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On consumer expectations in a network goods market: The monopoly case

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Abstract

We reconsider the effects of consumer expectations on the fulfilled expectations equilibrium in a network goods market. Based on a simple monopoly model incorporating network externalities, we examine how the degree of commitment of consumer expectations, conversely, the degree of the monopolist's commitment to actual output, affects outcomes in the fulfilled expectations equilibrium. We demonstrate that an increase in the proportion of consumers committing to an ex ante expectation for network size, reduces output, consumer surplus, and profit in equilibrium. We also examine the case of myopic expectations.

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1. Introduction

Since the early 21st. century, the world has witnessed remarkable growth in many information and communications technology and selected electronics industries, including telecommunications, computer hardware and software, Internet services, and others. One particular feature of these industries is the presence of network externalities for goods and services in digital markets. In this regard, many studies have analyzed the role of network externalities in giving rise to demand-side economies of scale, a common general property being that individual consumer utility increases alongside an increase in the total number of consumers purchasing either the same brand or compatible brand products.

In a network goods market, the role of consumer expectations of network size is a critical determinant of market outcomes. For example, Rohlfs (1974), a seminal study analyzing network externalities in telecommunications, considers the importance of a critical mass needed to organize the market and the possibility of coordination failure. Baraldi (2012) empirically examines the role of the size of critical mass in a mobile phone market, while Hurkens and López (2014) highlight the importance of consumer expectations in any market with network externalities, including mobile telephony. To avoid coordination failure with multiple equilibria, Shy (2002, Definition 2.4 and Assumption 2.2, p. 20) assumes consumers have perfect foresight. Lambertini and Orsini (2004) also consider the coordination problems in these markets.

In this paper, by focusing on the formation (or timing) of consumer expectations, we reconsider the idea of a fulfilled expectations equilibrium (e.g., Katz and Shapiro, 1985, 1994; Economides, 1996a, 1996b). That is, with respect to the derivation of the fulfilled expectations equilibrium in Cournot oligopolistic competition, Katz and Shapiro (1985) examine two cases: (i) consumers expect the network size before the firms' output decisions, and (ii) consumers expect the network size following the firms' output decisions. In case (i), because consumers commit to *ex ante* expectations, firms are not able to affect network size, whereas in case (ii), because consumers believe the announced actual output level will be the network size, firms can control it.

In this paper, using a spatial monopoly model à la Hotelling including network externalities, we examine how the degree of commitment of consumer expectations affects the fulfilled expectations equilibrium. We demonstrate that an increase in the proportion of consumers, who committing to *ex ante* expectations of network size, reduces output, consumer surplus, and profit in equilibrium. In other words, our finding is that the *ex ante* sticky expectations of consumers, whether rational or myopic, are not beneficial for both consumers themselves and the monopolist.

2. The model

2.1 Consumer expectations and a direct network externality

We deal with the case of direct network externalities as already observed in telecommunications industries. We consider a monopoly market where there is a continuum of consumers, indexed $\theta \in [0,1]$. To simplify, we assume that consumers are uniformly distributed with a density of one in the market, and the utility function (or the willingness-to-pay) of consumer θ is given by $u(\theta) = N(S^e)\theta,$ where $N(S^e)$ represents the network externality function of the expected network size, i.e., S^e. In this case, we assume that all consumers' expectations of network size are identical, i.e., ${S_\theta}^e = S^e.$

We also assume that (i) a linear network externality function given by $N(S^e) = nS^e,$ where

$n(>0)$ represents the network externality parameter, and (ii) production costs are zero. For example, the marginal costs of production and service in network goods industries such as telecommunications are either negligible or zero.

Given the price, a consumer purchases at most either one unit of the product or none. Hence, we express the net surplus of consumer θ as $v(\theta) = \max\{u(\theta) - p, 0\}$. Thus, the index of the marginal consumer who has the same net surplus from purchasing either one unit of the product or none is:

$$\hat{\theta} = \frac{p}{N(S^e)}. \tag{1}$$

The quantity demanded of the product in the market, i.e., the actual network size (output level), is given by $x = 1 - \hat{\theta}$, $x \in [0,1]$. Thus, the monopolist's profit function and consumer surplus are represented as $\pi = px = p(1-\hat{\theta})$ and $CS = \int_{\hat{\theta}}^{1} \{N(S^e)\theta - p\} d\theta$, respectively.

2.2 Fulfilled expectations equilibrium under monopoly

With respect to a fulfilled expectation, taking the notion of Katz and Shapiro (1985), we assume that the formation of consumer expectations for the network size is:

$$S^e = \lambda x^* + (1-\lambda)x, \quad \lambda \in [0,1], \tag{2}$$

where λ represents the proportion of consumers who commit to the *ex ante* expectation of network size before the monopolist's decision (hereafter, we refer to this parameter as the proportion of a consumer's *ex ante* expectations). x^* is the equilibrium output, and x is the actual output announced by the monopolist in advance. Because the other consumers, i.e., $1-\lambda$, accept the announced actual output (or market share) the monopolist can affect the proportion of the expected network size.

Equation (2) implies that there are two types of consumers in the market, i.e., the *ex ante* and the *ex post* expectations type, and that S^e represents the weighted network size. That is, if $\lambda = 1$, then $S^e = x^*$ holds. This implies that all consumers form an expectation for network size before the monopolist's decision, so that the monopolist cannot affect the expected network size. Conversely, if $\lambda = 0$, then $S^e = x$ holds. This implies that because consumers form an expectation for network size after the monopolist's decision, the monopolist can affect the expected network size. In other words, the monopolist can control (or internalize) the expected network size as related to the network externalities.

Based on (1), because the indirect demand function is given by $p = nS^e(1-x)$, the profit function is expressed as $\pi = nS^e(1-x)x$. Accordingly, taking (2), we derive the first-order condition (FOC) for profit maximization and the second-order condition (SOC) as follows:

$$\frac{\partial \pi}{\partial x} = n\{\lambda x^*(1-2x) + (1-\lambda)x(2-3x)\} = 0, \tag{3}$$

$$\frac{\partial^2 \pi}{\partial x^2} = -2n\{\lambda x^* - (1-\lambda)(1-3x)\} < 0. \tag{4}$$

Thus, in the fulfilled expectations equilibrium, i.e., $x = x^*$, from (3), we have:

$$x^* = \frac{2-\lambda}{3-\lambda}(<1), \tag{5}$$

where the SOC as per (4) is satisfied in the equilibrium.

Given (5), it holds that $\frac{dx^*}{d\lambda} < 0.$ That is, from the slope of the indirect demand function, we derive $-\frac{\partial p}{\partial x} = n\{\lambda x^* + (1-\lambda)(2x-1)\} \equiv \eta.$ In this case, the effect of an increase in the proportion of a consumer's *ex ante* expectations concerning the slope in the equilibrium is given by $\left.\frac{d\eta}{d\lambda}\right|_{x=x^*} = n(1-x^*) > 0.$ This increase then steepens the slope of the inverse demand curve, and thus reduces output in the equilibrium.

We also obtain $\frac{dp^*}{d\lambda} = nx^*(1-2x^*)\frac{dx^*}{d\lambda} \geq 0,$ because $\frac{1}{2} \leq x^*.$ With respect to the consumer surplus, which is given by $CS^* = \frac{n(x^*)^3}{2},$ we derive $\frac{dCS^*}{d\lambda} < 0.$ Furthermore, the monopolistic profit in equilibrium is given by $\pi^* = n(x^*)^2(1-x^*).$ Thus, we have $\frac{d\pi^*}{d\lambda} = nx^*(2-3x^*)\frac{dx^*}{d\lambda} \leq 0,$ because $\frac{2}{3} \geq x^*.$

Based on the above results, we present the following proposition.

PROPOSITION 1
An increase in the proportion of consumers bearing ex ante expectations of network size reduces output, consumer surplus, and profit in equilibrium.

Therefore, an increase in the share of rational consumers bearing *ex ante* expectations is preferable for neither consumers themselves nor the monopolist.

2.3 Indirect network externality case

Here, we address the case of indirect network externalities, i.e., system network products (e.g., personal computers and software, smartphones, Internet services). That is, we assume that the utility function of consumer θ is given by $u(\theta) = \theta + N(S^e).$ In this case, because the indirect demand function is given by $p = 1 - x + nS^e,$ the profit function can be expressed as $\pi = (1 - x + nS^e)x,$ where we assume $\frac{1}{2} > n.$

Thus, we derive the FOC and the SOC for profit maximization as follows:

$$\frac{\partial \pi}{\partial x} = 1 + n\lambda x^* - 2\{1 - n(1-\lambda)\}x = 0, \tag{6}$$

$$\frac{\partial^2 \pi}{\partial x^2} = -2\{1 - n(1-\lambda)\} < 0. \tag{7}$$

Under a fulfilled expectation, i.e., $x = x_{idn}{}^*,$ based on (6), we have:

$$x_{idn}{}^* = \frac{1}{2 - n(2-\lambda)} (< 1), \tag{8}$$

where subscript *idn* denotes indirect network externalities. From (8), we can easily derive as follows: $\frac{dx_{idn}{}^{*}}{d\lambda}<0$, $\frac{dCS_{idn}{}^{*}}{d\lambda}<0$, and $\frac{d\pi_{idn}{}^{*}}{d\lambda}<0$.

Therefore, we have the same result for indirect network externalities as we found for direct network externalities.

2.4 Discussion: The case of myopic expectations

To consider the implication of a fulfilled (rational) expectation, taking the viewpoint that the monopoly cannot affect the network size if consumers commit to the *ex ante* expectation of network size, i.e., x^* in (2), which is identical to the equilibrium output, we examine the case of myopic expectations in which some consumers commit to expect any given output level (market share), i.e., $(1>)x_0 \neq x^*$, for network size prior to the monopolist's decision. In this case, we revise the expected network size to be: $S^e = \lambda x_0 + (1-\lambda)x$.

First, with direct network externalities, using (3) and (4), we have the FOC and the SOC for profit maximization as follows:

$$\frac{\partial \pi}{\partial x} = n\{\lambda x_0(1-2x)+(1-\lambda)x(2-3x)\}=0, \tag{9}$$

$$\frac{\partial^2 \pi}{\partial x^2} = -2n\{\lambda x_0 - (1-\lambda)(1-3x)\}<0. \tag{10}$$

Based on (9), we derive the equilibrium output in the case of myopic expectations as follows:

$$x_{myopic}{}^{*} = \frac{1}{3}\left\{1-\frac{\lambda}{1-\lambda}x_0+\sqrt{1+\frac{\lambda}{1-\lambda}x_0+\left(\frac{\lambda}{1-\lambda}x_0\right)^2}\right\}, \tag{11}$$

where $\frac{1}{2}<x_{myopic}{}^{*}<\frac{2}{3}$ and $\lambda \neq 1$. The SOC holds in the equilibrium. Furthermore, in view of (11), we can easily obtain $\frac{dx_{myopic}{}^{*}}{d\lambda}<0$.

Given (3) and (9), if all consumers commit to the *ex ante* expectation for network size, i.e., $\lambda = 1$, it holds that $x_{myopic}{}^{*} = x^* = \frac{1}{2}$. That is, the result where all consumers are rational is identical to where they are all myopic. It is then not beneficial for consumers in the presence of direct network externalities to commit to the *ex ante* expectation for network size, regardless of whether they are rational or myopic.

Second, in the case of indirect network externalities, using (6) and (7), we have the FOC and the SOC for profit maximization as follows:

$$\frac{\partial \pi}{\partial x} = 1+n\lambda x_0 - 2\{1-n(1-\lambda)\}x = 0, \tag{12}$$

$$\frac{\partial^2 \pi}{\partial x^2} = -2\{1-n(1-\lambda)\}<0. \tag{13}$$

Based on (12), we have the equilibrium output with myopic expectations as follows:

$$x_{myopic-idn}{}^{*} = \frac{1+n\lambda x_0}{2\{1-n(1-\lambda)\}}(<1), \tag{14}$$

where $\dfrac{dx_{myopic-idn}{}^{*}}{d\lambda} < 0.$

This means that regardless of whether the network externalities are direct or indirect, an increase in the proportion of consumers with *ex ante* expectations decreases the equilibrium output.

Furthermore, using (8) and (14), if $\lambda = 1$, it holds that $x_{idn}{}^{*} = \dfrac{1}{2-n}$ and $x_{myopic-idn}{}^{*} = \dfrac{1+nx_0}{2}$. Thus, we obtain the following relationship:

$$x_{idn}{}^{*} > (\leq) x_{myopic-idn}{}^{*} \Leftrightarrow x_{idn}{}^{*} > (\leq) x_0. \qquad (15)$$

Unless the market share with myopic expectations is larger than that with fulfilled expectations, the equilibrium output for the former is smaller than that for the latter. Conversely, when all consumers are myopic in the case of indirect network externalities, if they commit to the *ex ante* expectation of a larger market share regarding network size than with fulfilled expectations, then the larger output level also arises in the equilibrium. This result differs from the case of direct network externalities. That is, in view of (14), an increase in the given market share x_0 increases the equilibrium output with indirect network externalities, whereas given (11), the increase reduces the equilibrium output with direct network externalities.

3. Conclusion

Based on a very simple monopoly model, we considered how consumer expectations of network size affect the fulfilled expectations equilibrium by focusing on the proportion of consumers committing to an *ex ante* expectation of network size. In particular, it is not beneficial for both the monopolist and consumers themselves for consumers to hold the *ex ante* sticky expectations of network size. This implies that the behavior of consumers, who form expectations of network size before a firm's decision, may be rational, but not be necessarily natural in terms of the fulfilled expectations equilibrium.

From the viewpoint of "consumer coordination in mass marketing of network products industries" (Spulber, 2007, p. 236), we consider the implications of consumer expectations of network size. If consumers believe the announcement of planned output (market share, network size), the monopolist's commitment is credible. In this case, a Pareto-improving output level arises for both the monopolist and consumers. However, if the announcement is not credible, consumers form their expectations prior to the output decision. Thus, the expectation is self-fulfilling, that is, the equilibrium output is equal to the initial expectation. This implies that a too low output level arises in the network market. To mitigate such risk, the monopolist may invest in costly and frequent advertising as measures of commitment and for signaling.

As noted by Spulber (2009, p.236), "network effects provide firms with the incentive to advertise, whether through informative message or signaling message." For example, advertising in communications networks helps consumers infer that many consumers subscribe to the network service. Accordingly, an individual consumer can suppose that he/she obtains benefits from the consumption (subscription) of many other consumers. As a result, allowing consumers to achieve mutual benefits of consumption, we can achieve consumer coordination. In our model, this implies that consumers form their expectation of network size using the actual output level announced by the monopolist.

There are some remaining issues to explore. In particular, we assumed a simple convex combination with respect to the formation of expected network size. However, we should examine the general formation of consumer expectations. Furthermore, we dealt with a monopoly case in which there are no strategic effects or network externalities with other firms, so we should consider the cases of duopoly and oligopoly. For example, Suleymanova and Wey (2012) examine the role of consumer expectations in a duopoly model à la Hotelling including network externalities. However, we can appreciate that the equilibrium outcomes in duopoly and oligopoly depend on the degree of strategic effects and network externalities as related to consumer expectations. If the degree of the latter is sufficiently larger than that of the former, the results may be very similar to those in the monopoly analyzed here.

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