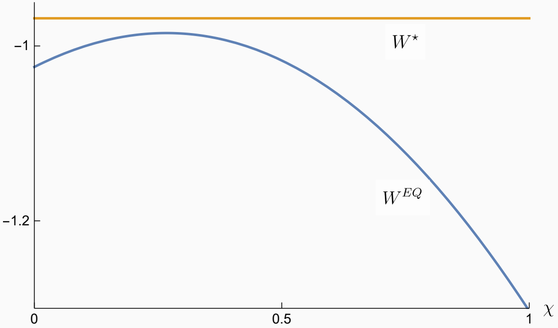
- Comovement of aggregate action and the state

$$\mathrm{Cov}\left(\theta, \overline{a}\right) = 1 - \frac{\sqrt{c}\tau_\theta}{1-r}$$

  - **Invariant in χ and τ_p**: Processing bias doesn't reduce informational efficiency
  - **"Naive" traders don't just inject noise, they also inject private information!**

Welfare

Cursedness is Bliss



- EQ never efficient: too little dissemination ($\chi = 0$), inefficient use ($\chi > 0$)
- Local to the rational equilibrium, an increase in cursedness means
  - More (efficient) information dissemination (first order gain at $\chi = 0$)
  - Less efficient information use (second order loss at $\chi = 0$)
- **(Individual) Cursedness is a (collective) blessing**

The Impact of Information Policies: Fundamental Information

- Lower acquisition costs and more precise fundamental information can backfire!
- Higher public fundamental information ($\tau_y \uparrow$) means
  1. Environment is more informative: beneficial
  2. **Substitution away from** p: loss for cursed agents (already underused).
- Second effect can dominate at interior χ (for r sufficiently large)
  - "Paradoxical" policy comparative statics emerge because of **partial cursedness**

The Impact of Information Policies: Transparency

- Cursed agents undervalue the aggregative signal, yet only unambiguously positive welfare effect
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- Reason: $\delta_1^2 \tau_p$ increases in τ_p (while it decreases in c, τ_y)

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- Reason: $\delta_1^2 \tau_p$ increases in τ_p (while it decreases in c, τ_y)
- If agents **undervalue** (but not completely disregard) a **source of information**, the **only unambigously beneficial policy** is **increasing the informativeness** of this very source
  - otherwise, problematic substitution effects
  - safe vs effective policy?

Conclusion

Questions And Answers

- **How does this bias affect the use, acquisition and dissemination of information?**
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Back to Information Acquisition

- Subjective Envelope
  - reasonable
  - tractable
  - and it doesn't matter
- We also consider the quasi-Bayesian setting
  (= integrating interim subjective welfare with true signal distribution)
  - only numerical
  - same qualitative results on welfare and policy

Thank You!

Li and Cohen in Our Setting

- Can embed our game to the setting of Cohen&Li '23
  - choose τ_s, observe s_i, y, submit a demand function $a_i = \alpha_0 + \alpha_3 p$
- Fully cursed sequential equilibrium:
  - ex-ante: $\bar{a} = 0$ deterministically!
  - acquire information according to this belief
  - ex-interim: $\bar{a} = \alpha_1 \mathbb{E}[\theta | s_i, y] + \alpha_2 y$ deterministically!

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  - ex-interim: $\bar{a} = \alpha_1 \mathbb{E}[\theta | s_i, y] + \alpha_2 y$ deterministically!
- This is how it has to be
  - cannot expect that others will react to their signals
  - cannot expect that I will believe so based on my future information
  - otherwise, we could just add a superfluos stage at the end to break cursedness
- Still, I don't think it fits our applications well