Network Externalities, Competition, and Compatibility
Katz and Shapiro (AER, 1984)

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October 11, 2013

Networks at Tepper
Network Externality

Definition: the utility that a user derives from consumption of the good depends on the number (condition) of other agents consuming the good.

Key features
- interconnected payoff/utility
- economies of scale
- market failures

Applies to: e.g. new high-tech industries, information production, social network, financial network

Positive or negative externalities
Different Forms of Network Externality

Direct physical network effects
- e.g. a fax machine is useless if one’s counterparts do not have one.

- communications/trading networks (e.g., telephone, fax, mobile phone, repo, ABS, etc.).

- public good adoption, Dybvig and Spatt (1983)
Different Forms of Network Externality

Indirect network effects: market mediated effects

- complementary goods are available or lower in price as the number of users of a good increases
- economies of scale, complementarity
- vaccination, bank runs, systemic risk, beauty contest, analysts herding

Pecuniary externality: do not impose deadweight losses if left uninternalized

Literature: selection among competing networks vs. marginal adjustment of the level of network activity
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This Paper Studies

- oligopoly model to analyze market equilibrium which consumption externalities are present.
- competition
- compatibility: e.g. android vs. apple
- private vs. social incentives for network compatibility/formation
Findings

- Competition
  - demand-side economies of scale
  - multiple fulfilled expectations equilibria may exist: only one firm or several firms produce

- Compatibility
  - endogenous formation of network: incentive to produce compatible goods
  - firms with larger existing networks are more against compatibility
  - firms’ joint incentives for compatibility lower than optimal
Model

- $x_i^e$: expected number of consumers (output) for firm $i = 1, 2, \ldots, n$

- $y_i^e$: size of network of firm $i$
  - incompatible: $y_i^e = x_i^e$
  - all compatible: $y_i^e = \sum_{j=1}^{n} x_j^e$

Consumers

- heterogeneous in valuation $r \in U[-A, A]$
- given value of consumption externality $v(y^e)$, price $p_i$

$$\max_i : r + v(y_i^e) - p_i = \max_i : r - (p_i - v(y_i^e))$$
Firm’s problem

- Homogeneity of product: \( p_i - v(y_i^e) = p_j - v(y_j^e) \equiv \phi \)

- \( A - \phi = z \rightarrow A + v(y_i^e) - p_i = z \) where \( z = \sum_{j=1}^{n} x_j \)

- Therefore price is \( p_i = A + v(y_i^e) - z \).

- Profit maximization

\[
\max_{x_i} \pi_i = x_i \left( A - z + v(y_i^e) \right)
\]

- At equilibrium
  - consumers form expectation about size of network
  - firms give prices, output
  - market clear and expectations are fulfilled
Complete Incompatibility: multiple equilibria

Possibility 1: Unique symmetric equilibrium

Figure 2. Firm $i$'s Equilibrium Reaction Correspondence

$\hat{x}_{-i}$

$A$

$x_i$

$x_{-i} = A + v(x_i) - 2x_i$

Figure 3. Unique Symmetric Equilibrium with Complete Incompatibility

$A + v(z/n)$

$\frac{n+1}{n}z$

$z_1$

TOTAL OUTPUT
Complete Incompatibility: multiple equilibria

Natural Oligopoly (Not All Firms Active)

Asymmetric Oligopoly
Complete Compatibility

- There is a unique symmetric equilibrium.

- As the number of firms becomes increasingly large, the compatibility equilibrium $\rightarrow$ perfectly competitive equilibrium; hedonic price $\rightarrow$ the marginal cost.
Implications of Compatibility on Output

- Higher compatibility → higher total output
- When two firms make their products compatible.
  - the average output of the firms in the merging coalitions rises
  - the output of any firm not in the merging coalitions falls
- industry output rises
Private vs. Social Incentives for Network Compatibility

- Key: mechanism to achieve compatibility, whether side payments are feasible

- Joint investment of compatibility (bilateral stable)
  - With no side payments, network compatible iff all firms are better-off.

- With side payments, coalitions.
Construction of an adapter (unilateral)

- With no side payments, network compatible if either firm finds it profitable

- (two firms) With no side payments, a symmetric incompatibility equilibrium has insufficient inventive for compatibility

- (two firms) Smaller market share group has excessive incentives for compatibility
Applications and Extensions


- product market, marketing, organization design

- finance: Economides(1993), price discovery (Electronic call markets), market liquidity (OTC), risk sharing (interbank market), contagion (toxic/distressed assets), coordination (runs, VCs)