Does Public Information Help Social Learning?

An Anti-Transparency Result

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Introduction

- It is well known that social learning generates herds and/or information cascades
  - People herd when (bounded) private information is outweighed by public observations
  - Consequently no more private information is revealed and social learning stops
- *Bikhchandani et al. (1992)*: cascades/herds are nevertheless "fragile" as social learning stops
  - Extra public information might break cascades and reinstate learning
- It leads to a question on *public information policy* in such contexts
  - If extra information is indeed achievable (through external tests or experimentations), should it be revealed publicly?
  - *e.g.*, schedule of public debates during presidential elections

Findings

- The question is modelled, in a "$2 \times 2 \times 2$" social-learning model, as a planner's decision on information disclosure to improve social learning
  - A simple canonical setting with binary states, actions, and signals
- Main result - *anti-transparency*: noisy public information hurts social learning and hence should not be revealed
- An "$2 \times 2 \times \infty$" extension with continuous private signals is considered to investigate the threshold on the informativeness of public information for anti-transparency
  - lower threshold than the average informativeness of private signals
  - no threshold under certain information structures of private signals

Literature

- Social learning: *Banerjee (1992), Bikhchandani et al. (1992), Smith&Sørensen (2000), etc.*
  - Conventional focus on whether learning is complete (long-run efficiency), or whether herding exists (behavior implication)
    - Based on a variety of settings: preferences, information structures, observation structures, *etc.*
  - We have a similar objective but consider the effect of public experimentation or information disclosure in such contexts
- Anti-transparent information policy: *Morris&Shin (2002), Morris et al. (2006), Svenson (2006), etc.*
  - Public information as a coordination device when payoffs have social-value terms
  - No payoff externality but *information externality* in social learning

Canonical Binary Setting

- An infinite number of agents, $t \in \{1, 2, \dots\}$, sequentially make a binary choice $a_t \in \{A, B\}$
- An underlying state of the world $\theta \in \{A, B\}$ with uniform prior
- Every agent t receives a conditionally i.i.d. signal s_t with commonly known precision q
  - $\Pr(s_t = \theta | \theta) = q \in (\frac{1}{2}, 1)$
- Every agent t makes his choice after receiving s_t and observing action history $\mathbf{h}_t = (a_1, a_2, \cdots, a_{t-1})$
  - Everyone is assumed to follow their own signal when indifferent
- Every agent t's payoff is $U_t(a_t; \theta) = 1_{\{a_t = \theta\}}$

Planner's Problem

- A social planner can choose a period $\tau \in \{1, 2, \ldots\}$ to run a public test or experiment, which generates an extra signal $\widetilde{s} \in \{A, B\}$
  - $\widetilde{s}$ has commonly known precision $\widetilde{q} \in (\frac{1}{2}, 1)$
  - Alternative interpretation: the planner knows $\widetilde{s}$ and commits a calendar time τ to disclose it
- The social planner's objective is to improve social learning
  - As actions converge eventually, she wants to maximize $\Pr(\lim_{t\to\infty} a_t = \theta)$
    - In line with the common objective of long-run efficiency in the literature
  - Utilitarian social welfare: $\lim_{T\to\infty} \frac{\sum_{t=1}^{T} U_t(a_t;\theta)}{T}$

Main Result

- Define 'relative precision' $\lambda \equiv \log_{\frac{q}{1-q}}\left(\frac{\widetilde{q}}{1-\widetilde{q}}\right)$
  - The public signal is as powerful as λ private signals with the same realization, in terms of informativeness
- Let $V(\tau;\lambda) \equiv \Pr(\lim_{t\to\infty} a_t = \theta \,|\, \text{setting the test at } \tau)$
  - $V_0 \equiv \frac{q^2}{(1-q)^2+q^2}$ is the long-run efficiency without the test

Proposition (Anti-transparency)

1. $V(\tau;\lambda) < V_0$ *for any* $\tau \geq 1$ *if and only if* $\lambda < 1$.
2. $V(\tau+1;\lambda) \geq v(\tau;\lambda)$ *for any* $\tau \geq 1$ *and any* $\lambda > 0$.

Discussion

- Anti-transparency: a public experiment generating noisy information is suboptimal
  - No reinstatement - cannot not break cascades
  - Crowding out - leads to a worse cascade with higher probability than a private signal
- Patience: the planner should aim to postpone a public experiment
  - The planner does not have time preference (utilitarian objective)
  - The benefit of information disclosure is at largest when a cascade starts
  - The probability of a cascade is (weakly) increasing over time

Contingent Disclosure

- Suppose now that the social planner's decision is contingent on the realization of $\widetilde{s}$ and the existing history

$$g_t = g(\mathbf{h}_t, \widetilde{s}) \in \{Y, N\}$$

- Refinement on off-equilibrium beliefs by the agents - *"non-excessive"*
  - When the planner is supposed to reveal $\widetilde{s}$ unconditionally at a certain period but did not reveal anything after all, the agents do not make any inference about $\widetilde{s}$
- The social planner's objective is to maximize $\widehat{V}(g; \lambda)$

Proposition (Contingent disclosure)

Under non-excessive beliefs, contingent disclosure does not do better than simple calendar timing: $\max_\tau V(\tau; \lambda) = \max_g \widehat{V}(g; \lambda)$. *In particular, anti-transparency still holds.*

Continuous Signals

- Suppose now that every agent t receives a signal $s_t \in [-1, 1] \subset \mathbb{R}$
  - Conditional on θ, s_t is i.i.d. $\sim F_\theta$
  - Interpretation: heterogeneous informativeness among the population
- F_θ is twice differentiable with strictly positive density f_θ on $[-1, 1]$
  - MLR: $\frac{f_B(s)}{f_A(s)}$ is (strictly) increasing on $[-1, 1]$
  - Symmetry (not crucial): $f_B(s) = f_A(-s)$
- Consider the private belief generated by signal s_t: $\mu(s_t) = \ln \frac{f_B(s_t)}{f_A(s_t)}$
  - Average informativeness: $\overline{\mu} = \frac{\int_0^1 \mu(s) f_B(s) d(s)}{\int_0^1 f_B(s) d(s)} \left(= \frac{\int_{-1}^0 \mu(s) f_A(s) d(s)}{\int_{-1}^0 f_A(s) d(s)}\right)$
- Extra signal $\widetilde{s} \in \{A, B\}$ has informativeness $\lambda = \ln \frac{\Pr(\widetilde{s}=\theta|\theta)}{\Pr(\widetilde{s}\neq\theta|\theta)} > 0$
- Restrict attention on the case of calendar timing: $\widetilde{V}(\tau; \lambda)$
  - $\widetilde{V}_0$ denotes the planner's payoff without any disclosure

No Anti-Transparency

- The signal distributions satisfy (strictly) *increasing hazard ratio (IHR)* property if

$$H(s) \equiv \frac{1-F_A(s)}{1-F_B(s)} \frac{f_B(s)}{f_A(s)} \text{ is (strictly) increasing on } (-1,1)$$

  - Identified by *Horner&Herrera (2013)* for no information cascades
  - Refined by *Smith et. al. (2021)* as **(strictly) log-concave** density of the distribution of log-likelihood ratio

Proposition (No Anti-transparency)

1. If strictly IHR property holds, $\forall \lambda > 0, \exists \tau \geq 1$ *s. t.* $\widetilde{V}(\tau;\lambda) > \widetilde{V}_0$.
2. If $\exists \widehat{\lambda}$ *s. t.* $\forall \tau \geq 1, \forall \lambda < \widehat{\lambda}, \widetilde{V}(\tau;\lambda) \leq \widetilde{V}_0$, *then* $\widehat{\lambda} < \overline{\mu}$.

- No anti-transparency under IHR (Log-concavity)
  - No cascades $\Longrightarrow$ No anti-transparency
- The threshold for anti-transparency is lower than the average informativeness of the population

Concluding Remarks

- This paper studies the effect of public information disclosure in the context of social learning
- It is not necessarily true that "more information is better"
  - Noisy public information is bad for social learning and should be banned
  - Unless private signals are continuous and exhibit IHR property
- It is not true either that "sooner is better"
  - Postponing information disclosure is good for social learning
  - Unless time preference exists or action space becomes richer
- Possible extensions:
  - Multiple pieces of information
    - Should not affect any asymptotic result
  - Information disclosure by a biased planner

Last But Not Least

THANK YOU!