# Eliciting Informative Feedback: The Peer-Prediction Method

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# The Problem

Get honest informative feedback from users.

- E.g. eBay, NetFlix, Amazon, ePinions, Zagat.
- Users may be too nice, fear retaliation, or have conflicts of interest.
- The truth is never observed (doesn't exist or can't be observed).

# Model Setup

- Product is type $t \in \{1, \cdots, T\}$ with common prior $p(t)$.
- Risk-neutral rater $i \in I$ receives noisy signal $S^i \in S = \{s_1, \cdots, s_M\}$.
- $f(s_m|t) := \Pr(S^i = s_m|t)$ is common to all agents and known to the center.
- Announcement of agent $i$ is $a^i \in S$. Denote rater $i$'s announcement when she receives $s_m$ as $a^i_m$.
- $\tau_i(a_1, \cdots, a_I)$ is rater $i$'s payoff given everyone's announcement.

# Regularity Condition

## Definition

A random variable $X$ is **stochastically relevant** for a random variable $Y$, if, for every $x \neq \hat{x}$,

$$\Pr(Y = y|X = x) \neq \Pr(Y = y|X = \hat{x})$$

for some $y$.

We assume that $S^i$ is stochastically relevant for $S^j$ for all $i \neq j$.

# Problems with Setup

- $f$ is common to all agents and known to the center.
- Common (objective) types.
- Common prior beliefs about the type.
- External disincentives for honesty are not modelled.

# Initial Game

- Players each observe a noisy signal and then simultaneously announce.
- $g(s_x^j | s_y^i) = \Pr(S^j = s_x | S^i = s_y) \forall i \neq j$ .
- Let $R(\cdot|\cdot) : S \times S \to \mathbb{R}$ be a proper scoring rule.
- e.g. $R(s_n^j | a^i) = \log(g(s_n^j | a^i))$.
- Their proposal: $\tau_i^*(a^i, a^{r(i)}) = R(a^{r(i)} | a^i)$, where $r : I \to I$ such that $r(i) \neq i$.

# Proposition 1

## Theorem (Proposition 1)

*For any admissible $r$ and $R$, truthful reporting is a strict Nash equilibrium for the simultaneous game with $\tau = \tau^*$.*

# So what?

In the simple two-player two-type case with log scoring and $p(H) = p(L) = 0.5$, $p(h|H) = 0.85$, and $p(h|L) = 0.45$ we have the following payoffs.

| | h | l |
|---|---|---|
| h | $-0.34, -0.34$ | $-1.2, -0.62$ |
| l | $-0.62, -1.2$ | $-0.77, -0.77$ |

The expected payoff for being honest is $-0.63$.

# Effort

Suppose obtaining a signal is optional and has fixed cost $c > 0$.

## Theorem (Proposition 2)

*There exists $\alpha > 0$ such that for $\tau(a^i, a^{r(i)}) = \alpha R(a^{r(i)}|a^i)$, there exists a Nash equilibrium where all players are acquiring signals and reporting honestly.*

Problem: No one acquiring signal, and everyone announcing the same thing is a Nash equilibrium (probably Pareto-improving).

# Participation and Budgeting

- We need to add a constant to the payoffs $\tau_i$ to ensure that it is worthwhile to participate.
- The center wants to balance his budget. He wants to cancel out the variability in the sum of payoffs.
- Set $\tau_i(a) = \tau_i^*(a) - \tau_{b(i)}^*(a)$, where $b : I \to I$ satisfies $b(i) \neq i$ and $b(i) \neq r(i)$.
- This adds variabilty to everyone's payoffs. The center must pay a risk premium.

# Sequential Game

- Play the game sequentially with perfect information. This is more realistic.
- Need to update priors (assuming truthfulness).
- Either infinite players or the game ends in a simultaneous sub-game.
- Still has the problem of multiple equilibria, and with improved coordination.

# Other Extensions

- Continuous signal space.
- Normally distributed noise.
- Coarse reports.

# Implementation Issues

- Risk aversion.
- Choosing a scoring rule.
- Estimating types, priors, and signal distributions.
- Taste differences.
- Noncommon priors, private information.
- Collusion.
- Multi-dimensional signals.
- Trust in the system.

# Suggestions

- Align user incentives with the company's. Payoff depends on profit. Users want to preserve company's reputation.
- Punish regularity systematically. Add collusion-resistance mechanisms.
- This sort of game seems well-suited to experimental validation.
- Multiple reference raters to reduce variability.

# Conclusion

- It still depends on a certain level of honesty in the user population.
- It doesn't deal well with differences between users.
- This paper got the ball rolling.
- Are there impossibility results?

# Experiment

- Sequential
- Two types H and L and two corresponding signals h and l.
- Prior $p(\mathsf{H}) = p(\mathsf{L}) = 0.5$.
- Conditionals
  - $\Pr(\mathsf{h}|\mathsf{H}) = 0.85$
  - $\Pr(\mathsf{l}|\mathsf{H}) = 0.15$
  - $\Pr(\mathsf{h}|\mathsf{L}) = 0.45$
  - $\Pr(\mathsf{l}|\mathsf{L}) = 0.55$
- Natural logarithm scoring.