Viral Social Learning

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Motivation: idea/product that spreads like a virus

Example 1: job-market papers

- Hiring committees learn about JMPs socially, as well as in applications
- For a committee member: not knowing a paper prior to interview season is a bad signal
- For a candidate: when to publish JMP matters

Motivation: idea/product that spreads like a virus

Example 2: influencer marketing

- Customers find out new products from others' adoption
- If a better product is adopted faster, seeing it early is a good signal
- Viral campaign vs. advertising campaign for producer

This paper

Questions

- Demand side: lifecycle of viral diffusion?
- Supply side: is a viral campaign optimal? For how long? Does it facilitate quality improvement?

Novelty of problem

- Endogeneity of awareness and action sequence
- Time-varying inference affected by producer's strategy

Literature

Classical models of social learning

- Foundation: Bikhchandani et al. (1992), Banerjee (1992), Smith and Sorensen (2000)
- Extensions: Banerjee (1993), Celen and Kariv (2004), Acemoglu et al. (2011), Song (2016)

SIR model of viral transmission

- Theory: Kermack and McKendrick (1927, 1932, 1933)
- Applications: Newman (2002), McAdams (2017a,b)

Other works on viral marketing and competitive contagion

- Kempe et al. (2003, 2005), Mossel and Roch (2010)
- Goyal et al. (2014)

Basic structure

One product with uncertain quality

- Quality $\omega \in \{g, b\}$, with probability $\alpha \in (0, 1)$ and $1 - \alpha$
- Sells at price $p \geq 0$
- Good product has value $\bar{u}$, bad product $\underline{u}$, assume $p = \frac{\bar{u}+\underline{u}}{2}$

A unit mass of consumers

- Each has a unit demand
- At $t = 0$ of a continuous time line, a small $\Delta > 0$ fraction of consumers are exposed to the product

Independent private signals

- Consumer i sees $s_i \in \{G, B\}$ upon exposure
- $Prob(s_i = G|g) = Prob(s_i = B|b) = \rho \in (\frac{1}{2}, 1)$

Viral transmission

Three types of consumers

- Susceptible: $S_\omega(t)$. $S_\omega(0) = 1 - \Delta$
- Infected (adopting product): $I_\omega(t)$
- Recovered (not adopting product): $R_\omega(t)$

Transmission rule

- Each infected consumer meets other consumers randomly at rate $\beta > 0$
- $S_\omega(t)$, $I_\omega(t)$ and $R_\omega(t)$ are determined dynamically by

$$
\begin{aligned}
I'_\omega(t) &= \beta I_\omega(t) S_\omega(t) p_\omega(t) \\
R'_\omega(t) &= \beta I_\omega(t) S_\omega(t)(1 - p_\omega(t)) \\
S'_\omega(t) &= -\beta I_\omega(t) S_\omega(t)
\end{aligned}
$$

where $p_\omega(t)$ is the probability of adoption given ω.

Belief evolution

Upon awareness at t, a consumer's *interim belief* $q(t;\emptyset)$ is characterized by

$$\frac{q(t;\emptyset)}{1-q(t;\emptyset)} = \frac{\alpha I_g(t)S_g(t)}{(1-\alpha)I_b(t)S_b(t)}.$$

Hence, her *posterior beliefs* are

$$q(t;G) = q(t;\emptyset)\frac{\rho}{\rho q(t;\emptyset)+(1-\rho)(1-q(t;\emptyset))}$$

$$q(t;B) = q(t;\emptyset)\frac{1-\rho}{(1-\rho)q(t;\emptyset)+\rho(1-q(t;\emptyset))}.$$

Consumer's decision

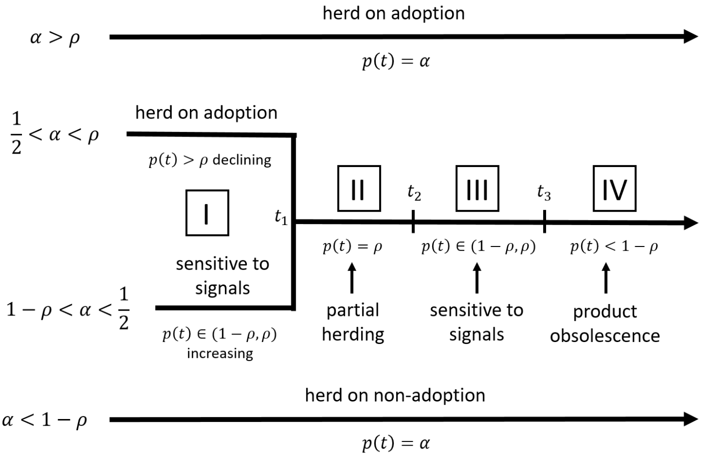
A consumer will

- *Herd on adoption* if $q(t; \emptyset) > \rho$
- *Be sensitive to signals* if $q(t; \emptyset) \in (1 - \rho, \rho)$
- *Herd on non-adoption* if $q(t; \emptyset) < 1 - \rho$

$q(t; \emptyset) = \rho$ or $1 - \rho$: to be discussed later.

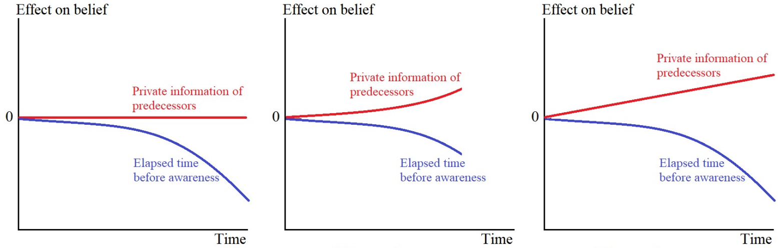
Result 1: lifecycle

Unique equilibrium



Result 1: lifecycle

Two forces on consumer belief



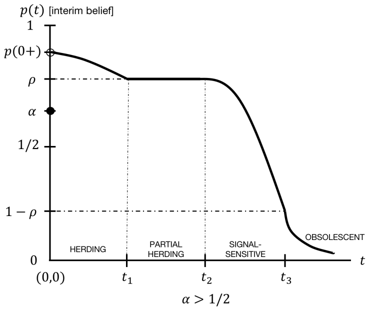
When predecessors herd on adoption

When predecessors use a mixed strategy

When predecessors are sensitive to signals

Result 1: lifecycle

Belief evolution



Implications of consumer equilibrium

With viral social learning:

- True quality remains unrevealed
- Product obsolescence always occurs
- Behavior of product reputation and adoption likelihood are sensitive to initial beliefs
  - High $\alpha \rightarrow$ both are monotone in time
  - Low $\alpha \rightarrow$ neither is monotone in time

Result 2: robust occurrence of viral campaign

A model with endogenous campaign choice

- Nature draws quality $\omega \in \{g, b\}$ with distribution $(\alpha, 1 - \alpha)$
- Producer's choice (before knowing quality): $t = T$ to stop viral campaign and switch to advertising campaign

Trade off in a viral campaign

- Some adoption given bad signal
- Long viral campaign $\rightarrow$ no adoption in advertising campaign

Result 2: robust occurrence of viral campaign

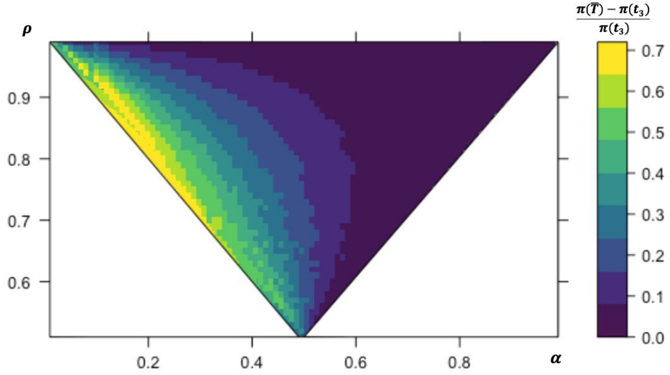
Theorem

The earliest optimal stopping time T^* is always positive.

- Belief from advertising campaign is below α, and decreases in T
- Always better to allow some viral spread
- Two possibilities of exact optimum
  - Stop in the middle → consumers with good signal buy from advertising campaign
  - Never stop → no one buys from advertising campaign

Result 2: robust occurrence of viral campaign

Numerically, stopping in the middle is almost always optimal.



Result 3: Goldilocks effect

A model with endogenous campaign choice + quality choice

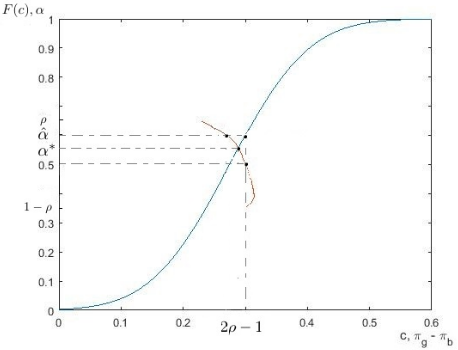
- Firm commits to marketing strategy: begin with viral campaign and switch to advertising campaign at $t = T$
- Firm observes cost $c > 0$ to improve quality
- $c \sim F(c)$ on $[0, \bar{c}]$

If there were no viral campaign, the market equilibrium induces a fraction $\hat{\alpha} = F(2\rho - 1)$ of good quality firm.

Result 3: Goldilocks effect

Proposition

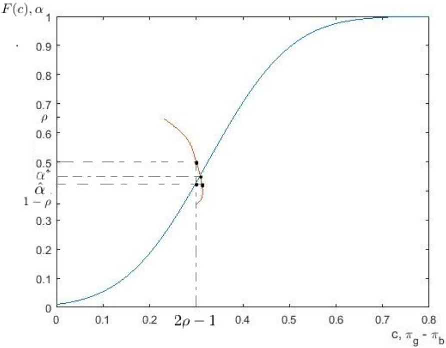
Suppose that $\hat{\alpha} \in [\frac{1}{2}, \rho)$. A market equilibrium always exists, and in every market equilibrium, $\alpha^* \leq \hat{\alpha}$. The inequality is strict if $\hat{\alpha} > \frac{1}{2}$.



Result 3: Goldilocks effect

Proposition

Suppose that $\hat{\alpha} \in (1-\rho, \frac{1}{2})$*. In every market equilibrium with profitable advertising campaign,* $\alpha^* > \hat{\alpha}$*.*



Extensions

Several topics for future research:

- Pricing
- Temporary infectiousness
- Option to wait
- Reversible adoption decisions