Economics Bulletin

Volume 40, Issue 3

Do Consumers Gain or Lose when Network Externalities Become Stronger?

Chung-Hui Chou
I-Shou University

Abstract

This paper constructs a duopoly market exhibiting network externalities to study the impacts of sales delegation on compatibility between firms' products and consumers' welfare. We find that modern enterprises are less-motivated to increase compatibility due to the fact that they need to provide more standalone value to cover the market fully than tradition firms do. Second, although stronger network externalities motivate firms to increase compatibility, depending on marginal cost of increasing compatibility, they may reduce consumers' surplus due to higher prices in a market with modern enterprises. On the other hand, consumers gain more surplus under stronger network externalities if the firms are traditional ones.

Citation: Chung-Hui Chou, (2020) "Do Consumers Gain or Lose when Network Externalities Become Stronger?", *Economics Bulletin*, Volume 40, Issue 3, pages 2193-2200
Contact: Chung-Hui Chou - chchou@isu.edu.tw.
Submitted: June 18, 2020. **Published:** August 19, 2020.

1. Introduction

In the past few decades, many papers have adopted different approaches to explore firms' behaviors in the markets with network externalities. [1] Katz and Shapiro (1985) constructed a model with direct network externalities and showed that firms earn more profit under compatibility. Matutes and Regibeau (1988) pioneered the components approach and demonstrated that producing compatible components brings firms more profit. Chou and Shy (1990) showed that indirect network effects can substitute for direct network effects if the production of software exhibits increasing returns to scale.

Fershtman and Judd (1987) and Sklivas (1987) pioneered the research of sales delegation and found that owners induce managers to act less aggressively to relax price competition by offering contracts with inflating production cost. Their results clearly offered an interpretation for the separation of ownership and management in modern enterprises. In the past decades, many papers extended Fershtman and Judd (1987) and Sklivas (1987) to study firms' behaviors with separation of ownership and management. Jansen et al. (2007) discovered that duopoly firms earn more profit under market share delegation than they do under sales delegation. Miller and Pazgal (2001) proved the equivalence of Bertrand and Cournot competition under relative performance delegation. Ishibashi (2001) examined the strategic delegation behaviors of firms competing in both prices and qualities.

Hoernig (2012) discussed the firms' delegation behaviors in a market with network externalities and showed that owners may encourage managers to act more aggressively in price competition when network externalities are strong enough. Chirco and Scrimitore (2013) presented that firms choose prices rather than quantities as their strategy variables under strategic delegation when network externalities are sufficiently large. Pal (2015) proved that relative performance delegation does not lead to equivalence of Bertrand and Cournot equilibria in a market with network externalities. Lee et al. (2018) revisited Hoernig (2012) and discovered that the results of Fershtman and Judd (1987) and Sklivas (1987) hold under fulfilled expectations.

More often than not, compatibility is a degree between 0 and 1 rather than "all or none". Full compatibility and incompatibility can be viewed as special cases under consideration of partial compatibility. Chou and Shy (1993) pioneered the research relating to partial compatibility and investigated the effect of increasing a brand's degree of compatibility on the supporting services industry. de Palma et al. (1999) analyzed firms' degree of compatibility decisions with considering consumers' multi-homing. Chou (2007) defined the degree of compatibility from the viewpoint of quality. [2] Garcia and Vergari (2016) investigated the incentives for compatibility provision in a vertically differentiated market with network externalities. They discovered that full compatibility is an equilibrium outcome for low compatibility cost and partial compatibility may be socially optimal when network externalities are very strong.

There are many examples for which our research could be applied. In operating systems market, compatibility between Mac and Windows which are produced by Apple

---

[1] There are three approaches here: network externalities approach, software approach, and components approach. Shy (2011) presented an ample survey on many topics relating to network economics.

[2] These three papers describe the notion of the degree of compatibility from different approaches. Chou and Shy (1993) used the software approach, de Palma et al. (1999) used the network externalities approach, and Chou (2007) used the components approach.

and Microsoft respectively is surely an important strategy for both firms. Second, compatibility between HD-DVD and Blu-Ray DVD is a crucial strategy for Toshiba (innovator of HD-DVD) and SONY (innovator of Blu-Ray DVD). Third, compatibility between Play Station 2 (released by SONY), GameCube (released by Nintendo), and Xbox (released by Microsoft) is a critical strategy for all three firms. The above examples are common in three aspects. The first one is that firms are large-scaled modern enterprises with separation of ownership and management. The second one is the existence of network externalities. The third one is incompatibility between platforms in the above industries.

Although compatibility has been found to be profitable in many pioneering research including Katz and Shapiro (1985) and Matutues and Regibeau (1988), it is hardly observed in many industries with modern enterprises. [3] This motivates us to analyze the impacts of sales delegation on compatibility between firms' products, and consumers' welfare. We find that higher compatibility degrees motivate owners of modern enterprises to ask managers to act less aggressively in price competition. This implies that modern enterprises are less-motivated to increase compatibility due to the fact that their products need to provide more standalone value to cover the market fully than traditional firms' do. Second, stronger network externalities arise compatibility effect and sales delegation effect. The former one is that stronger network externalities induce owners to increase compatibility which enhances consumers' surplus. On the other hand, the latter one is that more compatibility between products motivates owners to ask managers to act less aggressively in price competition which reduces consumers' surplus. From this viewpoint, stronger network externalities improve consumers' surplus in a market with traditional firm due to the absence of the latter effect. However, if owners delegate pricing to managers, then depending on marginal cost of increasing compatibility, stronger network externalities may reduce consumers' surplus. If marginal cost of increasing compatibility is low, then the latter effect offsets the former one; consequently, consumers' surplus is harmed by stronger network externalities. Conversely, if increasing compatibility is costly, then stronger network externalities improve consumers' surplus.

We introduce the basic model in the section 2. Section 3 analyzes the impacts of sales delegation on owners' compatibility decisions. Section 4 examines the impacts of sales delegation on consumers' surplus. Section 5 concludes.

2. The Model

Consumers are uniformly distributed on the interval $[0,1]$ with density 1. Firm 1 and firm 2 reside at points 0 and 1 respectively. The marginal cost of production is 1.

Consumers' utility depends on the number of consumers using compatible products, prices, and their subjective preferences for products. Let $x_i\ (i = 1,2)$ denote the number of consumers buying product i. If owner $i\ (i = 1,2)$ chooses $r_i \in [0,1]$ as his compatibility degree, then the network size corresponding to firm i's product is $x_i + r_i x_j$. Compatibility investment cost is $c(r)$, $c'(r) > 0$ and $c''(r) > 0$. Specifically, a consumer located at *t* has the following utility function. [4]

---

[3] Einhorn (1992) also showed that vertically differentiated producers of components earn higher profits when components are compatible.

[4] Garcia and Vergari (2016) depicted consumers' preferences similarly.

$$u(t)=\begin{cases}u_o+\alpha(x_1+r_1x_2)-p_1-t & \text{if he purchases product 1,}\\ u_o+\alpha(x_2+r_2x_1)-p_2-(1-t) & \text{if he purchases product 2.}\end{cases} \quad (1)$$

Here, u_o is the standalone utility of product which is sufficiently large that the market is covered, $\alpha<1$ denotes the strength of network externalities and p_i is product i's price.

Following Fershtman and Judd (1987) and Sklivas (1987), owners use linear combinations of profit and total revenue to evaluate managers' performances under sales delegation. In other words, manager $i\,(i=1,2)$ seeks to maximize the following performance function.

$$m_i=\lambda_i\pi_i+(1-\lambda_i)TR_i=\lambda_i(p_i-1)Q_i+(1-\lambda_i)p_iQ_i=(p_i-\lambda_i)Q_i \quad (2)$$

Here, π_i and TR_i are firm i's profit and sales revenue respectively. λ_i is the weight placed on profit.

The participants' interactions take place in the following four-stage game. In the first stage, firms' owners choose compatibility degrees. In the second stage, firms' owners write contracts with managers and delegate pricings to them. In the third stage, managers engage in price competition to maximize their performances. In the fourth stage, consumers make purchase decisions. In the following analysis, we use backward induction to derive the subgame perfect equilibrium.

3. Managers' Pricing and Owners' Incentive Schemes Offering Decisions

Given that owner $i\,(i=1,2)$ chooses r_i as his compatibility degree in the first stage, from the above utility function, the consumer indifferent between product 1 and product 2 is

$$t=\frac{1-p_1+p_2+x_1+r_1x_2-x_2-r_2x_1}{2}. \quad (3a)$$

$$t=x_1=1-x_2 \quad (3b)$$

From (3a) and (3b), firm 1's demand function can be derived as follows.

$$x_1=\frac{1-\alpha+\alpha r_2-p_1+p_2}{2-2\alpha+\alpha(r_1+r_2)}.$$

From the above results, manager $i\,(i=1,2)$ seeks to maximize the following performance functions.

$$m_1(p_1,p_2)=(p_1-\lambda_1)\frac{1-\alpha+\alpha r_2-p_1+p_2}{2-2\alpha+\alpha(r_1+r_2)}. \quad (4a)$$

$$m_2(p_1,p_2)=(p_2-\lambda_2)\frac{1-\alpha+\alpha r_1-p_2+p_1}{2-2\alpha+\alpha(r_1+r_2)}. \quad (4b)$$

Solving the first-order conditions of the above performance functions simultaneously yields the following managers' pricings.

$$p_1=\frac{2\lambda_1+\lambda_2+2\alpha r_2+\alpha(r_1-3)+3}{3}, \quad (5a)$$

$$p_2=\frac{\lambda_1+2\lambda_2+\alpha r_2+\alpha(2r_1-3)+3}{3}. \quad (5b)$$

From the above pricings, owners' profit functions are derived as follows.

$$\pi_1(\lambda_1,\lambda_2)=\frac{(3-3\alpha+\alpha r_1+2\alpha r_2-\lambda_1+\lambda_2)(-3\alpha+\alpha r_1+2\alpha r_2+2\lambda_1+\lambda_2)}{9[2-2\alpha+\alpha(r_1+r_2)]}-c(r_1), \quad (6a)$$

$$\pi_1(\lambda_1,\lambda_2)=\frac{(3-3\alpha+2\alpha r_1+\alpha r_2+\lambda_1-\lambda_2)(-3\alpha+2\alpha r_1+\alpha r_2+\lambda_1+2\lambda_2)}{9[2-2\alpha+\alpha(r_1+r_2)]}-c(r_2). \quad (6b)$$

Solving the first-order conditions of the above profit functions simultaneously yields the following owners' contracting behaviors.

$$\lambda_1^*=\frac{10-5\alpha+2\alpha r_1+3\alpha r_2}{5}, \quad (7a)$$

$$\lambda_2^*=\frac{10-5\alpha+3\alpha r_1+2\alpha r_2}{5}. \quad (7b)$$

Inserting (7a) and (7b) into (5a) and (5b) yields the following prices.

$$p_1^* = \frac{15-10\alpha+4\alpha r_1+6\alpha r_2}{5}, \quad (8a)$$

$$p_2^* = \frac{15-10\alpha+6\alpha r_1+4\alpha r_2}{5}. \quad (8b)$$

From the above pricings, owner $i's$ profit functions under sales delegation are derived as follows.

$$\pi_1(r_1.r_2) = \frac{2(3\alpha r_2+2\alpha r_1-5\alpha+5)^2}{25(\alpha r_2+\alpha r_1-2\alpha+2)} - c(r_1), \quad (9a)$$

$$\pi_2(r_1.r_2) = \frac{2(3\alpha r_1+2\alpha r_2-5\alpha+5)^2}{25(\alpha r_1+\alpha r_2-2\alpha+2)} - c(r_2). \quad (9b)$$

If owners do not delegate pricings to managers, prices can be derived by inserting $\lambda_1 = \lambda_2 = 1$ into (5a) and (5b). They are stated as follows.

$$p_1^{**} = \frac{6-3\alpha+\alpha r_1+2\alpha r_2}{3}, \quad (10a)$$

$$p_2^{**} = \frac{6-3\alpha+2\alpha r_1+\alpha r_2}{3}. \quad (10b)$$

From the above pricings, owner $i's$ profit functions without sales delegation are derived as follows.

$$\pi_1(r_1.r_2) = \frac{(2\alpha r_2+\alpha r_1-3\alpha+3)^2}{9(\alpha r_2+\alpha r_1-2\alpha+2)} - c(r_1), \quad (11a)$$

$$\pi_2(r_1.r_2) = \frac{(2\alpha r_1+\alpha r_2-3\alpha+3)^2}{9(\alpha r_1+\alpha r_2-2\alpha+2)} - c(r_2). \quad (11b)$$

Proposition 1 *Higher compatibility degrees induce owners to ask managers to act less aggressively in price competition. In other words, higher compatibility degrees relax price competition more under sales delegation than they do without sales delegation.*

Proof:

From (7a), $\frac{d\lambda_1^*}{dr_1} > 0$.

From (8a) and (10a), $\frac{dp_1^*}{dr_1} = \frac{4\alpha}{5} > \frac{dp_1^{**}}{dr_1} = \frac{\alpha}{3}$

This completes the proof. ■

In the terminologies of Fudenberg and Tirole (1984), compatibility degrees are fat-cat strategies. This results implies that modern enterprises' products need to provide more standalone value than traditional firms' do. Hence, modern enterprises are less-motivated to increase compatibility. This result offers an interpretation for the fact that full compatibility can be hardly observed in the industries with modern enterprises.

Proposition 2 *The owner choosing a higher degree of compatibility asks his manager to act more aggressively in price competition than the owner choosing a lower degree of compatibility does.*

Proof:

From (7a) and (7b), $\lambda_1^* - \lambda_2^* = \frac{\alpha(r_2-r_1)}{5}$.

Hence, $r_1 > r_2$ iff $\lambda_1^* < \lambda_2^*$.

This completes the proof. ■

The owner choosing a higher degree of compatibility is more-motivated to enlarge rival's network than the owner choosing a lower degree of compatibility. Therefore, the

owner with a higher degree of compatibility asks his manager to act more aggressively to toughen price competition than the owner with a lower degree of compatibility does.

Proposition 3 *Compatibility degrees increase with the extent of network externalities.*
Proof:
In the proof, without loss of generalities, we analyze firm 1's decisions.
The first-order condition of firm 1's optimal compatibility degree is

$$\frac{d\pi_1(r_1,r_2)}{dr_1} = 0.$$

Hence,

$$sign[\frac{dr_1^*}{d\alpha}] = sign[-\frac{\frac{d^2\pi_1(r_1,r_2)}{d\alpha dr_1}}{\frac{d^2\pi_1(r_1,r_2)}{dr_1^2}}] = sign[\frac{d^2\pi_1(r_1,r_2)}{d\alpha dr_1}].$$

$$\frac{d^2\pi_1(r_1,r_2)}{d\alpha dr_1}\Big|_{r_1=r_2} = \frac{3}{10}.$$

Hence, $\frac{dr_1^*}{d\alpha} > 0$.
This completes the proof. ■

From (7a) and (7b), when network externalities get stronger, owners tend to ask managers to act more aggressively in price competition. [5] As a consequence, owners are motivated to increase compatibility degrees in the first stage to prevent a tough price competition.

4. Consumers' Surplus

This section examines the impacts of sales delegation on consumers' surplus. From the above analysis, consumers' surplus in a market with modern enterprises can be derived as follows.

$$\begin{aligned} CS^*(\alpha) &= 2\int_0^{\frac{1}{2}}\left[u_o + \frac{1}{2}(1 + r_1^{**}) - p_1^{**} - t\right]dt \\ &= u_0 + \frac{\alpha}{2}(2 + r_1^* + r_1^*) - \frac{15-10\alpha+4\alpha r_1^*+6\alpha r_1^*}{5} - \frac{1}{4}. \\ &= u_0 + \frac{-13 + 12\alpha - 2\alpha(r_1^* + r_1^*)}{4} = u_0 - \frac{13}{4} + \alpha(3 - r_1^*) \end{aligned} \quad (12)$$

Here r_1^* is symmetric firms' optimal compatibility degree under sales delegation.

From (10a) and (10b), consumers' surplus in a market with traditional firms can be derived as follows.

$$\begin{aligned} CS^{**}(\alpha) &= 2\int_0^{\frac{1}{2}}\left[u_o + \frac{1}{2}(1 + r_1^{**}) - p_1^{**} - t\right]dt \\ &= u_0 + \frac{\alpha}{2}(2 + r_1^{**} + r_1^{**}) - \frac{6-3\alpha+\alpha r_1^{**}+2\alpha r_1^{**}}{6} - \frac{6-3\alpha+2\alpha r_1^{**}+\alpha r_1^{**}}{6} - \frac{1}{4}. \\ &= u_0 - \frac{9}{4} + 2\alpha \end{aligned} \quad (13)$$

Here, r_1^{**} is symmetric firms' optimal compatibility degree without sales delegation.

---

[5] From (7a) and (7b), $\frac{d\lambda_1^*}{d\alpha} < 0$ and $\frac{d\lambda_2^*}{d\alpha} < 0$.

From the above derivations, consumers' surplus is independent of compatibility degrees in the absence of sales delegation. Conversely, compatibility degrees influence consumers' surplus under sales delegation.

Proposition 4

(1) *Stronger network externalities enhances consumers' surplus in a market with traditional firms.*

(2) *If* $c''(r)$ *is relatively small , then stronger network externalities reduce consumers' surplus under sales delegation. Conversely, if* $c''(r)$ *is sufficiently large, then stronger network externalities enhance consumers' surplus under sales delegation.*

Proof:

(1) From (13), $\frac{dCS^{**}(\alpha)}{d\alpha} = 2$.

Hence, stronger network externalities improve consumers' surplus in a market with traditional firms.

(2) From the first-order conditions,

$$\frac{d}{dr_1}\frac{2(3\alpha r_1^* + 2\alpha r_1^* - 5\alpha + 5)^2}{25(\alpha r_1^* + \alpha r_1^* - 2\alpha + 2)} - c'(r_1^*) \equiv 0$$

$$\Rightarrow \quad \frac{3\alpha}{10} \equiv c'(r_1^*)$$

$$\Rightarrow \quad 3\alpha \equiv 10c'(r_1^*)$$

From (12),

$$\frac{dCS^*(\alpha)}{d\alpha} = \frac{d}{d\alpha}[\alpha(3 - r_1^*)]$$

$$= \frac{d}{d\alpha}[10c'(r_1^*) - \alpha r_1^*]$$

$$= 10c''(r_1^*)\frac{dr_1^*}{d\alpha} - \left(r_1^* + \alpha\frac{dr_1^*}{d\alpha}\right)$$

$$= [10c''(r_1^*) - \alpha]\frac{dr_1^*}{d\alpha} - r_1^*$$

The above derivations imply that if $c''(r)$ is relatively small, then $\frac{dCS^*(\alpha)}{d\alpha} < 0$. A sufficient condition for $\frac{dCS^*(\alpha)}{d\alpha} < 0$ is $c''(r_1^*) < \frac{\alpha}{10}$. Conversely, if $c''(r)$ is sufficiently large, then $\frac{dCS^*(\alpha)}{d\alpha} > 0$.

Finally, it is worth noting that $c''(r_1^*) < \frac{\alpha}{10}$ does not contradict with second-order condition. The second-order condition is

$$\frac{d\pi_1(r_1^*, r_1^*)}{dr_1^2} = \frac{\alpha^2}{50(1-\alpha+\alpha r_1^*)} - c''(r_1^*) < 0.$$

$\alpha < \frac{5}{6}$ ensures $\frac{\alpha^2}{50(1-\alpha+\alpha r_1^*)} < \frac{\alpha}{10}$.

This completes the proof. ■

Stronger network externalities arise two effects: compatibility effect and sales delegation effect. The former one means that stronger network externalities induce owners to increase compatibility which enhances consumers' surplus. On the other hand, the latter one means that more compatibility between products motivates owners to ask

managers to act less aggressively in price competition which reduces consumers' surplus. From this viewpoint, stronger network externalities improve consumers' surplus in a market with traditional firms due to the absence of the latter effect. On the other hand, depending on marginal cost of increasing compatibility, stronger network externalities may reduce consumers' surplus in a market with modern enterprises. If marginal cost of increasing compatibility is low, then the latter effect offsets the former one; consequently, stronger network externalities reduce consumers' surplus. Conversely, if increasing compatibility is costly, then former effect offsets the latter one. Hence, stronger network externalities enhance consumers' surplus under this situation.

5. Conclusion

This paper constructs a duopoly market with network externalities to study the impacts of sales delegation on compatibility between products and consumers' surplus. We find that modern enterprises are less-motivated to increase compatibility due to the fact that they need to provide more standalone value to cover the market fully than traditional firms do. This result offers an explanation for the phenomenon that full compatibility is hardly observed in many industries with network externalities. Second, stronger network externalities improve consumers' surplus in a market with traditional firms. However, depending on marginal cost of increasing compatibility, stronger network may reduce consumers' surplus in a market with modern enterprises. If marginal cost of increasing compatibility is low, then stronger network externalities reduce consumers' surplus. Conversely, if increasing compatibility is costly, then stronger network externalities improve consumers' surplus.

References

Chirco, A and M. Scrimitore (2013) "Choosing price or quantity? The role of delegation and network externalities" *Economics Letters*, **121**, 482-486.

Chou, C and O. Shy (1990) "Network effects without network externalities" *International Journal of Industrial Organization*, **8**, 259-270.

Chou, C and O. Shy (1993) "Partial compatibility and supporting service" *Economics Letters* **41**, 193-197.

Chou, C. (2007) "Partial compatibility and vertical differentiation" *Economics Bulletin* **12:21**, 1-8.

de Palma, A., L. Leruth and P. Regibeau (1999) "Partial compatibility with network externalities and double purchase" *Information Economics and Policy* **11**, 209-227.

Einhorn, M. (1992) "Mix and match compatibility with vertical product dimensions" *RAND Journal of Economics* **23**, 535–547.

Fershtman, C and K. Judd (1987) "Equilibrium incentives in oligopoly" *American Economic Review* **77**, 927-940.

Fudenberg, D and J. Tirole (1984) "The fact-cat effect, the puppy-dog play, and the lean and hungry look" *American Economic Review* **74**, 361-366.

Garcia, F and C. Vergari (2016) "Revealing incentives for compatibility provision in vertically differentiated network industries" *Journal of Economics and Management Strategy* **25**, 720-749.

Hoernig, S. (2012) "Strategic delegation under price competition and network effects" *Economics Letters* **117**, 487-489.

Ishibashi, K. (2001) "Strategic delegation under quality competition" *Journal of Economics* **73**, 25-56.

Jansen, T., A. van Lier and A. van Witteloostuijn (2007) "A note on strategic delegation: The market share case" *International Journal of Industrial Organization* **25**, 531-39.

Katz, M and C. Shapiro (1985) "Network externalities, competition, and compatibility" *American Economic Review* **75**, 424-440.

Lee, D., K. Choi and J. Han (2018) "Strategic delegation under fulfilled expectations" *Economics Letters* **169**, 80-82.

Matutes, C and P. Regibeau (1988) "Mix and match: product compatibility without network externalities" *RAND Journal of Economics* **19**, 221-234.

Miller, N and A. Pazgal (2001) "The equivalence of price and quantity competition with delegation" *RAND Journal of Economics* **32**, 284-301.

Pal, R. (2015) "Cournot vs. Bertrand under relative performance delegation: Implications of positive and negative network externalities" *Mathematical Social Sciences* **75**, 94-101.

Shy, O. (2011) "A short survey of network economics" *Review of Industrial Organization* **38**, 119-149.

Sklivas, S. (1987) "The strategic choice of managerial incentives" *RAND Journal of Economics* **18**, 452-458.