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9: Network externalities and compatibility

Games, Competition and Markets 2024/25

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Overview

1. Where We Stand
2. Network Externalities
3. Positive Network Externalities
4. Compatibility
5. Compatibility without network externalities

Where We Stand

Topics

1. Preliminaries

Introductory lecture. Review of game-theoretic concepts. Some basic models of competition.

2. Consumer Search

What if consumers have to engage in costly search to find out about products and/or prices?

3. Advertising

What if producers have to inform consumers about their products and/or prices?

4. Menu Pricing

What if firms design different products and different prices for different consumers?

5. Durable Goods

What if a monopolist sells a durable good and cannot commit to future quantities?

6. Switching Costs

What if consumers have to pay extra if they switch suppliers?

7. Behavior-Based Price Discrimination

What if firms can base their prices on a consumer's past behavior?

8. Vertical control

What if firms sell products to retailers who then sell it to final consumers?

9. Bundling

What if firms can sell bundles of products?

10. Network externalities and compatibility

What if products exhibit network effects: they becomes more (or sometimes less) useful if more consumers use it. Also: when do firms want to make their products compatible with that of their competitor?

11. Platform competition

What if online platforms bring buyers and sellers together? Or consumers and advertisers?

Network Externalities

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Network Externalities

- For some products, your utility of using them increases if the number of users increases.
- Positive network externalities.
- Examples: Social networks. But also: software.
- More indirectly: Google search, Other online platforms.
- In some cases, your utility of using a product may also decrease in the number of users.
- These are negative network externalities.
- Prime example: congestion.

Positive Network Externalities

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The Classic Network Externality Model

- This is Rohlfs (1974)
- Mass η of telecom customers uniformly indexed by x on $[0, 1]$.
- Those with low x have high willingness to pay.
- Utility of x is $(1 - x)q^e - p$ iff she subscribes, with q^e the expected number of subscribers.
- For connection fee p, the indifferent consumer is given by $\hat{x} = (q^e - p)/q^e$.
- All $x > \hat{x}$ will not subscribe.
- Actual number of consumers: $q = \eta\hat{x}$.
- In equilibrium, $q^e = q = \eta\hat{x}$, so $p = (1 - \hat{x})\eta\hat{x}$.
- Demand is upward sloping at small demand levels and downward sloping at high demand levels.

Network externalities

- Assume connection costs are zero.
- The monopoly maximizes profits

$$\pi(\hat{x}) = p\eta\hat{x} = (1 - \hat{x})(\eta\hat{x})^2 .$$

- $\hat{x} = 2/3$
- $p = \frac{2\eta}{9}, \pi = \frac{4\eta^2}{27}$.
- For consumers that buy, utility is

$$U = \frac{2}{3}(1 - x)\eta - \frac{2\eta}{9} = \frac{2\eta(2 - 3x)}{9}.$$

- An increase in η increases prices, the absolute number of consumers increases, as do profits and utility of connected consumers.

Welfare

- Social welfare is given by

$$
\begin{aligned}
& (1-\hat{x})(\eta\hat{x})^2 + \eta\int_0^{\hat{x}} \left(\hat{x}(1-x)\eta - (1-\hat{x})\eta\hat{x}\right) dx \\
= \; & (1-\hat{x})(\eta\hat{x})^2 + \eta\int_0^{\hat{x}} \left(\hat{x}\eta(\hat{x}-x)\right) dx \\
= \; & (1-\hat{x})(\eta\hat{x})^2 + \frac{1}{2}\hat{x}^3\eta^2
\end{aligned}
$$

- This is maximized by setting $\hat{x} = \frac{4}{3}$
- Corner solution $\hat{x} = 1$.

Compatibility

What if we have competing firms?

- Crucial question then becomes: what is the size of the network?
- Only your own consumers or also that of your competitor?
- Depends on whether your products are *compatible* or, in this context, whether the relevant network includes the consumers of your competitor.
- Compatible: Vodafone and KPN Mobile.
- Incompatible: Threads and X.

Compatibility with network externalities

- Add network effects to the standard Hotelling model.
- Utility of consumer located at x that buys from firm 0:

$$U = v + \alpha q_0 - tx - p_0.$$

- q_0 is the number of users from which x_i enjoys network externalities.
- Production costs are zero.

Case 1: Incompatibility

- q_0 is mass of consumers buying from firm 0.
- Indifferent consumer z has $v + \alpha z - tz - P_0 = v + \alpha(1 - z) - t(1 - z) - P_1$
- so $z = \frac{1}{2} + \frac{P_1 - P_0}{2(t - \alpha)}$.
- Network externalities have same effect as decrease in transportation costs.
- Hence $P_1^* = P_2^* = t - \alpha$.
- Net utility for some $x < 1/2$ thus equals

$$U = v + \frac{1}{2}\alpha - tx - (t - \alpha) = v - t(1 + x) + \frac{3}{2}\alpha.$$

- Equilibrium profits are $\Pi^1 = \Pi^2 = \frac{1}{2}(t - \alpha)$.

Case 2: Compatibility

- The size of the network is simply the mass of consumers: $q_0 = q_1 = 1$.
- Indifferent consumer: $v + \alpha - tz - P_0 = v + \alpha - t(1 - z) - P_1$
- or $z = \frac{1}{2} + \frac{P_1 - P_0}{2t}$.
- This is the standard Hotelling case.
- α now adds to v rather than to t.
- Equilibrium: $P_0 = P_1 = t, \Pi_0 = \Pi_1 = \frac{1}{2}t$.
- Net utility for a consumer located at $x < 1/2$:
- $U = v + \alpha - tx - t = v - t(1 + x) + \alpha$.
- Consumer utility is higher with incompatibility!
- Social welfare is higher with compatibility.

Compatibility without network externalities

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Compatibility without network externalities

- Compatibility can also be an item absent network externalities.
- It then concerns the compatibility of *components* rather than *networks*.
- Example: can you use an iPhone charger for an Android phone and vice-versa?
- Classic example: computer and monitor

Compatibility without network externalities

- Matutes and Regibeau (1988)
- Duopoly.
- Consumers are only interested in a full system consisting of two components.
- Both firms produce both components, costs are normalized to zero.
- Consumers are uniformly distributed on the unit square.
- Firm A is located at the origin, B is located at (1,1).
- Essentially, this boils down to Hotelling in two dimensions.
- Transport costs are λ in each dimension.

Incompatibility

- Only two systems are available: X_{AA} and X_{BB}.
- Indifferent consumer:
- $P_{AA} + \lambda(z_1 + z_2) = P_{BB} + \lambda(2 - z_1 - z_2)$.
- Set of consumers, given by the line $z_2 = 1 + \frac{P_{BB} - P_{AA}}{2\lambda} - z_1$.
- With $P_{AA} \geq P_{BB}$, total mass of consumers buying 1 is a triangle.
- Total demand for firm A:
- $Q_{AA} = \frac{1}{2}\left[1 + \frac{P_{BB} - P_{AA}}{2\lambda}\right]^2$
- Maximizing profits and imposing symmetry yields $P^*_{AA} = P^*_{BB} = \lambda$, and $\Pi^*_A = \Pi^*_B = \lambda/2$.
- Consumer surplus $2\int_0^1 \int_0^{1-z_1} \left[v - \lambda\left(z_1 + z_2\right) - P^*\right] dz_2 dz_1 = v - 5\lambda/3$.

Compatibility

- Consumers can now choose from four options: $X_{AA}, X_{AB}, X_{BA}, X_{BB}$.
- They can mix and match
- The two purchase decisions are independent.
- Equilibrium prices per item: λ,
- Consumer surplus: $4\int_0^{1/2}\int_0^{1/2}[C-2\lambda-\lambda z_1-\lambda z_2]\,dz_1dz_2=v-5\lambda/2$.
- Consumer surplus is higher with incompatibility
- Profits are higher with compatibility.
- Social welfare with compatibility is higher:
- $v-\frac{2}{3}\lambda$ vs. $v-\frac{1}{2}\lambda$.

Thank you for your attention

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