Alma Mater Studiorum - Università di Bologna
DEPARTMENT OF ECONOMICS

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Quaderni - Working Papers DSE N° 716

Is conformism desirable? Network effects, location choice, and social welfare in a duopoly.*

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October 7, 2010

Abstract

In this paper we study a duopoly where the network effect is nonmonotone and the network can be overloaded. The firms choose prices and locations endogenously, and the agent's utility is influenced by the number of people patronizing the same firm she does. We determine the market equilibrium, and we study how the network effect influences social welfare. We compare this setting with the standard horizontal differentiation model with no network effects to understand whether and how conformism is socially desirable. The results show that whether network effects are desirable depends on *how* people are conformist, and whether overloading is feasible. If overloading is not possible (in either of the firm's network), and the total consumers' mass is sufficiently high, a network effect which is slightly concave increases social welfare. By contrast, if overloading is feasible, and the total consumers' mass is sufficiently small, social welfare is increased if the network effect is more concave than in the previous case.

JEL classification: L14, D62.

Keywords: network effects, horizontal differentiation, duopoly, overloading, non-monotonicity.

*I thank my supervisor, Vincenzo Denicolò and Raimondello Orsini for useful suggestions. I am also grateful to STICERD - The London School of Economics and Political Science, where part of this work has been developed while I was a visiting research student. The usual disclaimer applies.

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1 Introduction

Yesterday evening I met some friends for a pub crawl in London. We first went to George IV, the pub of the university, but it was crowded, with many people standing outside. We thus decided to go to the Ship Tavern, which is the closest. Once entered the pub, we realized that it was almost empty. Finally, even though it was a little farer away from the university, we moved to the Shakespeare's Head, on Kingsway, where we found a fair amount of customers, and sat and drunk our drinks.

This little narrative entails the main ingredients of this paper: the nonmonotonicity of network effects, the distance of goods, and the positioning of retailers. As the story suggests, network effects are not always increasing in the number of people participating in the network. Casual observation suggests that people prefer a fair amount of the others sharing a place, or exhibiting the consumption of a good. This fact can be noticed also in the market for fashion products: you may want neither to be the only weird person wearing a kind of clothes nor that everyone dresses like you.[1]

Excessive crowding could moreover generate disutility as well as a standard overloaded network, or traffic jam. The marketing literature has shown extensive evidence about how retail crowding affects consumers' behavior (e.g. Eroglu and Harrell, 1986; Eroglu et al. 2005). Individuals vary in their tolerance to crowding and excessive crowding can decrease hedonic utility or generate disutility. Nevertheless, crowding tolerance does not only depend on individual factors, but also has cultural roots which make the average level of crowding tolerance differing across cultures.[2] For example, Kaya and Weber (2003) study a sample of American and Turkish students, showing that the Turkish students have a higher perception of crowding with respect to the Americans. Pons and Laroche (2007) study a sample of Canadian and Mexican students and find that the perceived level of crowding in the same situation is on average higher among the Mexican students. In an analogous study, Pons et al. (2006) find that Lebanese students' average perception of crowding is higher than Canadian students'. These differences can be explained by national cultural dimensions, such as the degree of individualism, i.e. the extent to which

[1] For an explanation of this phenomenon in terms of signalling see Pesendorfer (1995), considering fashion cycles.

[2] Tabellini (2008) observes that in the economic literature the notion of culture has been defined in different ways as: a) a selection mechanism among multiple equilibria or in repeated interactions; b) the set of beliefs manipulated by earlier generations regarding the consequences of the individual's actions; c) primitives values and individual preferences. Guiso et al. (2006) suggest that, whichever the definition, the identification of the cultural influence should exploit those aspects not changing along the individual's life and typically inherited from generation to generation.

people are expected to look after only themselves or the closest relatives. On the basis of the work by Hofstede (2001)[3], America and Canada score high in individualism, while Mexico, Turkey, and Lebanon score low. Mooij and Hofestede (2002) hypotize that, more in general, converging of technology and income will lead to heterogeneity in consumer behavior based on cultural differences, with relevant implications for social welfare.

For these reasons, the aim of this paper is to understand whether and how the shape of network effects influence social welfare. While casual observation is confirmed by the evidence shown above, the majority of research on network effects and externalities has concentrated on monotonicity. We thus focus on network effects which are nonmonotone in the number of people consuming a good at the same location (in a dimension of the product). We introduce moreover the possibility for overloading.

We consider a duopoly where the firms can choose prices and locations, and where the utility of a consumer is influenced by the number of people patronizing the same firm. We determine the market equilibrium and the incentives for each firm to undercut the rival both at the price stage and at the location stage. We then proceed to study how the network effect influences social welfare, and the role played by its concavity, nonmonotonicity, and the possibility of overloading. Finally, we compare this setting with the standard horizontal differentiation model to understand when conformism is socially desirable.

We find that the firms have no incentives to undercut at the price stage, while at the location stage there are incentives for displacing the location to capture the rival's market. The introduction of nonmonotonicity and overloading thus imposes further conditions on the existence of a subgame perfect equilibrium in pure strategies. The equilibrium can exist either at the increasing or at the decreasing part of the network effect, or both. It can also exist when the network is overloaded. We moreover show that the overloading of the network raises prices and thus has anti-competitive effects. We observe that the endogenous determination of the locations allows the firms to differentiate only horizontally. This suggests that the choice of differentiating vertically by firms should entail some rigidity in the location choice of the firms.

Comparing the social welfare in the case with network effects to the case in which they

[3] The most widely used measurements of culture across the social sciences are the Hofstede's dimensions. The Hofstede's book is one the most quoted in the Social Science Citation Index, but, surprisingly, it is little known among the economists. Hofstede (2001) proposes four dimensions of national culture: individualism (IDV), power distance (PDI), uncertainty aversion (UAI), and masculinity (MAS). They are based on 117000 questionnaires surveyed in the period 1967 – 1973 at the IBM Corporation, with 88000 employees responding, across 72 countries and 20 languages. They are stable across years, as numerous studies have subsequently validated them, and they exhibit a high degree of correlation with competing frameworks.

are absent, we find that the firms' profits are increasing in the network effects only if the network can be overloaded. The consumers' surplus is decreasing in the concavity of the network effect, while by contrast profits are increasing. The results show that whether network effects are socially desirable depends on *how* people are conformist, and whether overloading is feasible. If overloading is not possible (in either of the firms' network), and the total consumers' mass is sufficiently high, a network effect which is slightly concave increases social welfare. By contrast, if overloading is feasible, and the total consumers' mass is sufficiently small, social welfare is increased if the network effect is more concave than in the previous case.

We extend the existing literature along the following lines: in this paper the network effect can be nonmonotonic and negative; it does not depend directly on the total size of the network, but only on the size of consumers patronizing the same store; finally, the network can be overloaded. Pesendorfer (1995) proposes a model of fashion cycles, where the consumers' utility displays nonmonotonic features similar to those adopted in this paper. He gives the conditions under which the consumers could be better off by banning fashion. Our approach is different from Pesendorfer's since we do not rely on signalling arguments, and we do not focus explicitly on fashion goods, even though our model could be applied to the fashion market. Nevertheless we share Pesendorfer's interest in the welfare analysis of exclusivist-conformist effects. Yang and Barrett (2002) study a continuous time optimization model considering a monopoly characterized by nonconcave and nonmonotonic network externalities. Their model differs from ours since strategic considerations are absent, and they do not study neither the case of overloaded networks, nor social welfare. Lambertini and Orsini (2005) study the existence of the equilibrium in a duopoly with Bertrand competition and endogenous choice of the locations. In their framework the network externality can be only monotone increasing, and the welfare analysis is not explicitly performed. We extend their contribution allowing it for nonmonotonicity and overloading. Our paper also relates to Grilo et al. (2001), who studies as well a duopoly with Bertrand competition, but with exogenously given locations of the firms. Even if they allow the network effect to be nonmonotone, in fact they focus on the role played by the *total* size of the network in the market equilibrium and mostly on the case of monotonic externalities, without considering the possibility for overloading. Our paper generalizes the functional form of the network externality adopted in their paper, and focuses on the role played by the number of people patronizing the same store.[4] Moreover, in our paper the firms locate endogenously, and we perform welfare analysis studying when the

[4] Of course, the total mass of consumers is going to play as well an important role in the determinants of the equilibrium and of social welfare.

network effects are beneficial. Finally, Grilo and Friedman (2005) consider a circular city model where consumers care about the others' identity. They study the optimal number of firms entering the market, and compare the case in which the network effect depends on consumers' identity with the case in which consumers are anonymous. Here we focus on anonimous consumers who care only about the number of people patronizing their store, we consider a standard differentiation model with quadratic transportation costs, and our welfare analysis targets the role of network effects on social welfare.

The paper is organized as follows. In the following section we present the duopoly sequential game and study the existence of an equilibrium. In section 3 we perform the social welfare analysis and we discuss the desirability of conformism, and in the last section we provide conclusions and directions for future research.

2 The model

Consider two firms, A and B, whose locations are x_A and x_B, where x_i, $i = A, B$ belongs to the compact subset $[\underline{x}, \overline{x}] \subset \mathbb{R}$. They sell at price p_i, have no production costs, and their locations are determined endogenously. The consumers are uniformly distributed over the interval $[0, 1]$ and n is their total mass. A consumer's indirect utility function is given by

$$U_i = K - p_i - t(x - x_i)^2 + E(n_i),$$

where K is the gross utility from consumption; $t(x - x_i)^2$ is the total trasportation cost, where $x \in [0, 1]$ is the location of the consumer and $t > 0$ is the unit transportation cost; n_i is the number of consumers patronizing store i, such that $\sum_i n_i = n$. The last term represents the network effect function. Analogously to Grilo et al. (2001), we define it as follows:

$$E(n_i) = \alpha n_i - \beta n_i^2, \tag{1}$$

and throughout the paper we will assume that $\alpha, \beta \geq 0$.[5] Notice that the network effect depends only on the number of consumers buying from the firm i, and not on the total mass of consumers. The network effect function is depicted in Figure 1. When the consumers' mass n is lower than $\alpha/2\beta$, it is clear that the individuals can face only an increasing network effect. By contrast, if $n > \alpha/2\beta$ the function can be nonmonotone. We will exploit

[5] We thus assume that the function is always concave. Considering the possibility for convexity could be a useful extension of this paper. For a case in which the externality function is convex, see Yang and Barret (2002).

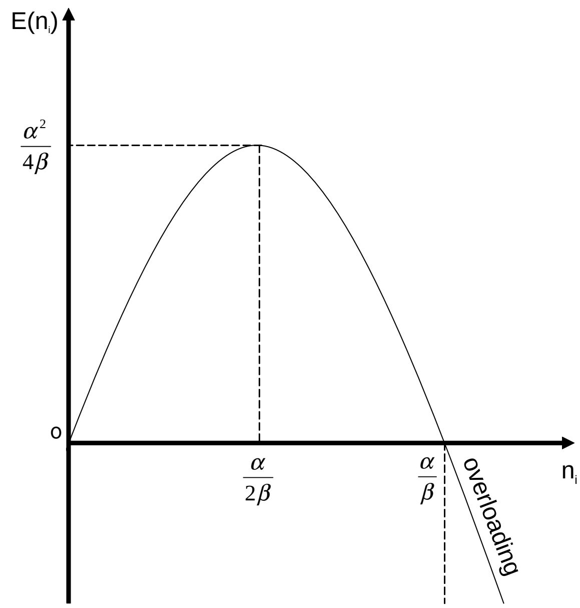

Figure 1: The network effect function

this fact to explore the role of monotonicity in this environment. The "OverLoading" threshold is n_{OL} [6], over which the excessive crowding of the market generates disutility.[7] The model reduces to a standard positional (or status) goods model setting $\alpha = 0$, to a standard linear network effect model setting $\beta = 0$. The comparison with the case in which the network effect is absent can be easily obtained by setting $\alpha = \beta = 0$.

The market is modelled as a two stage game, where in the first stage the firms choose their locations over the interval $[\underline{x}, \overline{x}] \subset \mathbb{R}$, and in the second stage choose prices. The

[6] It can be alternatively thought as congestion, or a vanity effect. Grilo et al. (2005) give two definitions in the same paper for vanity. The first is given by considering only the externality $E(n_i)$, and it says that vanity is displayed in consumer behavior when $\alpha < 0$, because consumers are always worse off when the size is increasing. This is true, but incomplete, since as noticed in the text, $E(n_i)$ can be negative also with $\alpha > 0$ and $n_i > \alpha/\beta$. In the same paper Grilo et al. (2005) state as well that consumer's preferences display vanity or conformity depending on whether the value of the externality is lower or greater than the transportation costs. Yang and Barret (2002) tribute the nonmonotonic shape of the network externality to the sum of a functionality effect and an exclusivity effect.

[7] The possibility for overloading was allowed also in Grilo et al. (2005), Young and Barret (2002), but the two papers nevertheless do not consider overloading (Grilo et al. limit the analysis to $n_i < \alpha/2\beta$, with brief considerations in the conclusions for the other case, and Young and Barret leave it for future extensions).

equilibrium is derived by backward induction as a subgame perfect Nash equilibrium in pure strategies.[8] We proceed to derive the solution of the second stage of the game.

2.1 Undercutting incentives and price stage

We denote with $\widehat{x}$ the position of the consumer indifferent between buying from A or B. Her position can be derived by setting $U_A(\widehat{x}) = U_B(\widehat{x})$, and by satisfying the condition $n_A = \widehat{x}n$ and $n_B = (1 - \widehat{x})n$. Then the indifferent consumer is given by:

$$\widehat{x} = \frac{p_A - p_B + t(x_B^2 - x_A^2) - \alpha n + \beta n^2}{2[t(x_B - x_A) - \alpha n + \beta n^2]}. \tag{2}$$

Focusing on the case of an interior equilibrium, the two firms maximize the profit $\Pi_i = p_i n_i$ choosing the price level. The solution for the prices at this stage is given by

$$p_A^* = \frac{t}{3}(x_B - x_A)(2 + x_B + x_A) - \alpha n + \beta n^2 \tag{3}$$

$$p_B^* = \frac{t}{3}(x_B - x_A)(4 - x_B - x_A) - \alpha n + \beta n^2. \tag{4}$$

Notice that whenever $n > n_{OL}$, that is the total size of the market allows at least one of the firms network to be overloaded, firms increase prices with respect to the standard case where $\alpha = \beta = 0$. This leads to the following Proposition.

Proposition 1 *If the total network size allows at least one of the firms' network to be overloaded, the network effect is anti-competitive.*

Any of the two firms can have incentives, provided that the other is playing p_i, to capture the whole market by undercutting the price. In the following Lemma we check that in fact an equilibrium in prices does exist.

Lemma 1 *Undercutting at the price stage is never profitable.*

Proof. The two firms are symmetric, we will thus provide the proof only for firm A's incentives to undercut. Firm A considers (4) as given, and to undercut sells at a price such that

$$\widehat{x}(p_A) = \frac{6n(\alpha - \beta n) + 3p_A + 2t(x_A - x_B)(2 + x_A + x_B)}{6[n(\alpha - \beta n) + t(x_\alpha - x_\beta)]} = 1.$$

[8] We limit ourselves to pure strategies and concave profit functions. When the pure-strategy equilibrium does not exist, a mixed-strategy equilibrium always exists in a finite strategic-form game. (see e.g. Nash, 1950; Osborne and Pitchik, 1987).

Solved for p_A and inserting into firm A's profits gives

$$\Pi_A^c = -\frac{2}{3}t(x_A - x_B)(x_A + x_B - 1)$$

i.e. firm A's undercutting profits, which are positive if and only if either $x_A > x_B \wedge x_B < 1/2 \wedge x_A + x_B < 1$, or $x_B > 1/2 \wedge x_A < x_B \wedge x_A + x_B > 1$. Let Π_A^* be the equilibrium profits, then undercutting is profitable if and only if $\Pi_A^* - \Pi_A^c < 0$, that is

$$\frac{n[t(x_A - x_B)(x_A + x_B - 4) - 3(\alpha n - \beta n^2)]^2}{18[t(x_B - x_A) - (\alpha n - \beta n^2)]} < 0,$$

which is never verified for any of the relevant values of the locations and of the parameters. The proof of the theorem for firm B's can be analogously obtained by inverting the indexes. ■

The equilibrium prices at the price stage are thus p_A^* and p_B^*. What follows takes into account the conditions for positive prices. In the next subsection we proceed to derive the condition for the existence of the equilibrium and the endogenous location choices of the firms.

2.2 The existence of an equilibrium and the location stage

We first study the conditions for a subgame-perfect equilibrium in pure strategies to exist. We then derive the candidates for the optimal locations, confining ourselves to the case of concave profit functions, and study whether there are any undercutting incentives to change the locations. Finally, we study the characteristics of the equilibrium.

Inserting p_i^* into the profit functions, $\Pi_i(x_A, x_B)$ depends only on the firms' locations. Considering the symmetry of the two firms, the second order conditions (SOCs henceforth) are given by

$$\frac{\partial^2 \Pi_i}{\partial^2 x_i^2} < 0. \tag{5}$$

The condition for (5) to be verified are stated in the following Lemma.

Lemma 2 $\frac{\partial^2 \Pi_i}{\partial^2 x_i^2} < 0$ *if and only if the conditions of either of the following cases are satisfied:*

1. $0 < \alpha n \leq \frac{\alpha^2}{2\beta} \wedge \alpha n - \beta n^2 > \frac{3}{2}t$;

2. $\frac{\alpha^2}{2\beta} < \alpha n < \frac{\alpha^2}{\beta} \wedge (\alpha n - \beta n^2 < \frac{9}{8}t \vee \alpha n - \beta n^2 > \frac{3}{2}t)$;

3. $\alpha n \geq \frac{\alpha^2}{\beta}$.

The proof is in the Appendix.

Let's now consider the solution of the location stage. Deriving the first order conditions, solving for x_A and x_B gives five critical points. The only candidate equilibrium such that the SOCs are verified is at the locations $x_A = -\frac{1}{4}$ and $x_B = \frac{5}{4}$, which are consistent with the results in the previous literature on product differentiation.[9]

The nonmonotonic network effects introduce conditions on the positivity of profits, as stated in the following lemma.

Lemma 3 *Consider the two locations $x_A = -\frac{1}{4}$ and $x_B = \frac{5}{4}$. The firms' profits*

$$\Pi_i = \frac{3}{4}nt - \frac{n}{2}(\alpha n - \beta n^2), \tag{6}$$

are positive if and only if either:

1. $0 < \alpha n \leq \frac{3}{2}t$;

2. $\alpha n > \frac{3}{2}t \wedge \alpha n - \beta n^2 < \frac{3}{2}t$;

for any $\alpha, \beta, n, t > 0$.

The proof is in the Appendix. Note that the first term of (6) represents the profits of the firms absent the network effect. The second part thus represents the component of the profits that is owed to the presence of the effects. If the term in brackets is positive, the network effect affects negatively the profits of the firms. In other words, profits decrease if the network effect is sufficiently low so as not to allow for overloading even if all consumers would be served by the same firm.

At $(-\frac{1}{4}, \frac{5}{4})$ the equilibrium prices are $p_i = \frac{3}{2}t - E(n)$. As long as $E(n) < \frac{3}{2}t$, the prices are thus above the marginal costs (here set equal to zero). Therefore, at the location stage each firm may displace its location so as to undercut the rival and capture the whole market. The following Lemma states the conditions under which this may happen.

Lemma 4 *At the two locations $x_A = -\frac{1}{4}$ and $x_B = \frac{5}{4}$, firm A monopolizes the market by displacing its location if and only if*

$$\alpha n \geq \frac{3}{2}t \wedge \frac{5}{6}t \leq \alpha n - \beta n^2 < \frac{3}{2}t. \tag{7}$$

[9] The equilibrium locations of the firms are outside the extremes of the consumers' positions, and are the same of those in the game without network effects. What is interesting is that the existence of an externality does not influence the strategic choice of the firms, see also Lambertini and Orsini (2005).

Proof. The setting is symmetric as in the undercutting price case. We thus consider the possibility for firm A to displace its location, given $x_B = \frac{5}{4}$. Thus we solve for which location $\widehat{x}(x_A, \frac{5}{4}) = 1$, which gives

$$x_A^{'} = \frac{1}{2} - \frac{[48t\ (\alpha n - \beta n^2) + 9t^2]^{\frac{1}{2}}}{4t};\ x_A^{''} = \frac{1}{2} + \frac{[48t\ (\alpha n - \beta n^2) + 9t^2]^{\frac{1}{2}}}{4t} \tag{8}$$

This means that the locations of firm A such that all the consumers buy from A are symmetrical with respect to the centre of the location interval. We thus study the incentive to undercut B when $x_A = x_A^{'}$. In this case, the profits from displacement are given by:

$$\Pi_A^{dis} = \frac{n[48t\ (\alpha n - \beta n^2) + 9t^2]^{\frac{1}{2}}}{2} - 2n(\alpha n - \beta n^2) - \frac{3}{2}nt. \tag{9}$$

Firm A's displacement profits are positive if and only if $0 < n < \frac{\alpha}{\beta}$ and $\alpha n - \beta n^2 < \frac{3t}{2}$, i.e. if the network effect evaluated at the total size is not overloading, and the level of the externality is sufficiently low. The profits for firm A at the $(x_A = -\frac{1}{4}, x_B = \frac{5}{4})$ equilibrium are given by

$$\Pi_A = \frac{n(\alpha n - \beta n^2)}{2} - \frac{3}{4}nt \tag{10}$$

and they are positive, according to Lemma 3, if and only if $\alpha n > \frac{3}{2}t \wedge \alpha n - \beta n^2 < \frac{3}{2}t$; or always when $0 < \alpha n < \frac{3}{2}t$. Let's call $\triangle\Pi = \Pi_A^{dis} - \Pi_A$. Firm A has an incentive to displace its location and capture the rival's share whenever $\triangle\Pi > 0$. Taking into account the conditions $\Pi_A^{dis} > 0$ and $\Pi_A > 0$, this happens if and only if either of the following holds:

1. $\frac{5}{6}t < \alpha n < \frac{3}{2}t \wedge (\alpha n - \beta n^2) > \frac{5}{6}t$;
2. $\alpha n \geq \frac{3}{2}t \wedge \frac{5}{6}t \leq (\alpha n - \beta n^2) < \frac{3}{2}t$.

The first can be ruled out by checking the SOCs. ■

Considering jointly Lemmata 1 - 4, in the following proposition we state the main result of this section.

Proposition 2 *The two locations* $x_A = -\frac{1}{4}$ *and* $x_B = \frac{5}{4}$ *are the unique subgame perfect equilibrium of the game in pure strategies if and only if either of the following holds:*

1. $\alpha n - \beta n^2 > \frac{3}{2}t \wedge \frac{\alpha-(\alpha-6\beta t)^2}{2\beta} < n < \frac{3t}{2\alpha}$;
2. $\alpha n - \beta n^2 < \frac{5}{6}t \wedge n > \frac{3\alpha+\sqrt{3}(3\alpha-10\beta t)^{\frac{1}{2}}}{4\beta}$;

and no subgame perfect equilibrium in pure strategies exists otherwise.

Proof. The proof is readily obtained by merging the conditions of Lemmas 2 - 4. Let's first consider the monotonic increasing part of $E(n)$, i.e. when $n < \frac{\alpha}{2\beta}$. By Lemma 1, the SOCs hold only if $E(n) > \frac{3}{2}t$, which implies $\frac{\alpha-(\alpha-6\beta t)^2}{2\beta} < n$; by Lemma 2 profits are positive for both firms if $0 < \alpha n \leq \frac{3}{2}t$, i.e. $0 < n \leq \frac{3t}{2\alpha}$. Thus, joining the two inequalities we get $\frac{\alpha-(\alpha-6\beta t)^2}{2\beta} < n \leq \frac{3t}{2\alpha}$, which leads to the first part of the proposition. Notice that by Lemma 4 in this range of n no undercutting incentives are at work, and of course if $t > \frac{\alpha^2}{3\beta}$ no subgame perfect equilibrium in pure strategies exists.

Consider now the monotonic decreasing part of $E(n)$. By Lemma 2, if $n > \frac{\alpha}{\beta}$ the SOCs are always met in the relevant range of the parameters. By Lemma 3 the positive profits' condition hold, since $E(n) < 0$. Finally, by Lemma 4 there are no incentives for displacement in this region. Let's now consider the case in which $\frac{\alpha}{2\beta} < n < \frac{\alpha}{\beta}$. In this region, SOCs require $E(n) < \frac{3}{2}t$ and profits' positivity is obtained if $E(n) < \frac{9}{8}t$. The latter is a more stringent condition. Nevertheless, by Lemma 4 in this region incentives for displacement are at work if $\frac{5}{6}t \leq E(n) < \frac{3}{2}t$, thus a subgame perfect equilibrium exists only for $E(n) < \frac{5}{6}t$, which corresponds to $n > \frac{3\alpha+\sqrt{3}(3\alpha-10\beta t)^{\frac{1}{2}}}{4\beta}$.This provides the second part of the Proposition. ■

The intuition for the proposition is represented in Figures 2-3, which show four possible cases emerging. Remember that the figure represents the conditions on the *total size* of the network, but the parameters are determined by the network effect on consumers' preferences for the number of people *patronizing the same store*.

In Figure 2 the total network size can be greater than α/β, i.e. there is the possibility for overloading. Consider A: the parabola represents the network effect evaluated at n, while the straight line is the linear positive component of it, which obviously cuts it in its maximum. The shadowed areas represent the locus where an equilibrium in pure strategies exists. On the right part of the parabola, the dashed area represents the part of the existence locus which is eroded by incentives to displace.

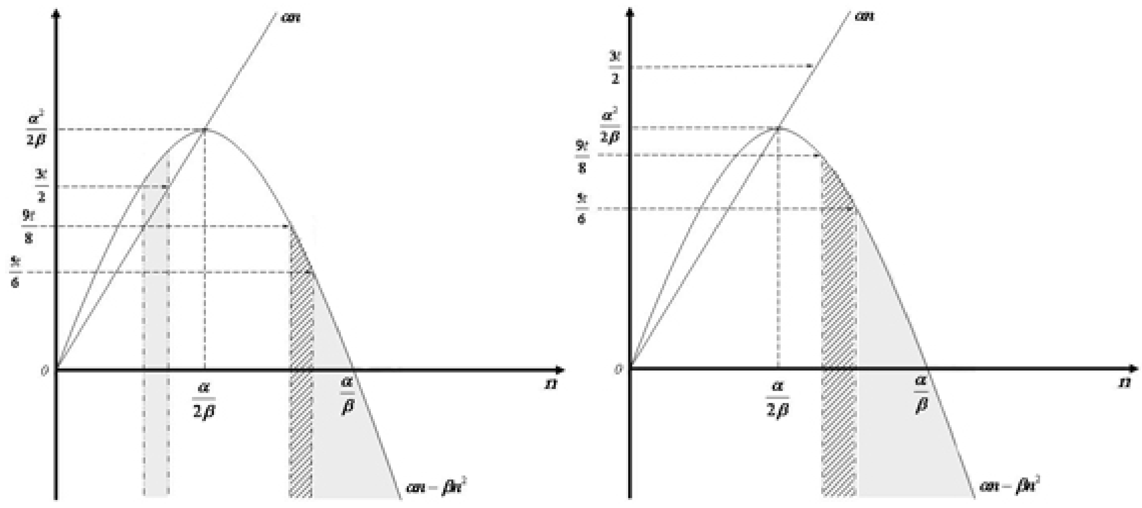

Figure 2: Overloading is feasible.

In this case an equilibrium exists both on the increasing side and on the decreasing size of the network effect. Consider now figure B: when the transportation cost is sufficiently high (that is when 3/2 of it are greater than the maximum value of the network effect), the equilibrium does not exist any more on the left side of the parabola. On the contrary, on the right side both the undercutting and the equilibrium spaces are increased. In both case A and case B notice that an equilibrium may exist as well in the overloading area[10].

Let's now consider in Figure 3 the case in which the total network size is such that overloading is impossible. In this case, the equilibrium does not exist anymore on the right side of the parabola. It is thus striking that the existence of the equilibrium in that area depends on the possibility for overloading. Figure 3C shows that an equilibrium can exist on the increasing side of the network effect if the transportation rate is sufficiently low (as in figure 2A). When this is not verified, figure 3D shows the case in which no equilibrium exists.

A further comment on the above proposition concerns the *kind* of differentiation of the products. As observed in Grilo et al. (2001), the differentiation in the model can be interpreted as *horizontal* if $0 < x_A + x_B < 2$, and *vertical* if either $x_A + x_B > 2$ or $x_A + x_B < 0$. The following Corollary thus stems directly from Proposition 1.

[10] As we will show in Lemma 5, the firms have unilateral incentives to deal with a market which could be overloaded.

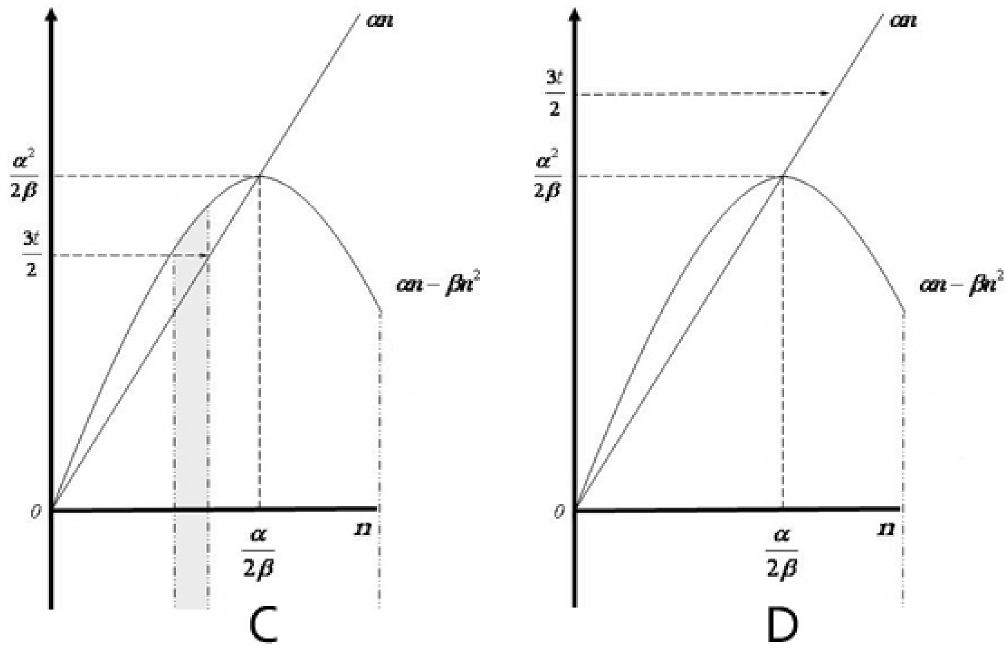

Figure 3: Overloading is not feasible.

Corollary 1 *If the firms choose endogenously their locations, at the equilibrium only horizontal differentiation can result.*

This result thus suggests that the choice of vertical differentiation should be driven by some rigidities in the location choice, so that horizontal differentiation is either non-available or does not entail a market equilibrium. We now proceed in the following section to perform the analysis of social welfare.

3 Social welfare and conformism desirability

In this section we study how the presence of the network effect influences social welfare, and the role played by concavity, monotonicity, and overloading. The consumer's surplus evaluated at the equilibrium values obtained in Proposition 1 is given by

$$
\begin{aligned}
CS &= \int_0^{\widehat{x}} K - p_A - t(x - x_A)^2 + \alpha n_A - \beta n_A^2 \, dx + \\
&\quad \int_{\widehat{x}}^{1} K - p_B - t(x - x_B)^2 + \alpha n_B - \beta n_B^2 \, dx \\
&= K - \frac{13}{48} t + \frac{1}{4}(2\alpha n - \beta n^2). \qquad (11)
\end{aligned}
$$

The last term is the component of the consumer's surplus deriving from the network effect. The following Lemma states when the presence of the externality positively affects CS and industry profits.

Lemma 5 *The network effect increases*

1. *consumers' surplus if and only if* $0 < n < \frac{\alpha}{\beta}$;
2. *firms' profits if and only if* $n > \frac{\alpha}{\beta}$.

See the Appendix for the proof. An interpretation of this result is that a positive network effect in the utility function (which depends only on the number of people consuming the good at the same firm) in equilibrium translates into a negative effect of opposite sign in the firms' profits, depending on the *total mass.* The consumers' preferences nevertheless determine the shape of the network effect evaluated at n. The firms thus have an inherent preference for markets in which the parameter α is low and concavity β is high. Looking at (11) and (6), notice that the consumers' surplus is decreasing, and the profits are increasing in the concavity of the effect.

Comparing the parts of the above Lemma, it is thus clear that, for some range of the parameters, the network effect increases industry profits while decreasing consumer's surplus. This happens when the size of the market allows it for overloading in the network patronizing either of the firms. Summing up, the net effect on social welfare is ambiguous, and there is the suspicion that the degree of concavity is crucial at determining social welfare. Social welfare is given by the sum of the consumer surplus and industry profits, that is:

$$
SW = CS + \sum \Pi_i = K + (\frac{3}{2}n - \frac{13}{48})t + \frac{\alpha n}{2}(1 - 2n) + \frac{\beta n}{4}(4n - 1). \qquad (12)
$$

Notice that SW is increasing in β if and only if $n > \frac{1}{4}$. We now want to compare (12) with the situation in which the effect is absent, that is if $\alpha = \beta = 0$. Social welfare with no externality is then given by:

$$SW^{ne} = K + (\frac{3}{2}n - \frac{13}{48})t. \tag{13}$$

The comparison of SW and SW^{ne} leads to the following Proposition, which states under what conditions the presence of the network effect increases social welfare.

Proposition 3 *Let* $\alpha, \beta > 0$.

The network effect increases social welfare if and only if either of the followings holds:

1. $\frac{1}{2} < n < \frac{\alpha}{\beta} \wedge \beta < \frac{\alpha(2-4n)}{n-4n^2}$;

2. $\frac{\alpha}{\beta} < n < \frac{1}{4} \wedge \beta > \frac{\alpha(2-4n)}{n-4n^2}$.

The proof is in the Appendix. The first part of the above proposition states the condition when the total mass of consumers does not allow for overloading. In this case, the network effect is desirable only if the mass of the population is sufficiently high and the concavity of the network effect is sufficiently small. The second part of the proposition considers the possibility for overloading. With respect to the other case, the externality is socially desirable only if the consumers' mass is low and the concavity sufficiently high. Notice, referring to Lemma 5, that the industry profits are increased by the network effect only in case 2.

Is thus conformism desirable? The above results show that the answer to this question depends on *how* people are conformist. If the consumers' mass does not allow for overloading (in either of the two firms), and is sufficiently high, then a network effect not too much concave increases social welfare. By contrast, if the consumers' mass allows for overloading, and is sufficiently small, a network effect more concave than in the previous case is needed to increase social welfare.

4 Conclusions

In this paper we studied how the existence of nonmonotonic network effects influences the welfare and the equilibrium properties of a Bertrand duopoly where the choice of locations is endogenous. We have shown the conditions for a firm to capture the rival's share at the location stage, and when an equilibrium in pure strategies exists. We then asked whether and how the presence of networks effects influences social welfare, and the answer is that it depends on the shape of the networks effect. Indeed, consumer's surplus is increasing while industry profits are decreasing in its level of concavity, thus creating ambiguity in the overall effect on social welfare. Considering social welfare, the determinants of the results are three: the consumer mass, the possibility of overloading, and the concavity of the network effect. We found that social welfare is increased by a network effect with small concavity when the consumers' mass is high and overloading is not feasible. By contrast, when the consumers' mass is low and overloading is feasible, social welfare is increased by a network effect that is highly concave.

The present work suggests that *how* people are conformist is an important part of the study of network effects. Nevertheless, it limits its analysis to a linear Bertrand duopoly, and to a specific network effect shape. Future research could explore a more general framework in which the network effect has a general shape, and in which the transmission of cultural values of collectivist societies versus individualism is challenged. By contrast, studying in detail markets with specific characteristics, such as the physical location of retailers or of restaurants and pubs, as well as the fashion designers choices in the space characteristics of the clothes, could provide useful insights on the determinants of social welfare, and eventually on regulation and public policy. Finally, it is interesting noticing that Mooij and Hofestede (2002) studying 14 different countries, without suggesting a causal effect, find that the number of cafè per million of inhabitants is negatively correlated with the degree of individualism. Given the existence of evidence about differences in the tolerance of crowding across cultures, an empirical study could attempt to find how different attitudes towards socialization marginally impacts the density and the locations of shops and retailers.

5 Appendix

5.1 Lemma 2

Proof. The second derivative $\frac{\partial^2 \Pi_A}{\partial^2 x_A^2} = \frac{\partial^2 \Pi_B}{\partial^2 x_B^2}$ with respect to locations is given by

$$\begin{aligned}
\frac{\partial^2 \Pi_i}{\partial^2 x_i^2} = & \frac{1}{9[n(\alpha - \beta n) + t(x_A - x_B)]^3} nt\{-6(\alpha^3 n^3 - \beta^3 n^6) - \\
& -t^2(x_A - x_B)^2[4\beta n^2(x_A + 2x_B - 6) + t(x_A - x_B)(x_A + 3x_B - 8)] + \\
& +2n^2 t(\alpha^2 + \beta^2 n^2 - \beta)[x_A(x_A - 10) - 3x_B(x_B - 4) - \frac{1}{2}] + \\
& +18\alpha^2 \beta n^4 + 2\alpha n[2t^2(x_A - x_B)^2(x_A + 2x_B - 6) - 9\beta^2 n^4]\}.
\end{aligned}$$

We then study when $\frac{\partial^2 \Pi_i}{\partial^2 x_i^2} < 0$ in the relevant parameter space, that is $\alpha, \beta, t, n > 0$ and $x_A, x_B \in \mathbb{R}$. Given the complexity of the SOCs, we split the parameter space of n in three sub-intervals, which correspond to the network effect function evaluated at n to be: a) monotonic increasing ($0 < n \leq \alpha/2\beta$), b) monotonic decreasing up to overloading ($\alpha/2\beta < n \leq \alpha/\beta$), and c) monotonic decreasing and overloaded ($n > \alpha/\beta$). Thus, solving the inequalities, $\frac{\partial^2 \Pi_i}{\partial^2 x_i^2} < 0$ if and only if either:

a) $0 < n \leq \frac{\alpha}{2\beta} \wedge \alpha n - \beta n^2 > \frac{3}{2}t$;

b) $\frac{\alpha}{2\beta} < n < \frac{\alpha}{\beta} \wedge (\alpha n - \beta n^2 < \frac{9}{8}t \vee \alpha n - \beta n^2 > \frac{3}{2}t)$;

c) $n \geq \frac{\alpha}{\beta}$. ∎

5.2 Lemma 3

Proof. By Lemma 1, each firm's profits are given by $\Pi_i = -\frac{2}{3}t(x_A - x_B)(x_A + x_B - 1)$. Substituting the equilibrium values $x_A = -\frac{1}{4}$ and $x_B = \frac{5}{4}$ and rearranging, one gets $\Pi_i = \frac{3}{4}nt - \frac{n}{2}(\alpha n - \beta n^2)$. The second part is the network effect evaluated at the consumer mass. In this paper we assume that $\alpha, \beta, n, t > 0$. It is clear that, whenever the overall network effect evaluated at the consumers' mass is positive ($\alpha n - \beta n^2 > 0$), profits are reduced from its presence. Then, profits are positive whenever $\alpha n - \beta n^2 < \frac{3t}{2}$. Since this implies $\alpha n < \frac{3t}{2} + \beta n^2$, this is clearly verified whenever $0 < \alpha n \leq \frac{3}{2}t$; if $\alpha n > \frac{3t}{2}$, then the it must be that $\alpha n - \beta n^2 < \frac{3}{2}t$. ∎

5.3 Lemma 5

Proof. Part one of the Lemma can be easily checked by solving $2\alpha n - \beta n^2 > 0$. To prove part 2, recall now from (6) that firms' profit are given by $\Pi_i = \frac{3}{4}nt - \frac{n}{2}(\alpha n - \beta n^2)$. Then the result is easily obtained by solving $\alpha n - \beta n^2 < 0$. ∎

5.4 Proposition 2

Proof. To check when the network effects are beneficial we consider the difference $\Delta SW = SWN - SW = \frac{\alpha n}{2}(1 - 2n) + \frac{\beta n}{4}(4n - 1)$. Notice that the transportation rate cancels out. Thus, whether $\Delta SW \lesseqgtr 0$ does not depend on the cost of transportation. First, $\Delta SW > 0$ if and only if

$$0 < \frac{\alpha n}{2}(1 - 2n) + \frac{\beta n}{4}(4n - 1). \tag{14}$$

Notice that for any $\alpha, \beta > 0$, this condition is never verified if and only if and only if $\frac{1}{4} < n < \frac{1}{2}$. Established this point, then consider two cases, when overloading is feasible and when it is not feasible. In the first case, $0 < n < \frac{\alpha}{\beta}$. It needs be $\frac{\beta n}{4}(4n-1) < \frac{\alpha n}{2}(1-2n)$, that is $\beta < \frac{\alpha(2-4n)}{n-4n^2}$. Since $\beta > 0$, to be verified it needs that $\frac{\alpha(2-4n)}{n-4n^2} > 0$. This is verified either if $n > \frac{1}{2}$ or if $n < \frac{1}{4}$, but the second solution can be discarded since it would imply that (14) is not verified. Analogously, in the second case, $n > \frac{\alpha}{\beta}$ (14) is verified if and only if $\beta > \frac{\alpha(2-4n)}{n-4n^2}$, which is verified if and only if either $n < \frac{1}{4}$ or $n > \frac{1}{4}$, but the latter can be discarded since (14) would be then negative. ■

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