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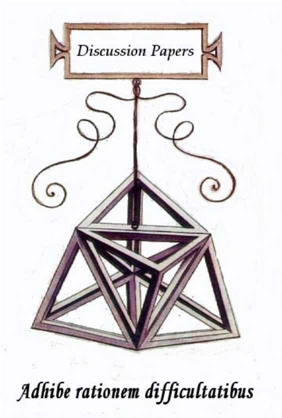

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The effect of network externalities on entry in a Spence-Dixit model

Discussion Paper n. 212
2016

Discussion Paper n. 212, presentato: **novembre 2016**

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Please quote as follows:

Domenico Buccella and Luciano Fanti (2016), "The effect of network externalities on entry in a Spence-Dixit model", Discussion Papers del Dipartimento di Economia e Management – Università di Pisa, n. 212 (http://www.ec.unipi.it/ricerca/discussion-papers.html).

Discussion Paper
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Domenico Buccella and Luciano Fanti

The effect of network externalities on entry in a Spence-Dixit model

Abstract

This paper studies the effect of consumption externalities on entry decision in network industries in a Spence-Dixit entry model. It is shown that, when entry is considered, the presence of network externalities raises the sunk cost threshold that blocks the potential competitor's entry. However, the difference between the thresholds to deter and accommodate entry enlarges: entry is relatively "less blockaded" but "more deterred" than in a standard goods industry.

Keywords: Network externalities; Entry; Deterrence; Monopoly; Duopoly.

JEL classification: L13; L20; L21

1 Introduction

In the recent decades network industries have reached an undeniable strong relevance in economics. The extensive circulation of mobile devices (smartphones and tablets) as well as the coupled use of computers and software in virtually all social and economic activities epitomize the increasing importance of network goods in contemporary everyday life.

As a broad definition, network goods are those in which the utility the typical consumer derives from the goods increases as the number of other consumers/users of those goods rises. Thus, positive network externalities occur whenever the amount of goods a consumer/user demands increases because of the purchase growth of other consumers/users of the same goods. Namely, the reason for a single consumer/user to buy a product lies partially behind the fact that other clients/users do. Moreover, additional product users can positively affect the demand for the network goods also because it may represent a signal of quality and availability of after-sale services for long-lasting consumers.

Because of the growing importance of network goods in recent decades, scholars have analyzed the impact of positive consumption externalities (or network effects) on the standard models of imperfect competition, focusing on which strategies can be used to gain larger market share, for instance stressing the importance of *i)* the compatibility between products (e.g. Katz and Shapiro, 1985; Farrell and Saloner, 1985), *ii)* pricing practices aimed at attracting the opportune number of adopters to influence market share dynamics (Cabral et al., 1999; Cabral, 2011), *iii)* consumer's behaviours in terms of expectations which can be influenced by pre-announcement effects on the product (Farrell and Saloner, 1986). In particular, the role played by the network externalities on the adoption of new technologies has been investigated by Farrell and Saloner (1985, 1986), Katz and Shapiro (1992), Farrell and Klemperer (2007) and recently by Norbäck et al. (2014). Other authors have more recently focused on the themes of managerial delegation (Hoernig, 2012; Chirco and Scrimitore, 2013; Battacharjee and Pal, 2013, 2014; Fanti and Buccella, 2016a), labour market bargaining agenda (Fanti and Buccella, 2016b), tacit collusion (Pal and Scrimitore, 2016) and Cournot-Bertrand profit ranking (Pal, 2014) in network industries.[1] The present work takes a different route and investigates the issue of the effects of network externalities on entry.

In his pioneering work, Spence (1977) analyses the strategic choice of the incumbent firm's capacity in the presence of potential entry in an industry with standard goods. That author explicitly distinguishes between capacity and quantity produced. The amount of capacity the incumbent invests in the first period represents a constraint on the quantity produced. If the costs of entry

[1] The issue of network externalities in economics has been surveyed from the main points of view: for instance, to mention a few, empirically (Birke, 2009), experimentally (Ruffle et al., 2015) and theoretically (Shy, 2011).

costs are sufficiently low, the incumbent will accommodate entry. In the event of a threat of entry, the incumbent can fix a sufficiently high capacity and, eventually, expand its output level to reduce the price and deter the potential competitor's entry. However, if entry does not occur because of high entry costs, the capacity turns out to be underutilized. Dixit (1980) further investigates the role of an irrevocable investment commitment as entry-deterrence tool to alter the initial conditions of the post-entry game to the advantage of the incumbent firm obtaining that, in contrast to Spence (1977), if the players agree to play the post-entry game according to Nash rules, the incumbent will not wish to install capacity that would be left idle in the pre-entry phase. However, those papers do not consider network industries.[2]

Some papers have investigated the influence of the network effect on the profits of the incumbent and the entrant arguing that network externality may have not univocal effects. For instance, Economides (1996) concludes that the incumbent monopolist will always invite entrants while Kim (2002), reconsidering the result of Economides (1996), demonstrates that it is inapplicable, particularly for homogeneous goods. Buccella and Fanti (2016) suggest that network effects may be an incentive to block market entry when their intensity is not excessively strong. However, these analyses focused on the concept of structural or "innocent" barriers to entry[3] rather than a more proper concept of strategic barriers to entry as in the Dixit-Spence framework which is commonly adopted in the industrial organization literature to study the issue of market entry. If the role played by network effects on the equilibrium outcomes of given markets has been deeply analysed, especially in the articles above mentioned, less attention has been devoted to the role exercised on the shaping of the market structure.

To the best of the authors' knowledge, the unique paper examining the subject of entry in network industries is Norbäck et al. (2014).[4] Those authors

[2] There is a large economic literature which investigates different aspects of entry. For example, under diverse frameworks, several papers have challenged the traditional view that entry decreases the incumbent's profits, see inter alias Tyagi (1999), Naylor (2002a,b) and Mukherjee et al. (2009) for vertical relations; Pal and Sarkar (2001) and Mukherjee and Zhao (2009) for asymmetric cost firms; Coughlan and Soberman (2005); Chen and Riordan (2007) and Ishibashi and Matsushima (2009) for differentiated goods; Ashiya (2000) and Ishida et al. (2011) for technology. Another line of research has studied the impact on entry of different alternative labour market institutions - see Bughin (1999), Buccella (2011) and, very recently, Fanti and Buccella (2016b) - and of corporate social responsibility (Fanti and Buccella, 2016c).

[3] This terminology refers to Church and Ware (1999, 487), as discussed in Buccella and Fanti (2016, 412-413).

[4] The role of product incompatibility together with incumbents' installed bases with regard to the formation of barriers to entry has been also noted, still focusing on the issue of the adoption of new technologies in industries with network effects, by Farrell and Klemperer (2007) who argued that when the network effects are strong these entry barriers can disfavour the development of innovations.

investigate how bidding competition between incumbents for new entrepreneurial firms affects the incentives for innovation in industries in which an installed bases and network externalities exist,[5] showing that network effects and installed bases do not necessarily limit the innovation incentives.

This paper contributes to the literature on network effects by developing an extremely simplified version of the Spence-Dixit model of competition in network industries that allows for investigating whether and how entry into the industry is affected by network effects.

The paper's findings complement those of the preceding literature as below presented. The main messages of the present paper are as follows. In an entry game with incumbent and potential entrant producing homogeneous network goods, the presence of network externalities raises the critical threshold of the sunk costs that blocks the entry of the potential competitor. However, at the same time, the difference between the sunk cost thresholds that deter and accommodate entry in the industry enlarges. In other words, in network industries, entry is relatively "less blockaded" but "more deterred" than in industries with standard products.

The remainder of the article is organized as follows. Section 2 describes the model and revisits the issue of output choice to deter entry in a network industry. Finally, the last section summarises the key findings of the paper and their implications, and suggests possible directions for further research on the subject.

2 The model

In the present work, we assume that the simple mechanism of network externalities is represented by the fact that the surplus a firm's client obtains increases directly with the number of the clients of all firms in the market (i.e. Katz and Shapiro, 1985). This can be a fairly reasonable assumption if one thinks that smartphone, tablet and laptop users' utility deriving, for example, from the utilization of mailboxes, instant messaging apps, video calling etc. increases independently of the specific brand of these devices: the relevant thing is to possess one of them.

Following Fanti and Buccella (2016a,b) and Buccella and Fanti (2016), the monopolist faces the following linear direct demand:

$$q = a - p + ny \qquad (1)$$

where q denotes the quantity of the goods produced and y is the consumers' expectation about the monopolist's equilibrium production. The parameter

[5] The authors show to what degree the opportunity of selling out to an incumbent raises the incentives for innovation for entrepreneurs when the network intensity is strong and incumbents compete to buy preventively innovations.

$n \in [0,1)$ represents the intensity of the network externalities: the higher the value of the parameter is, the stronger the externalities are. The inverse demand function is:

$$p = a - q + ny \quad (2)$$

where p is the price of goods. To focus on the impact of the network effect in this industry, the marginal cost is set to $c = 0$. Another interpretation of the latter condition could be that the labor market is competitive, and the firm can hire workers at the competitive wage, normalized here to zero.

2.1 Monopoly

Given (2), the monopolist's profit function is

$$\Pi = (a - q + ny)q\,. \quad (3)$$

Maximization of (3) yields

$$q = \frac{a + ny}{2} \quad (4)$$

From (4), after the imposition of the "rational expectations" condition $y = q$, the equilibrium output level is

$$q^M = \frac{a}{2 - n} \quad (5)$$

where the upper script M stands for "monopoly". After substitution of (5) into (3), the profits of the monopolist are

$$\Pi^M = \frac{a}{(2 - n)^2} \quad (6)$$

2.2 Output choice in the Spence-Dixit model

This subsection analyzes the incumbent output choice in a Spence-Dixit framework (Spence, 1977; Dixit, 1980) when there is potential entry in the industry. For the scope of the present paper, we follow the simplified version of the Spence-Dixit model presented in Shy (1995, pp. 188-192), and we adapt it to network industries. We define Firm 1 as the incumbent while firm 2 defines the potential entrant. As in Fanti and Buccella (2016a) and Buccella and Fanti

(2016), the firms are assumed to produce homogeneous network goods. As a consequence, in duopoly, the demand function becomes

$$p = a - q_1 - q_2 + n(y_1 + y_2). \quad (7)$$

The firms' profit function are defined by

$$\Pi_1 = pq_1 \quad (8)$$

$$\Pi_2 = pq_2 - F \quad (9)$$

for the incumbent and the entrant, respectively. The term $F > 0$ represents an exogenous fixed cost that the entrant faces if it enters the market. The game is a two-stage game in which, in stage 1, the incumbent sets its output q_1, and in stage 2 the entrant, after observing the incumbent's choice, decides its own production level q_2. In case of no-entry, $q_2 = 0$.Taking into consideration the rational expectation hypothesis, then the firms set the market clearing price when they produce at full capacity, that is

$p = a - (1-n)(q_1 + q_2)$, and $p = 0$ *if* $a \leq (1-n)(q_1 + q_2)$.

Therefore, the incumbent profits are

$$\Pi_1 = [a - q_1 - q_2 + n(y_1 + y_2)]q_1 \text{ if } a > (1-n)(q_1 + q_2) \quad (13a)$$
$$\Pi_1 = 0 \text{ if } a \leq (1-n)(q_1 + q_2), \quad (13b)$$

and for the entrant,

$$\Pi_2 = [a - q_1 - q_2 + n(y_1 + y_2)]q_2 - F \text{ if } (1-n)q_2 > 0 \text{ and } a > (1-n)(q_1 + q_2) \quad (14a)$$

$$\Pi_2 = -F \text{ if } (1-n)q_2 > 0 \text{ and } a \leq (1-n)(q_1 + q_2) \quad (14b)$$

$$\Pi_2 = 0 \text{ if } q_2 = 0 \quad (14c)$$

In case of no threat of entry, the incumbent chooses the output level q_1 such that it acts as a monopolist. Therefore, the incumbent maximizes (3) which, after imposing the "rational expectations" condition $y = q$, leads to the equilibrium output level in (5) and profits in (6). At firm 1's output level in (5), and given the rational expectation hypothesis $y_i = q_i$, $i = 1, 2$, the maximum profit that firm

2 can earn in case of entry is obtained by solving the problem in (14) which yields $q_2 = \frac{a}{(2-n)^2}$ and $\Pi_2 = \frac{a^2}{(2-n)^4} - F$. Therefore, it follows that for

$$F \geq F^B \equiv \frac{a^2}{(2-n)^4} \qquad (15)$$

entry in the industry is blockaded (the upper script B stands for blockaded). A direct comparison with the case of standard goods ($n = 0$) reveals the following result.

Result 1 *Network externalities make the threshold of the sunk cost that block entry higher than that with standard goods. In other words, in network industries, entry is "less" blockaded.*

However, the entry of the potential competitor can be deterred by the incumbent via the decision of a suboptimal quantity with respect to the case of absence of threat of entry.

If $F < F^B$, entry will occur if the incumbent disregards the competitor's possibility of entry and maintains the monopoly output. However, if it selects an output level adequately high, entry will be unprofitable for the competitor. The threshold level of the incumbent's output q_1^{ED} (where ED stands for entry deterrence) such that the entrant becomes indifferent between entry the industry or stay out can be found by solving the following problem

$$\max_{q_2}[a - q_1^{ED} - q_2 + n(y_1 + y_2)]q_2 = F \qquad (16)$$

Given the rational expectation hypothesis, the entrant's reaction function is

$$q_2 = \frac{a-(1-n)q_1^{ED}}{2-n} \qquad (17)$$

and profits

$$\Pi_2 = \frac{[a-(1-n)q_1^{ED}]^2}{(2-n)^2} \qquad (18)$$

Substitution of (16) in (18) and solving for F yields

$$q_1^{ED} = \frac{a-(2-n)\sqrt{F}}{1-n} > \frac{a}{2-n} \; for\ F < F^B \tag{19}$$

In stage 2 of the game, if $F < F^B$ and the output in stage 1 is $q_1 \geq q_1^{ED}$, then entry does not take place. On the other hand, if $q_1 < q_1^{ED}$, firm 2 enters. Solving the maximization problem in (14a), the firm 2's reaction function is

$$q_2 = \frac{a - q_1 + n(y_1 + y_2)}{2}. \tag{20}$$

Substituting (20) into (13a), the incumbent profits are

$$\Pi_1 = \frac{[a - q_1 + n(y_1 + y_2)]q_1}{2}. \tag{21}$$

In stage 1, the incumbent payoffs are then as follows

$$\Pi_1 = \frac{[a - q_1 + n(y_1 + y_2)]q_1}{2},\ q_1 < q_1^{ED} \tag{22a}$$

$$\Pi_1 = [a - (1-n)q_1]q_1,\ q_1 \geq q_1^{ED} \tag{22b}$$

The incumbent does not produce at $q_1 > q_1^{ED}$ because $q_1^{ED} > q_1^M$ and, therefore, $\frac{\partial \Pi_1}{\partial q_1}\Big|_{q_1^{ED} > q_1^M} = a - 2(1-n)q_1 < 0$. It follows that the optimal output choice for the incumbent in the range $[q_1^{ED}, a]$ is $q_1^{ED} = \frac{a-(2-n)\sqrt{F}}{1-n}$ and, therefore, the deterring profits are

$$\Pi_1^{ED} = \frac{[a-(2-n)\sqrt{F}][(2-n)\sqrt{F}]}{(1-n)} \tag{23}$$

On the other hand, in the range $[0, q_1^{ED})$, the optimal output level for the incumbent is derived from (22a)

$$\frac{\partial \Pi_1}{\partial q_1}\Big|_{q_1 < q_1^{ED}} = 0 \Rightarrow q_1 = \frac{a + n(y_1 + y_2)}{2} \tag{24}$$

Recalling the rational expectation hypothesis, the incumbent and entrant's reaction functions are

$$q_1 = \frac{a + nq_2}{2-n}\text{; } q_2 = \frac{a-(1-n)q_1}{2-n}. \tag{25}$$

Solving the system in (25), the equilibrium output levels are for the incumbent and the entrant are, respectively,

$$q_1 = \frac{2a}{4-3n}\text{; } q_2 = \frac{a}{4-3n}. \tag{26}$$

Consequently, further substitution of the output levels in (26) leads to the accommodating (upper script A) profits, given by

$$\Pi_1^A = \frac{2a^2}{(4-3n)^2}. \tag{27}$$

A straightforward analytical inspection reveals that $\frac{\partial \Pi_1}{\partial n} > 0$: increasing network externalities allow to increase the incumbent's accommodating profits. It follows that the entry deterring profits in (23) are larger than the accommodating profits in (27) if

$$\frac{[a-(2-n)\sqrt{F}][(2-n)\sqrt{F}]}{(1-n)} \geq \frac{2a^2}{(4-3n)^2},$$

implying

$$F \geq F^{ED} \equiv \frac{a^2[12-20n+9n^2-(4-3n)\sqrt{9n^2-16n+8})]}{2(2-n)^2(4-3n)^2} \tag{27}$$

with $F^{ED} < F^B$ as shown in Figure 1. As a consequence, for $F \leq F^{ED}$, entry is accommodated, while for $F^{ED} < F \leq F^B$ entry is deterred with the incumbent setting the output level $q_1^{ED} = \frac{a-(2-n)\sqrt{F}}{1-n}$. On the other hand, for $F^B < F$, entry is blockaded. A direct analytical and graphical inspection reveals that increasing network externalities make entry easier to be deterred: in fact, $\frac{\partial(F^B - F^{ED})}{\partial n} > 0$. At the same time, network effects can make entry easier to be accommodated up to a certain level of their intensity: a numerical calculation allows to derive that for

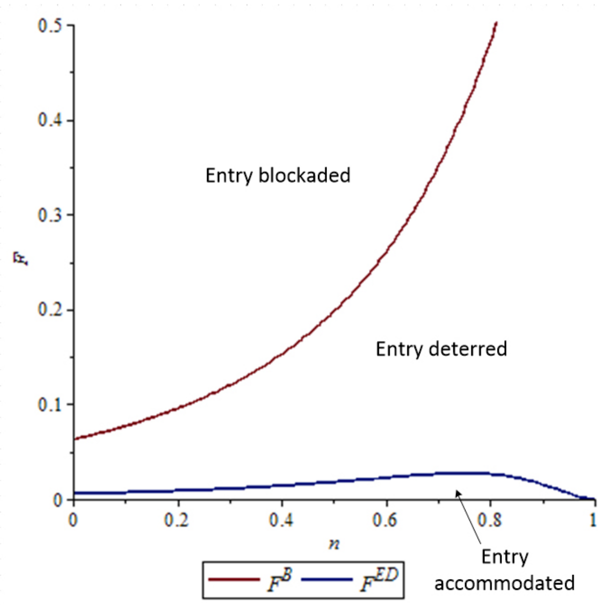

Fig. 1 *Plot of the sunk cost thresholds to blockaded and deterred entry in the "Spence-Dixit" framework. Legend:* The graph is drawn for $a = 1$.

$n \leq 0.752$, $\frac{\partial F^{ED}}{\partial n} \geq 0$. On the other hand, the presence of adequately strong externalities makes entry in the industry virtually impossible. Thus, network effects can work in favor of competition in a limited way; however, their presence makes the market more contestable. These findings are summarized in the following result.

Result 2 *Network externalities increase the difference between the thresholds of the sunk cost to block and deter entry. As a consequence, in network industries, entry is relatively "less blockaded" but "more deterred" than industries in which standard goods are produced.*

Finally, given the quantities in (26), it follows that the incumbent market share in case of accommodating entry is

$$MS_1 = \frac{q_1}{q_1 + q_2} = \frac{2}{3},$$

which is the standard result obtained in the classical Stackelberg leader-follower game with standard goods. Therefore, the following result holds.

Result 3 *In case of entry, the network externalities have no effect on the relative market share.*

3 Conclusion

This present work has investigated the impact of network externalities on the entry decision of a potential competitor in a network industry. In particular, the paper has analysed the impact of network effect on the capacity choice as entry deterrence mechanism in the Spence-Dixit model. It has been shown that the presence of network externalities increases the critical sunk cost threshold such that the entry of the potential competitor is blockaded. Nevertheless, the difference between the sunk cost thresholds such that entry is deterred and accommodated broaden. As a consequence, entry emerges to be relatively "less blockaded" but "more deterred" in network industries than in industries with standard goods. Therefore, the testable implication of this work is that in network industries where an "historical" incumbent operates the market structure is potentially more competitive.

The present study adds a further brick to a more extensive understanding of the subject of industry entry, a central aspect for the comprehension of product market competition, revealing that the intensity of network effects plays an important role in shaping the market structure. Nonetheless, the issues investigated in the current work are not exhaustive. First, the analysis has been focused only on the strategic moves of incumbent and entrant, while disregarding the impact on consumers and the overall social welfare. The peculiarity of the network industries should be taken into account when governments and antitrust authorities would design the appropriate regulatory framework intervention. A further investigation in this direction is, therefore, essential. Moreover, the results of the present are based on specific assumptions. The marginal cost of production has been considered constant at zero. Positive cost of production with different production technologies such as decreasing returns to scale, and the role of R&D investments are, for instance, further elements deserving research. Furthermore, given the widespread presence of firms' social concerns in network industries, also the effects on entry of the interplay of such social concerns with network effects is worth considering.

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