Herd Behavior, the "Penguin Effect," and the Suppression of Informational Diffusion: An Analysis of Informational Externalities and Payoff Interdependency.

by Jay Pil Choi, *RAND Journal of Economics*, Autumn 1997.

I. Introduction

Some economic activities that produce payoff-relevant information as a byproduct:

1- The quantity sold that results from a certain price

2- The qualities of a drug

3- Learning-by-doing production produces information about the learning process and thereby affects the efficiency of future production.

What happens if the payoff of an individual is affected significantly by the actions of others?

This paper addresses this phenomenon (informational spillover) in the context of irreversible technology choice with network externalities.

Assumptions:

(these will apply throughout the entire paper except where noted)

There are 2 new technologies available for adoption.

No one knows what a technology's value is until one person adopts it, and then everybody knows.

(Each individual can only adopt one technology; it cannot change its technology once it has adopted something)

First case (bottom of p408)

Suppose there are 100 people (P1, P2, ... P100), and 2 technologies: A and B.

P1 chooses A $\rightarrow$ The value of A (V_A) is known.

Consider P2's dilemma:

What does P2 know about the value of B (V_B) ?

If P2 knows (or strongly suspects) that $V_B > V_A$, he should choose B.

What if P2 does not know anything about V_B?

His information is only that P1 chose A, and so he will choose A also.

"Thus B may never be adopted by anybody, and a bandwagon for A can develop almost preemptively."

People adopt the strategy "Let someone else be the guinea pig."

Nobody experiments with the new technology.

Even for risk-neutral users, there is a bias in the first choice toward a safer technology.

Individually optimal behavior is socially subotpimal.

The example of modems.

The article relates to 2 strands of literature: herd behavior and network externalities

Herd Behavior

examples: Banerjee (1992), Bikchandani/Hirshleifer/Welch (1992), Scharfstein/Stein (1990)

Differences between this model (Choi) and Banerjee and B/H/W:

1- "In their models, herd behavior stems from each agent's effort to free-ride on information contained in the decisions already made. In my model, prevention of the adoption of an untested technology is instead driven by each agent's desire to inhibit the revelation of new information to the followers who can use the newly revealed information in a way that is detrimental to the creator of the information." (p410)

2- In the Choi article, informational externalities operate both forwards and backwards.

3- Other minor differences (p410)

Scharfstein and Stein (1990): A model in which investment managers receive private signals that are correlated across agents, which results in herding, rationalized by the "sharing-the-blame" effect.

Network Externalities Literature

Saloner (1985) has a model in which uncertainties about other individuals' preferences results in a "bandwagon" or "excess inertia."

Rob (1991) considers the entry process into a new industry with demand uncertainty. Due to informational externalities, the equilibrium rate of entry is lower than that which is socially optimal. Unlike Choi's model, there is no strategic interaction among agents.

II. The sequential-choice model

A more formal specification of the model previously mentioned.

There are N risk-neutral users/consumers.

There are 2 technologies: A and B.

Consumers are indexed according to their order of choice, and a consumer cannot delay his choice.

"Each consumer has the same valuation for ech technology that exhibits network externalities"

Network externalities create positive payoff interdependency: the more people adopt the same technology, the more valuable it is.

Interim payoffs are ignored.

Benefit of choosing A: $\alpha + v_n$ where n=number of people choosing A.

Benefit of choosing B: $\beta + v_n$ where n=number of people choosing B.

α and β can be interpreted as the intrinsic benefit of A and B, respectively.

v_n can be interpreted as the positive network benefit, which is increasing in n.

Assume $v_1 = 0$.

As mentioned before, as soon as a person chooses a technology, the value of that technology is revealed to everyone.

As before, the adoption of technology is irreversible.

III. The Equilibrium Decision Rule

Benchmark case: no externalities. (trivial)

P1 will choose the technology with the higher expected value.

Suppose P1 chooses A→ α is known.

P2 will choose the technology with the higher expected value:

If E(B)¿α, P2 chooses B. If not, P2 chooses A.

"For the values of the technologies to be fully disclosed in the decentralized adoption game in equilbrium, the first two users have to select different technologies." This property carries over when there are network externalities because "with network externalities, P2 has a stronger incentive than any of her followers do to adopt a technology different from the predecessor's."

(Possible contradiction here: if P1 chooses based off expected value, you must be allowing for there to be some information or signal of some kind, so it seems like it's possible that, say, P1 and P2 choose A, while P3 has some information that makes him think $\beta > \alpha$.)

Remember- the second user has the strongest incentive to try a new technology.

It will be shown that there is a bias against the new technology.

The reason is not a pre-existing base of old-technology-users (an "installed base") but the "fear of being stranded by future users."

The installed-base effect will dominate much later in the chain.

This argument can be made more precise by using a backward-induction argument.(p412-413)

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Proposition 1

Suppose that the first user adopted technology A, the value of which turned out to be α. The condition for the second user to adopt technology B is given by

(1) $E(\beta) - \alpha > [v_N - v_{N-1}] + G(\alpha)v_{N-1}$

$[v_N - v_{N-1}]$ is the "installed-base disadvantage."

$G(\alpha)v_{N-1}$ is the "fear of being left out."

where $G(\alpha)$ is the distribution of α.

If the LHS and RHS of (1) are equal, the value of α can be interpeted as a value at which user 2 is indifferent between experimenting with the new technology B and sticking to A. Since the LHS is decreasing in α and the RHS is increasing in α, this value is unique.

The degree to which the LHS does not equal the RHS of (1) can be interpreted as the bias against experimenting with a new technology.

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"The fear of being left out, rather than the disadvantage of the installed base, is largely responsible for the bias against adopting a new technology with uncertain value."

An Increase in Uncertainty about the New Technology

(represented by a mean preserving spread of $G(\beta)$)

The riskiness of $G(\beta;\theta)$ can be parametrized by θ, representing a greater degree of riskiness.

Suppose $G(\beta)$ and $G(\beta;\theta)$ intersect only once at their mean.

Proposition 2.

Let $\alpha^*(\theta)$ be the critical value defined in (1) corresponding to the level of riskiness θ. Then $\alpha^*(\theta)$ is decreasing in θ. In other words, the experimentation bias, $\mathrm{E}(\beta) - \alpha^*(\theta)$, is increasing with a mean-preserving spread in the distribution of the new technology. (Proof p415-416)

Proposition 2 implies that since P1 prefers not to be stranded, P1's adoption choice will be biased against risky technologies.

Proposition 3

The first user will adopt the less risky technology A over the more risky one B. (Proof p423-424)

So it's possible for the first user to adopt a technology with a lower expected payoff but less risk.

"The fear of being stranded induces risk-averse behavior."

(Long example p416-418)

IV. Endogenous Timing, The Penguin Effect, and the Role of the Committee as a Suppressor of Informational Diffusion

What happens if the timing of adoption can change?

You get the penguin effect: "each user will be reluctant to move first as long as there is a possibility that her choice may turn out to be so inferior as to make orphan her adoption." (p418)

People prefer to delay their choice in order to free ride on the informational externalities that come from others' decisions.

Why does the penguin effect generate an inefficient delay?

A discrete-tie information model:

Technology A has a deterministic value of m_A

Technology B has an unkown value, drawn from $G(\beta)$ with $E(\beta)=m_\beta$.

α and β are the present discounted values of technology A and technology B.

Δ = the present discounted value each user attaches to the network externalities conferred when the other user adopts the same technology.

δ = discount factor

Suppose these two conditions hold:

(2) $m_\beta > m_A + \Delta$

(3) $m_\beta + \Delta < \delta[G(m_A - \Delta)m_A^{\inf} + \int_{m_{A-\Delta}} (\beta + \Delta)dG(\beta)]$

(2) means that technology B is superior to technology A in expected value even if the other user is certain to adopt Technology A.

But if B's value is low enough, technology A may still be adopted:

If $\beta \leq m_A - \Delta$, A should be adopted.

This will hold with probability G($m_A - \Delta$)

So now we can explain what (3) means:

LHS: expected value of adopting technology B in the current period when the other user does the same

RHS: expected value of waiting when the other user adopts technology B in the current period.

What drives the process is "the inability to commit to not using newly revealed information against early adopters.

So one solution might be to force everyone to choose simultaneously.

Proposition 4.

The players are better off if both of them relinquish the waiting option and adopt technology B immediately. In other words, delay in the adoption dissipates the expected payoffs to the extent that they are actually worse off from the opportunity to learn. (proof p420)

Examples:

1 Urban real estate market

(Stores don't want to be the first person to buy space in an otherwise vacant building) (Caplin and Leahy 1993)