# The Economics of Network Industry (Ch1 ~ 2)


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1

# Introduction to Network Economics (Ch1)

2

## Agenda

- Overview of Network Industries
- Welfare Aspects

3

## Overview of Network Industries

- Complementarity, compatibility and standards
- Consumption externalities
- Switching costs and lock-in
  - Contracts
  - Training and learning
  - Data conversion
  - Search cost
  - Loyalty cost
- Significant economies of scale in production

4

## Welfare Aspects

- Government intervention
- “Natural” monopolies versus access pricing

5

# The Hardware Industry (Ch2)

6

## Agenda

- Hardware Compatibility
- The Network Externalities Approach
- The Component Approach
- Empirical Findings on Network Externalities
- Conclusion

7


8

## Hardware Compatibility

- **Compatibility（相容性）**

  Compatibility means that every software package written for one machine can be run on a machine with a different brand name

  - **Strongly compatible — Different computer hardware brands use the same operating system**
  - **Downward compatible — A new model is compatible with an older model, but not necessarily the other way around**
  - **One-way compatible — One machine can read the files generated by a competing machine, but not the other way around**

9


10

## The Network Externalities Approach

- **Network Externalities（網路外部性）**

  Consumers' preference are said to exhibit ***network externalities*** if the utility of each consumer increases with an increase in the total number of consumers purchasing the same or a compatible brand

  - **Monopoly selling a single brand to identical consumers**
  - **Monopoly selling a single brand to heterogeneous consumers**
  - **Duopoly selling differentiated brands to heterogeneous consumers**

11

## The Network Externalities Approach

- **Monopoly selling a single brand to identical consumers**

  $\eta$ : identical potential computer users who all value compatibility
  $q$ : computers sold or actual number of computer buyers
  $p$ : price of a computer
  $\beta$ >0, basic utility each consumer derives from using a computer regardless of compatibility
  $\alpha$ , measures the degree of importance of compatibility
  $\alpha q$, total utility gain from network externalities

  The utility function of each consumer is given by

  → $U \underline{def} \begin{cases} \beta - p + \alpha q & \text{adapter installed} \\ \beta - p & \text{adapter not installed} \\ 0 & \text{does not purchase a computer} \end{cases}$

12

## The Network Externalities Approach

- **Timing of decisions made by producer**

| Stage 3 | Stage 2 | Stage 1 |
|---|---|---|
| Consumers' purchasing decisions | Monopoly selects a price | Monopoly compatibility decision |
| ■ Total number of buyers when computer is produced without compatibility: $q=\begin{cases}\eta & \text{if } p\leqq\beta\\ 0 & \text{if } p>\beta\end{cases}$ ■ Total number of buyers when computer is produced with compatibility: $q=\begin{cases}\eta & \text{if } p\leqq\beta+\alpha\ \eta\\ 0 & \text{if } p>\beta+\alpha\ \eta\end{cases}$ | ■ Firm's total profit when computers are incompatible : $p=\beta$, $\pi_n=(\beta-\mu_n)\eta$ ■ Firm's total profit when computers are compatible: $p=\beta+\alpha\ \eta$, $\pi_c=(\beta+\alpha\eta-\mu_c)\eta$ | ■ The condition for the monopoly to produce compatible machines: $\mu_c$ : cost of compatibility / unit $\mu_n$ : cost of incompatibility / unit $\Delta_\mu=\mu_c-\mu_n\leq\alpha\eta$ Producing compatible machines is profitable if the cost difference does not exceed the gain from compatibility |

13

## The Network Externalities Approach

- **Is there a market failure ?**

**Social welfare = Consumers' utilities + monopoly's profit**

➔ $w=\eta U+\pi$

■ Comparing the social welfare between making compatible and incompatible machines yields that compatibility is socially preferred if :

$$\Delta_\mu \overset{def}{=} \mu_c-\mu_n\leq\alpha\eta$$

**Conclusion:** A monopoly selling computers to identical consumers will install compatibility adapters if and only if it is socially optimal to do so.

14

## The Network Externalities Approach

- **Monopoly selling a single brand to heterogeneous consumers**

$2\eta$ : computer users who value compatibility $\eta$ + computer users who does not value compatibility $\eta$

$q$ : computers sold or actual number of computer buyers

$p$ : price of a computer

$\beta$ >0, basic utility each consumer derives from using a computer regardless of compatibility

$\alpha$ ,measures the degree of importance of compatibility to type c consumers

$\alpha q$, total utility gain from network externalities

The utility function of each consumer type

= consumer who value compatibility = consumer who does not value compatibility

➔ $U_c$

$$U_c\overset{def}{=}\begin{cases}\beta-p+\alpha q & \text{adapter installed}\\ \beta-p & \text{adapter not installed}\\ 0 & \text{does not purchase a computer}\end{cases}$$

$U_n$

$$U_n\overset{def}{=}\begin{cases}\beta-p & \text{purchase any computer}\\ 0 & \text{does not purchase a computer}\end{cases}$$

15

## The Network Externalities Approach

- **Timing of decisions made by producer**

| Stage 3 | Stage 2 | Stage 1 |
|---|---|---|
| Consumers' purchasing decisions | Monopoly selects a price | Monopoly compatibility decision |
| ■ Total number of buyers when computer is produced without compatibility: $q=\begin{cases}2\eta & \text{if } p\leqq\beta\\ 0 & \text{if } p>\beta\end{cases}$ ■ Total number of buyers when computer is produced with compatibility: $q=\begin{cases}2\eta & \text{if } p\leqq\beta\\ \eta & \text{if } \beta<p\leqq\beta+\alpha\ \eta\\ 0 & \text{if } p>\beta+\alpha\ \eta\end{cases}$ | ■ Firm's total profit when computers are incompatible : $p=\beta$, $\pi_n=(\beta-\mu_n)2\eta$ ■ Firm's total profit when computers are compatible: $\pi_c=\begin{cases}(\beta+\alpha\eta-\mu_c)\eta & \text{if } p=\beta+\alpha\ \eta\\ (\beta-\mu_c)2\eta & \text{if } p=\beta\end{cases}$ | ■ The condition for the monopoly to produce compatible machines: $\mu_c$ : cost of compatibility / unit $\mu_n$ : cost of incompatibility / unit $\mu_c\leq\alpha\eta-\beta+2\mu_n$ |

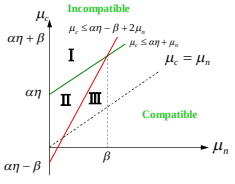
16

## The Network Externalities Approach

- **Is there a market failure ?**

Social welfare = Consumers' utilities + monopoly's profit ➔ $w=\eta U+\pi$

■ Comparing the social welfare between making compatible and incompatible machines yields that compatibility is socially preferred if : $\mu_c\leq\alpha\eta+\mu_n$




**Conclusion:**

Ⅰ : Cost of producing compatible machines is very high comparing to incompatible machines, both the social planner and the monopoly will choose incompatibility.

Ⅲ : Cost of producing compatible machines is not very high, in which case both the social planner and the monopoly will choose compatibility, no market failure.

Ⅱ : Illustrates a parameter range where a market failure occurs since the monopoly will choose to produce incompatible machines, but compatibility is socially optimal.

17

## The Network Externalities Approach

- **Duopoly selling differentiated brands to heterogeneous consumers**

■ **Profit-maximizing choice of compatibility / incompatibility by computer producers A and B and the welfare consequences of such choices**

Market has two brands brand A , brand B

Brand A-oriented consumers $\eta$ ， Brand B-oriented consumers $\eta$

Before Brand B decides its compatibility strategy, it will first consider Brand A's strategy

(1) A,B incompatible, profit level is: $\pi_A=\pi_B=2\eta(\delta-\alpha\eta)$

(2) A compatible with B ， B incompatible with A, profit levels are:

$\pi_A=2\eta(\delta-\frac{\alpha\eta}{3})$ $\pi_B=2\eta(\delta-\frac{2\alpha\eta}{3})$

(3) A,B compatible, profit level is: $\pi_A=\pi_B=2\eta\delta$

**Conclusion:**

A maximized its profit level when manufacturing compatible machines, based on (2)(3) B also decided to produce compatible machines to maximize its profit level as well.

Thus, we reach a **Nash Equilibrium.**

18

## The Network Externalities Approach

- **Duopoly selling differentiated brands to heterogeneous consumers**
  - Consumers' utility levels

(1) A,B incompatible: $U_A = 3\alpha\eta - 2\delta$ ← Consumer has highest utility level

(2) A compatible with B，B not compatible with A: $U_A = \frac{8\alpha\eta}{3} - 2\delta$

(3) B compatible with A，A not compatible with B: $U_A = \frac{7\alpha\eta}{3} - 2\delta$

(4) A,B compatible: $U_A = 2\alpha\eta - 2\delta$ ← Consumer has lowest utility level

**Reason:** Firms manage to extract more surplus under compatibility thereby making compatibility "bad" for consumers

19

## The Network Externalities Approach

- **Is there a market failure ?**
  - Using social welfare function W to exam consumer welfare under all possible compatibility decision outcomes:

(1) both machines are incompatible: $W = 2\alpha\eta^2$

(2) one-way compatibility: $W = 3\alpha\eta^2$

(3) both machines are incompatible: $W = 4\alpha\eta^2$

**Conclusion:** social welfare is maximized when both machines are compatible

20


21

## The Components Approach

- **Assume complementarity**
- **Incompatible systems**
- **Compatible systems**
- **Compatibility versus incompatibility**
- **Summary of the components approach**

22

## The Components Approach

**Computer systems** — Basic unit and the computer

**Firms and Compatibility**

DEFINITION 2.7:
- The components are said to be incompatible if the components produced by different manufacturers can not be assembled into systems. That is systems $X_AY_B$ and $X_BY_A$ do not exist in the market
- The components are said to be compatible if the components produced by different manufacturers can be assembled into systems. That is, $X_AY_B$ and $X_BY_A$ are available in the market

**Consumers** — Each consumer has an ideal combination of components:
Under equal prices, each consumer has a different ideal system.

23

## Incompatible systems

Price of $X_AY_A$: $P_{AA} \stackrel{def}{=} P_A^X + P_A^Y$

Price of $X_BY_B$: $P_{BB} \stackrel{def}{=} P_B^X + P_B^Y$

- Firm A sells to consumers AA and AB and firm B sells to consumer BB. Suppose both conditions in the following are simultaneously satisfied

$\pi_B^U = P_{BB}^U * 1 \geq \max\{(P_{AA}^U - \delta) * 2; ((P_{AA}^U - 2\delta) * 3\}$

$\pi_A^U = P_{AA}^U * 2 \geq (P_{BB}^U - 2\delta) * 3$

- In the case of "mild" undercutting, equilibrium prices and profit levels is given by

$P_{AA}^I = 3\delta, P_{BB}^I = 4\delta, and \pi_A^I = 6\delta, \pi_B^I = 4\delta$

- Aggregate consumer surplus as the sum of consumer utilities

$CS^I \stackrel{def}{=} U_{AA} + U_{BB} + U_{AB}$

$= (\beta - 3\delta) + (\beta - 4\delta) + (\beta - 3\delta - \delta)$

$= 3\beta - 11\delta$

- Social welfare is the sum of firms' profit levels and consumer surplus

$W^I = \pi_A + \pi_B + CS^I = 6\delta + 4\delta + 3\delta - 11\delta$

$= 3\beta - \delta$

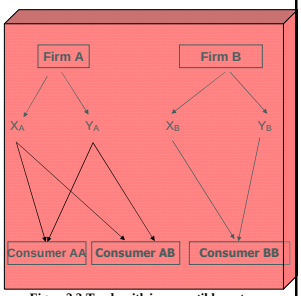



**Figure2.2:Trade with incompatible systems**

24

## Compatible systems

- Equilibrium prices and profit level is given by

$$P_A^X = P_B^Y = 12\delta/7, P_B^X = P_B^Y = 15\delta/7,$$
$$\pi_A^C = \pi_B^C = 2*12\delta/7 + 15\delta/7$$
$$= 39\delta/7$$

- Aggregate consumer surplus as the sum of consumers' utilities

$$CS^C \overset{def}{=} U_{AA} + U_{BB} + U_{AB}$$
$$= \beta - 12\delta/7 - 15\delta/7 + \beta - 15\delta/7 - 12\delta/7 + \beta$$
$$- 12\delta/7 - 12\delta/7$$
$$= 3\beta - 78\delta/7$$

- Social welfare is the sum of firms' profit levels and consumer surplus

$$W^C = \pi_A + \pi_B + CS^C$$
$$= 39\delta/7 + 39\delta/7 + 3\beta - 78\delta$$
$$= 3\beta$$

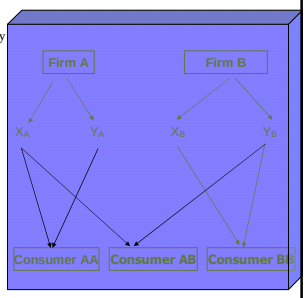



**Figure2.3:Trade with compatible systems**

25

## Compatibility versus incompatibility

**Proposition 2.8**
Consumers are better off when the firm produce Incompatible components than when firms produce Compatible components.

**Proposition 2.9**
(a) Aggregate industry profit is higher when firm produce compatible components than when they produce incompatible components.
(b) The firm with the higher market share under incompatibility earns a higher profit under incompatibility whereas the firm with the smaller market share under incompatibility earns a higher profit under compatibility.

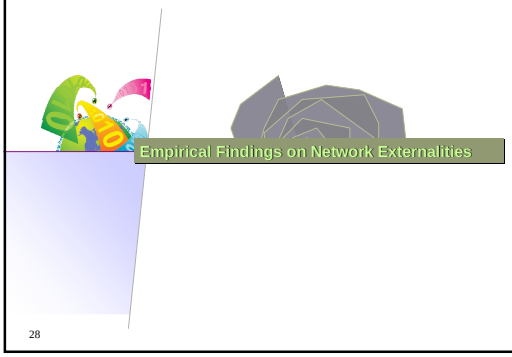
**Proposition 2.10**
Social welfare is higher when firms produce compatible components

26

## Summary of the components approach

| | |
|---|---|
| Comparing 2.6 & 2.9 | Industry profit is always higher when firms Choose Compatibility over incompatibility |
| Comparing 2.7 & 2.8 | Consumers are worse off under compatibility |
| Comparing 2.7 & 2.10 | The socially-optimal outcome is to have compatible machines and compatible components |

27




28

## Empirical Findings on Network Externalities

- **Keyboard compatibility and network externalities**

- **Mainframe computers**
- **Network externalities in the market for spreadsheet programs**

29

## Comment & Suggestion:

- 一般人面對賽局時，只想到要如何做才是對自己最好，卻不管別人會怎麼做，往往得不到自己想要的結果！
- 賽局理論致勝之道：先想別人如何做是對他們最好，再想何者是自己最好的回應，因而可以使自己獲得較佳的利益。
- 贏贏策略：試著讓每一位參與者都可自稱為勝利者，創造大家都贏的局面。

30


Q & A
31