Participation and endogenous communication costs: 
Why crowds may not be wise

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A Puzzle

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- “Diversity premium”
Gender diversity in management teams is inversely correlated with performance of mutual funds; there is no detectable difference, on average, between funds run only by men and those managed only by women. Both types of single-sex teams outperformed funds run by teams containing both men and women, on average, regardless of the exact makeup of the mixed team.

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- Spiral of silence (Noelle-Neumann, 1974, 1993)
A clue?

- Diversity and maverick opinions are important for information aggregation
  - Wisdom of crowds, diversity premium
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A clue?

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- Yet, mavericks are not always popular.
  - Spiral of silence
- What do you do when you have a deviant opinion?
This Talk:

- Diversity in perspectives can lead to superior performance.
- Yet, it sometimes fails to do so.
- Possible explanation: **communication costs**.
  - costs are *endogenous*
Outline

Introduction

Accuracy vs Communication Costs

Model

Wise crowds?

Discussion
(Surowiecki, 2004)
Wisdom of Crowds

(Surowiecki, 2004)

**(Strong Law of Large Numbers)** Let $X_1, X_2, \ldots$ be a sequence of independent and identically distributed random variables on some probability space $(\Omega, \mathcal{F}, \mathbb{P})$. Then, when $k \to \infty$,

$$
\frac{1}{k} \sum_{\ell=1}^{k} X_{\ell} \xrightarrow{a.s.} x \quad \text{for some } x \in \mathbb{R}
$$

if and only if $\mathbb{E}[|X_1|] < \infty$. In that case, $x = \mathbb{E}[X_1]$. 
Wisdom of Crowds (2)

Basically: if enough people submit their bets, then the average will be close to the true weight.
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- representative sample
Spiral of silence (Noelle-Neumann, 1974, 1993)

A person is less likely to voice an opinion if he feels that he is in the minority for fear of reprisal or isolation from the majority.

▶

Dynamic process:
Predictions about public opinion ⇝ fact/status quo ⇝ minority less likely to speak out (Miller 2005).
Spiral of Silence: A person is less likely to voice an opinion if he feels that he is in the minority for fear of reprisal or isolation from the majority.

- Dynamic process:
  Predictions about public opinion \(\leadsto\) fact/status quo \(\leadsto\) minority less likely to speak out (Miller 2005).
Tradeoff

Hence, interested in setting where agents tradeoff communication costs and estimation loss.

- to improve accuracy/reduce estimation loss, agents want to communicate;
- because of communication loss, agents are hesitant to communicate.

- No manipulation/lying.
- If agents would freely share their information, then crowds will be wise.
Simple Model (1)

- The state of the world is a random variable $\theta$ with a commonly known distribution on $\mathbb{R}$.
  - stock return, fundamentals of the economy, weight of an ox.
- Each agent $i$ receives a noisy signal $\theta_i$ on the state:
  \[ \theta_i = \theta + \epsilon_i \]
- Signals are conditionally independent given the state.
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Each agent $i$ receives a noisy signal $\theta_i$ on the state:

$$\theta_i = \theta + \epsilon_i$$

Signals are conditionally independent given the state.

Law of large numbers/ wisdom of crowds logic holds if all agents share their information.
Suppose agents can choose to share their information or not ($S/NS$).
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Assume they choose their action *strategically*.

- **Strategy**: function from set of signals $\mathbb{R}$ to $\{S, NS\}$. 

Agents care about:

- **Estimation loss/accuracy of their estimate**
  - want to share information
  - relative weight $\gamma \in [0, 1]$

- **Communication costs**
  - hesitant to share information
  - relative weight $1 - \gamma$

Hence, the goal of agent $i$: Choose $\alpha_i : \mathbb{R} \rightarrow \{S, NS\}$ to minimize

$$
costs_i(\alpha_i, \alpha_{-i}; \theta_i) = \gamma E[\text{Estimation loss}(\alpha_i(\theta_i), \alpha_{-i}) | \theta_i] + (1 - \gamma) E[\text{Communication costs}(\alpha_i(\theta_i), \alpha_{-i}) | \theta_i]
$$

for each $\theta_i$, given strategies $\alpha_{-i}$ of others.
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Simple model (4)

Estimation error when your signal is $\theta_i$ and you have $k$ signals from other agents:

$$\mathbb{E} \left[ (\Theta - \hat{\Theta}_{\Theta_i, \Theta_{j_1}, \ldots, \Theta_{j_k}})^2 \mid \Theta_i = \theta_i \right]$$

NB: depends on the strategies $\alpha_{-i}$ of others.

▶ in particular, may only receive biased signals
Simple model (5)

Communication costs when signal is $\theta_i$ and you communicate with $k$ others:

$$k \cdot \mathbb{E}[(\Theta_i - \Theta_j)^2 \mid \Theta_i = \theta_i]$$

- Depends on signal $\theta_i$: mavericks generally face higher communication costs.
- Depends also on strategies of others
  - in particular, if only non-mavericks communicate, then communication very costly for mavericks.
A strategy profile \((\alpha_i)_{i \in N}\) is a (Bayesian-Nash) equilibrium if for each agent \(i\), the strategy \(\alpha_i\) minimizes the (expected) costs of \(i\) for each signal \(\theta_i\) given \(\alpha_{-i}\).

That is, no agent can gain by deviating given the strategies of others.
The strategy profile in which each player always chooses NS regardless of his signal is always an equilibrium.

- No communication.
- No information aggregation.

**Intuition:** it is useless to communicate if no one else communicates.
There is full information sharing if and only if \(1 - \gamma = 0\).

- Crowds can only be wise if \(1 - \gamma = 0\).
Results (2)

There is full information sharing if and only if $1 - \gamma = 0$.

- Crowds can only be wise if $1 - \gamma = 0$.

**Intuition:**
Suppose $1 - \gamma = 0$, then agents can only gain by sharing information.
Suppose $1 - \gamma > 0$, then communication costs grow without bounds for mavericks, while accuracy gain is limited.
No full information sharing when $1 - \gamma > 0$
So,

- nobody sharing their information is always an equilibrium;
- everybody sharing their information is an equilibrium only if there are no communication costs \((1 - \gamma = 0)\).

Are there also equilibria with partial information sharing when there are costs to communication \((1 - \gamma > 0)\)?

- ... or do we get complete unraveling?
If communication costs need to be taken into account \((1 - \gamma > 0)\), then mavericks will not share their information. Communication costs prohibitively high.
Unraveling & Spiral of Silence

- If communication costs need to be taken into account \((1 - \gamma > 0)\), then mavericks will not share their information.
  - Communication costs prohibitively high.
- If the true mavericks drop out, others who have more moderate signals, will now feel that they are the mavericks.
- Hence, communication costs will be so high that they decide not to share their information/
- ...

Wise crowds?
If communication costs need to be taken into account ($1 - \gamma > 0$), then mavericks will not share their information. Communication costs prohibitively high.

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Hence, communication costs will be so high that they decide not to share their information.

Is there an equilibrium in which there is only partial unraveling, i.e., in which some agents still share their information?
Partial information sharing

Theorem
There exists $\gamma < 1$ such that for all $\gamma \geq \gamma$ there is $T > 0$ such that there is an equilibrium in which agents share information if and only if their signal is within $T$ of a priori expected state $\bar{\theta}$.

Intuition:

- for players with signals close to expectation, communication costs will be low (given strategies of others) while their estimation loss decreases when they communicate.

- for players with extreme signals, communication costs will be prohibitively high (given strategies of others).
Crowds are not wise in this equilibrium
- biased sample

Externality $\leadsto$ inefficiency
- Private costs $\leftrightarrow$ social benefits

Fragile equilibrium?
- Outcome of unraveling dynamics?
Making it Work

- Capping diversity can help
- Changing the game
  - physical environment affects costs and benefits
  - reward bridges
- identity multi-dimensional and dynamic