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Non-monotonic network effects and market entry

Alexander Lundberg *

Department of Economics, Emory University, 1602 Fishburne Drive, Rich Building 306, Atlanta, GA, 30322, USA

HIGHLIGHTS

- Equilibrium firm entry may not be optimal in markets with product diversity.
- With competition in price, entry is always excessive.
- Entry remains excessive for goods with monotonic network effects.
- Entry can be excessive or insufficient when network effects are non-monotonic.

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ABSTRACT

The simple circular model of horizontal product differentiation, in which firms compete in price, is characterized by excessive firm entry in equilibrium. When non-monotonic network effects are present, this result no longer holds. If consumers differ in their optimal number of other consumers choosing their same good, entry in equilibrium can be insufficient.

1. Introduction

When firms incur a fixed cost to enter a market, allowing them free entry can result in social inefficiency—too many or too few firms may enter the market. Following Spence (1976), Mankiw and Whinston (1986) show that when firms compete in quantity, entry can be either excessive or insufficient if consumers value product diversity. When firms compete in price, however, entry is always excessive (Salop, 1979).

Interestingly, entry is still excessive under price competition for network goods, assuming network effects are monotonic (Navon et al., 1995). The utility of a "network" good depends on the number of consumers using it. That effect may be positive, on account of a bandwagon effect or collaborative opportunity, or negative, on account of traffic congestion or the "snob effect" of exclusivity.

An understudied feature of network effects is their possible non-monotonicity. The utility of many goods can rise and fall with the population of consumers. At a restaurant, you might feel conspicuous as the only patron, but with too many patrons the venue becomes overcrowded, and service deteriorates. In fashion, most people want neither to stand out wildly nor conform exactly to those around them. That desire is not limited to clothing but extends to automobiles, music, and beer brands, among other goods.

This article shows that when consumers differ in their optimal number of other consumers choosing the same good, entry can be insufficient even in markets with price competition. Equivalently, if some consumers face positive network effects and others negative, too few firms may enter. The result is perhaps surprising since it does not arise under monotonicity, and the intuition is explained in the following.

* Tel.: +1 540 808 3812.
E-mail address: alundbe@emory.edu.

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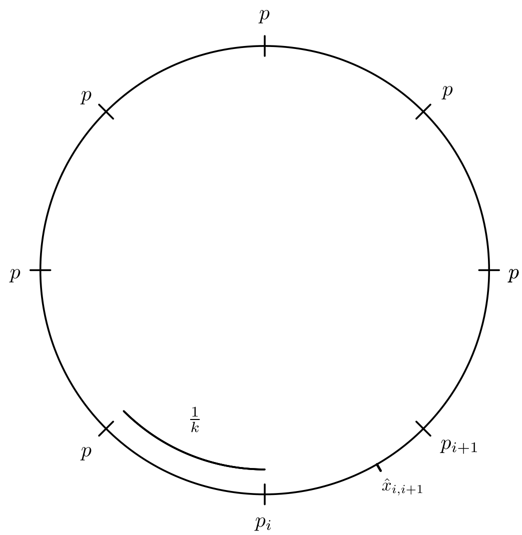

Fig. 1. Circular model.

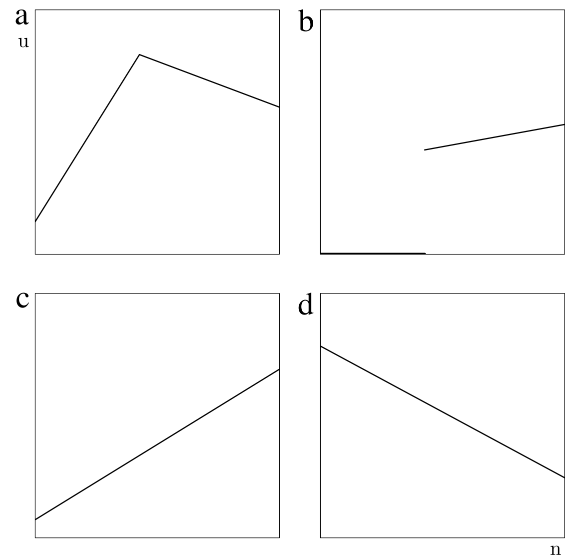

Fig. 2. Network preferences.

2. The basic model

Consider a modified version of the basic Salop circle model with a mass of N consumers distributed uniformly around a circle of unit length. The circle is an abstract product space meant to capture product differentiation. A total of k firms endogenously enter at equidistant locations and compete in price. Consumers buy one unit of a good from which they derive a benefit v but incur a cost τ for being away from their ideal location of the good. They also face identical, non-monotonic network effects, i.e., they all have the same optimal number of other consumers choosing their same good, n_{op}. Below this number, they benefit from additional consumers; above it, they are harmed by additional consumers. This effect is captured by a term in the consumer utility function,

$$NE(n_i - n_{op}) = \begin{cases} \theta_1 |n_i - n_{op}| & \text{if } n_i < n_{op} \\ -\theta_2 |n_i - n_{op}| & \text{if } n_i \geq n_{op}, \end{cases}$$

where n_i is the number of consumers buying good i, and θ_j $(j = 1, 2)$ measures the relative importance of the network effect.

When $\theta_1, \theta_2 > 0$, preferences are non-monotonic, as displayed in panel (a) of Fig. 2. Notice, however, that by allowing θ_j to take on different signs and n_{op} to be zero, various other examples are accommodated. If $\theta_1 = 0$ and $\theta_2 < 0$, as in panel (b) of Fig. 2, network effects do not provide utility until some critical population threshold is met. If $n_{op} = 0$, then we are back in the monotonic case of panel (c) or (d), depending on whether θ_2 is negative or positive.

The utility of a consumer located at x is $v - p_i + NE(n_i - n_{op}) - \tau |l_i - x|$ when she buys from firm i with location l_i and price p_i. A consumer located between firms i and $i + 1$ chooses from which firm to buy according to $\max_i \text{u} = v - p_i + NE(n_i^e - n_{op}) - \tau |l_i - x|$, where n_i^e is the expected number of consumers buying good i. The consumer $\hat{x}_{i,i+1}$ who is indifferent between buying from the two firms (see Fig. 1) is then defined by

$$v - p_i + NE(n_i^e - n_{op}) - \tau \hat{x}_{i,i+1}$$
$$= v - p_{i+1} + NE(n_{i+1}^e - n_{op}) - \tau \left(\frac{1}{k} - \hat{x}_{i,i+1} \right). \quad (1)$$

Customers to the left of $\hat{x}_{i,i+1}$ buy from firm i, and customers to the right buy from firm $i + 1$.

Under the common assumption of fulfilled expectations, consumers behave in such a way that their expected consumption of each good is equal to their actual consumption of it. Thus, $n_i^e = N(\hat{x}_{i,i+1} + \frac{1}{k} - \hat{x}_{i-1,i})$.

3. Equilibrium and excessive entry

3.1. Large market

Consider first the case of a "large" market (in terms of consumers), where N is great enough that $n_i^e - n_{op} > 0 \ \forall i$. Using an equation analogous to (1) for $\hat{x}_{i-1,i}$ along with the equilibrium conditions that $p_j = p \ \forall j \neq i$ and $\hat{x}_{j,j+1} = \frac{1}{2k} \ \forall j \neq i, i-1$, we have[1]

$$\hat{x}_{i,i+1} = \frac{p - p_i}{2\tau + 3N\theta_2} + \frac{1}{2k}.$$

Firm i faces demand $\text{D}(p_i, p) = N[\hat{x}_{i-1,i} + \hat{x}_{i,i+1}] = N[2\hat{x}_{i,i+1}]$ when other firms charge p (we confine attention to symmetric equilibria); its profit function is $\max_{p_i} \pi_i = (p_i - c)\text{D}(p_i, p) - F$, where c is marginal cost and F is fixed cost. Solving the profit maximization problem and imposing symmetry, the equilibrium price is

$$p^e = c + \frac{2\tau + 3N\theta_2}{2k}.$$

With free entry, firms enter until profits are zero, and the equilibrium number of firms is

$$k^e = \sqrt{\frac{N(2\tau + 3N\theta_2)}{2F}}.$$

A larger market size N supports a larger number of firms in equilibrium. A higher cost of travel τ effectively increases the market power of each firm, which also supports a greater number of firms. Naturally, as fixed costs rise, fewer firms enter.

Negative network effects increase market power. Consumers are reluctant to switch firms in response to a price increase because they want to avoid joining other consumers. Conversely, positive network effects limit market power. To see the intuition in the model, put k^e into p^e, which yields

$$p^e = c + \sqrt{\frac{F}{2}} \sqrt{\frac{2\tau + 3N\theta_2}{N}}.$$

Then $\text{d}p^e / \text{d}\theta_2 > 0$, and firms are able to charge a higher price as θ_2 increases.

[1] Assuming a "covered" market, where every consumer buys the good.