Price-Setting Behavior in the Presence of Social Interactions

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Abstract

We analyze the effects of the presence of social groups on the price-setting behavior of a profit-maximizing monopolist that produces a good with a positive (local) consumption externality. The partition of society into groups does not unambigiously give the monopolist the opportunity to raise its price and increase its profit. The effects depend on a non-trivial interplay between the strength of the consumption externality and on the specific composition of the social groups.

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1 Introduction

This paper analyzes the effects of the presence of different social groups in society on price-setting behavior of a profit-maximizing monopolistic firm. We use *social (sub)group* as the encompassing term for both social classes and social clusters. Social classes or subcultures are groups of individuals who are close according to some measure of social distance, like e.g. income, age or educational level, like for example yuppies or the population of students. Social clusters — which may alternatively be called cliques or peer groups — are groups of individuals with a high degree of personal interrelatonships, like for example children in the same class.[1] Authors like Akerlof have stressed the importance of social groups in individual decision making, calling "the potential existence of (. . .) subgroups in the population with their own norms and values (. . .) one of the most important consequences of

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[1]In the literature on networks, the *clustering coefficient* measures how closely knit a circle of friends is (Barabási, 2002).

social interaction theory." (Akerlof, 1997, p. 1010.) Within a group, there may be strong incentives to mimic the consumption behavior of the other members. This may be caused by social reasons (conformity), technological reasons (network effects), or by reasons of information dissemination. To give an example, consider a teenager thinking about buying a cell phone. The utility he derives from owning a cell phone is likely to increase with the relative number of members in his social subgroup that own a cell phone, for mere reasons of communication or because his peers will possibly ostracize him if he refuses to buy a cell phone.[2] We refer to these positive consumption externalities that are contingent on an individual's subgroup as *local* externalities. They have to be contrasted with the externalities that are commonly studied in the network literature. These are of a *global* nature in the sense that they work through the number of individuals in society as a whole that owns the good. The observed correspondence between network models and social interaction models[3] holds as long as society is considered as one large social group, but changes character when society is partitioned into different groups.

Since local externalities are dependent on the social groups within society, changes in the composition of these groups can lead to changes in equilibrium pricing decisions. In this paper, we develop a simple, two-stage model with a profit-maximizing monopolistic firm[4] to analyze a market with local consumption externalities. In the first stage, the firm sets a (uniform) price for its good and in the second stage, consumers decide whether or not they buy this good. Due to the consumption externality, the purchase decision of a consumer is postively dependent on the *fraction* of consumers in his or her group who buy the good. We analyze the consequences of the presence of different social groups by comparing a benchmark case without different subgroups with the situation in which society is partitioned into two non-overlapping social groups. The price set by the monopolist and its profit are dependent on the strength of the consumption externality and on the specific groups that are formed. Perhaps somewhat surprisingly, the presence of different groups does not automatically increase the profit of the monopolist. For some configurations, it lowers the price and incurs a loss as compared to the benchmark case.

In practice, changes to social groups can occur exogenously, as a result

[2]Ormerod (1998, p. 23) describes how the dissemination of information affects consumption decisions within social groups: "If a friend or neighbour buys a VHS machine and is satisfied, you are more likely to do the same."

[3]For example, Grilo, Shy and Thisse (2001) note with respect to the externality caused by network goods: "Though the reasons for this externality are technological rather than social, the corresponding models lead to reduced forms that can be used to study the market impact of the social phenomena described above."

[4]For simplicity, we focus on the monopolistic case, but the main message — profit-maximizing firms should react to the presence of different social groups in society — is equally valid in other market environments.

of societal or policy changes.[5] For example, the tendency to decrease class size can be viewed as a development toward smaller social groups, at least when one takes the position that a pupil's class is a good proxy for his social group.[6] In this paper, we focus on these exogenous changes in social groups.

Clearly, the monopolist may (besides changing its price) also react to the presence of different groups by means of advertising campaigns that are aimed at influencing an individual's perception of the fraction of members in his or her group that buy the product. A real-life example is the Vodafone 'How are you?'-campaign. To teenagers, Vodafone tries to point out that a large fraction of other teenagers in their subgroup own a cell phone by depicting young people having fun at a pop concert. In the same commercial, the company conveys a similar message to business men, by showing people gathered in an office for an important meeting. However, the monopolist's advertisement decisions are not explicitly modeled in our current model.

In studies on network effects, the existence of a positive consumption externality gives rise to the analysis of compatibility decisions — should firms opt for manufacturing compatible or incompatible products (Farrell and Saloner, 1985; Katz and Shapiro, 1985; Ellison and Fudenberg, 2000); should they choose whether or not to offer an adapter to make their products compatible (Baake and Boom, 2001) — and to the issue whether producers should engage in introductory pricing to attract a critical mass of consumers (Cabral, Salant and Woroch, 1999). We want to stress that one cannot simply interpret the partition of society into smaller social groups as some kind of 'reversed compatibility'. When compatibility is made undone, the absolute number of people in an individual's network unambiguously decreases. However, in our model, the key determinant is the *fraction* of individuals within your group that owns and uses the good. This fraction may as well go up as down due to the partition. Furthermore, in our model the separation between groups is not determined by product heterogeneity but by exogenous individual characteristics.

In the next section, the model is introduced. In Section 3, equilibrium demand, price and profit are derived for a society without different social groups, and in Section 4, the same is done for a society segmented into two non-overlapping social groups. Section 5 investigates under which conditions the presence of the two groups increases or decreases the monopolist's

[5] Deliberate changes in social groups by self-selection of individuals, an issue that plagues empirical studies on social interactions, is modeled in another branch of literature (see e.g. Evans, Oates and Schwab, 1992) and is not considered in this paper.

[6] The reason for this decrease is the impression that pupils in small classes have an advantage over pupils in larger classes in reading and math, and is as such exogenous to our analysis. The finding is e.g. stated by Jeremy Finn and C.M. Achilles in the American Educational Research Journal (Fall 1990) when they refer to the Student/Teacher Achievement Ratio (STAR) project: "This research leaves no doubt that small classes have an advantage over larger classes in reading and math in early primary grades." (see cited URL-address.)

equilibrium profit. Section 6 concludes.

2 The model

Consider a market on which a monopolistic firm supplies one good to a continuum of consumers with mass equal to 1. This continuum is segmented into $J \geq 1$ social groups. The market is modelled as a two-stage game. In stage 1 the monopolist determines the price p of the good. We assume that the firm is not able to charge different prices to the different groups. Given p, the consumers determine their demand for the good in stage 2. We will derive the equilibrium of this model using backward induction.

Every consumer buys either one unit of the good or none at all. Within a subgroup, consumers are heterogeneous in their intrinsic utility for the product, but homogeneous with respect to the consumption externality. The utility of a consumer in group j, $j \in \{1, 2, \ldots, J\}$, is given by:

$$U(\phi, \lambda_j, p) = \begin{cases} \phi + \gamma\lambda_j - p & \text{if the consumer buys the product;} \\ 0 & \text{otherwise.} \end{cases} \tag{1}$$

Here ϕ denotes the intrinsic utility of the consumer for the product, with ϕ uniformly distributed on the interval $[0, \hat{\phi}]$. Without loss of generality we take $\hat{\phi} = 1$. Social groups are formed by partitioning the population according to the intrinsic utility ϕ. λ_j is the fraction of consumers in social group j that buys the product, with $j \in \{1, 2, \ldots, J\}$. The parameter $\gamma > 0$ incorporates the strength of the bandwagon effect.[7] We assume that the bandwagon effect is equally pervasive in all groups, γ is the same for all groups.

It is important to note that λ_j represents the fraction of the agents in subgroup j consuming the good, not the absolute size of the local social network: other things equal, this means that the consumption externality is stronger if 2 out of 3 peers consume the good ($\lambda_j \approx 0.67$), than if 4 out of 10 peers consume the good ($\lambda_j = 0.40$), even though the absolute size of the local social network is larger in the latter instance. For example, in our mobile phone example it is easy to imagine that a consumer has a larger propensity to buy a mobile phone when he can use it to communicate with 2 out of his 3 peers than when only 4 of his 10 peers can be reached by means of mobile phone.

In stage 2, consumers maximize their utility, taking as given the decisions of all other consumers. We assume that each consumer has perfect foresight regarding the purchase decision of the other consumers. Further, the firm

[7] The bandwagon effect was defined by Leibenstein (1950) as 'the extent to which the demand for a commodity is increased due to the fact that others are also consuming the same commodity.' Note that $\gamma = 0$ corresponds to the classical case where externalities are absent.

has perfect foresight with respect to consumers' demand. The price that the firm charges in stage 1 is set so that profits are maximized. To ease the exposition, the marginal costs of the firm are normalized to be zero. Thus, the firm's decision process is

$$\max_{p} \pi = D(p)p, \tag{2}$$

where $D(p)$ denotes the total (equilibrium) demand for the good in stage 2.

Before entering upon the consequences of the presence of different subgroups, we will first analyze the outcomes when society is not segmented, that is $J = 1$. This analysis will serve as a benchmark for the results obtained in subsequent sections.

3 The unsegmented society

We assume from now on that $\gamma < 1$; that is, for the consumer with the highest valuation the effect of the consumption externality is always smaller than his intrinsic utility for the good. For larger values of γ, the bandwagon effect predominates, which results in rather trivial equilibria in which everyone buys the good.

3.1 Consumer's demand

In general, there are in stage 2 three possible (Nash) equilibria when the total population is not split into subgroups: one where none of the consumers buys; one where a fraction of consumers buys; and one where all consumers buy the good. In equilibria where only a fraction of consumers buys, they must group according to their type, since $\partial U(\cdot)/\partial \phi > 0$. For this reason, we define $\lambda = (1 - \bar{\phi})$, where $\bar{\phi}$ denotes the intrinsic utility of the marginal consumer who is indifferent between buying or not buying (note that, for notational simplicity, we delete the subindex of λ in this one-group case). Solving the indifference condition for this marginal consumer, we obtain:

$$\bar{\phi} + \gamma(1 - \bar{\phi}) - p = 0 \quad \Rightarrow \quad \bar{\phi} = \left(\frac{p - \gamma}{1 - \gamma}\right). \tag{3}$$

The consumers that buy the good are those with $\phi \in [\bar{\phi}, 1]$. We assume that the marginal consumer purchases the good as well. Equation (3) shows that $\bar{\phi} \leq 1 \Leftrightarrow p \leq 1$ and $0 \leq \bar{\phi} \Leftrightarrow p \geq \gamma$, and the following property is obtained:

Property 1 *In stage 2 equilibrium demand $D(p)$ is:*

(i) If $p \leq \gamma \Rightarrow D(p) = 1$;

(ii) If $\gamma \leq p \leq 1 \Rightarrow D(p) = 1 - \bar{\phi} = \left(\frac{1-p}{1-\gamma}\right)$;

(iii) If $p \geq 1 \Rightarrow D(p) = 0$.

Thus, demand is complete (the mass of consumers who buy the good is equal to zero) if the price is relatively small, demand is zero if the price is relatively large, and demand is incomplete (the mass of consumers who buy the good is between zero and unity) if the size of the price is in between.

3.2 Firm's pricing decision

Turning to stage 1, we derive the pricing behavior of the monopolist, given any γ. First, assume that (equilibrium) demand is $D(p) = (1 - p)/(1 - \gamma)$. It then easily follows that profit is maximized if the price equals $p^0 = \frac{1}{2}$, giving a profit of $\pi^0 = \pi(p^0) = 1/(4(1 - \gamma))$. Note that demand only takes on this form when $\gamma \leq p \leq 1$. Verifying this condition when $p^0 = \frac{1}{2}$ leads to the restriction that $\gamma \leq \frac{1}{2}$. If $\gamma \geq \frac{1}{2}$, all consumers want to buy the product as long as $p \leq \gamma$, leading to the optimal price $p^0 = \gamma$ with corresponding profit $\pi^0 = \pi(p^0) = \gamma$. The results are summarized below.

Property 2 *The profit-maximizing equilibrium price* p^0 *and corresponding profit* $\pi^0 = \pi(p^0)$ *are:*

(i) If $0 < \gamma \leq \frac{1}{2} \Rightarrow p^0 = \frac{1}{2}$; $\pi^0 = \frac{1}{4(1-\gamma)}$;

(ii) If $\frac{1}{2} \leq \gamma < 1 \Rightarrow p^0 = \gamma$; $\pi^0 = \gamma$.

The result shows that when the conformity effect is relatively weak ($\gamma < \frac{1}{2}$), the equilibrium price is unaffected by γ, but profit increases in γ, due to the fact that the demand increases if the bandwagon effect becomes stronger. When the propensity to conform is sufficiently strong ($\gamma \geq \frac{1}{2}$), the monopolist will always capture the entire market in equilibrium. In that case, profit increases in γ, since the optimal price increases if the bandwagon becomes stronger.

4 A society with subgroups

In this section, the consequences of social groups on equilibrium demand, price and profit are analyzed. For simplicity we focus on the case with two social groups ($J = 2$). The segmentation is implemented by splitting the original population into two groups according to the intrinsic utility of the consumers. Consumers with the *lower* intrinsic utility $\phi \in [0, \phi_s)$ are assigned to group 1 and consumers with the *higher* intrinsic utility $\phi \in [\phi_s, 1]$ are assigned to group 2. We assume that ϕ_s is exogenously given, with $0 < \phi_s < 1$.

One can interpret the segmentation process literally as sorting individuals according to their intrinsic utility. In differentiating between youth and business men, Vodafone possibly indirectly distinguishes between two groups with different intrinsic utilities for mobile phones, as it might be that the intrinsic utility that business men derive from a mobile phone is higher or lower than the intrinsic utility youth derives from the same product.

One can also interpret the segmentation based on ϕ as a segmentation on basis of income. This can be seen as follows. Suppose, for the moment, that a population of consumers have identical ordinal preferences, and differ only in their incomes. Consider the additive separable utility function

$$U = s + u(I - p), \tag{4}$$

where I is the income of the consumer, s is the utility associated with the good under consideration, and $u(I - p)$ the utility associated with all other goods. We assume that $u(\cdot)$ is strictly concave. If p is small relative to I, then the first-order Taylor expansion shows that

$$U = s - u'(I)p, \tag{5}$$

which implies that the utility function is formally equivalent with

$$U = \theta s - p, \tag{6}$$

with $\theta \equiv 1/u'(I)$. (See also Tirole, 1988, p. 97.) When income is high, marginal utility of income is low and the value of θ is large. This corresponds with a large value of ϕ in (1), when the externality effect in this equation is neglected. With reference to the examples, it is plausible that a segmentation into youth and business men also entails a segmentation on basis of income. With respect to schools, a segmentation of pupils, correlated with the funds they can draw on, occurs when richer families have a tendency to send their children to private instead of public schools.

Notwithstanding these interpretations, the treatment of the presence of different subgroups is, admittedly, somewhat stylized, but it allows us to derive tractable analytical results below for values of ϕ_s over the whole range $(0, 1)$.

4.1 Consumer's demand

The utility of the consumers in group 1 and 2 is still described by (1), with $j = 1$ and 2, respectively. The demand function for each of the groups is derived in a similar fashion as the demand function for the total population in the previous section. Again, in equilibria where only a fraction of the consumers buys, they must group according to their type, such that $\lambda_1 = (\phi_s - \bar{\phi}_1)/\phi_s$ and $\lambda_2 = (1 - \bar{\phi}_2)/(1 - \phi_s)$, where $\bar{\phi}_1$ and $\bar{\phi}_2$ denote the intrinsic utility of the marginal consumers in group 1 and 2, respectively, that are indifferent between buying and not buying. Solving the indifference conditions for these marginal consumers leads, respectively, to

$$\bar{\phi}_1 + \gamma \left(\frac{\phi_s - \bar{\phi}_1}{\phi_s} \right) - p = 0 \Rightarrow \bar{\phi}_1 = \left(\frac{p - \gamma}{\phi_s - \gamma} \right) \phi_s, \text{ for } \gamma < \phi_s, \tag{7}$$

and

$$\bar{\phi}_2 + \gamma \left(\frac{1 - \bar{\phi}_2}{1 - \phi_s} \right) - p = 0 \Rightarrow \bar{\phi}_2 = \left(\frac{(1 - \phi_s)p - \gamma}{1 - \phi_s - \gamma} \right), \text{ for } \gamma < 1 - \phi_s. \tag{8}$$

Using the expressions for $\bar{\phi}_1$ and $\bar{\phi}_2$, one can easily derive total equilibrium demand $D(p) = D_1(p) + D_2(p)$, whenever $\gamma < \min(\phi_s, 1 - \phi_s)$.

Whenever $\gamma \geq \min(\phi_s, 1 - \phi_s)$, multiple demand equilibria may arise for some price intervals in both group 1 and group 2. For example, take the situation with $\phi_s = \gamma$ and focus on group 1. We distinguish now three price intervals. First, suppose that $p < \gamma$. Then there is no equilibrium in which a fraction of the consumers buys the good. However, if all other consumers of group 1 buy the good, then even the consumer in group 1 with the lowest intrinsic utility ($\phi = 0$) will buy the good (that is, $0 + \gamma \cdot 1 - p > 0$). Thus, there is an equilibrium in which all consumers of group 1 buy. Further, there is no equilibrium in which no consumer of group 1 buys the good (since $\phi_s + \gamma \cdot 0 - p > 0$). Combining results, if $p < \gamma$, then there is a unique equilibrium given by $D_1(p) = \phi_s$. Second, suppose that $p = \gamma$. Using the same kind of reasoning, it can be seen that now we have an equilibrium in which all consumers buy the good as well as an equilibrium in which no consumer buys the good. Even more, it can be verified that equilibrium demand in group 1 can equal any number between 0 and ϕ_s. Thus, there is a continuum of equilibria in this case. Third, suppose that $p > \gamma$. Then, one can show in a similar way that the unique equilibrium is given by $D_1(p) = 0$.

Considering the continuum of equilibria for the case where $p = \gamma$, we remark that the equilibrium in which all consumers of group 1 buy the good Pareto dominates all other ones. For this reason, we follow Shy (2001, p. 20) and say that the latter equilibria are characterized by a coordination failure. From now on, we adopt the following assumption:

Assumption 1 *There is no coordination failure in equilibrium demand for the good.*

This assumption is commonly used to solve problems with multiple equilibria (see e.g. Shy, 2001; Baake and Boom). On basis of this assumption, the Pareto dominated equilibria are ruled out in favor of the equilibrium where all consumers buy. Invoking the assumption in our example, we have that $D_1(p) = \phi_s$ if $p = \gamma$.

Proceeding, it is useful to introduce a partition of the (γ, ϕ_s)-space (with $0 < \gamma < 1$ and $0 < \phi_s < 1$) into the following four domains:

DOMAIN A: $\gamma < \min(\phi_s, 1 - \phi_s)$;
DOMAIN B: $1 - \phi_s \leq \gamma < \phi_s$; $\phi_s > \frac{1}{2}$;
DOMAIN C: $\phi_s \leq \gamma < 1 - \phi_s$; $\phi_s < \frac{1}{2}$;
DOMAIN D: $\gamma \geq \max(\phi_s, 1 - \phi_s)$.

See also Figure 1 (in which domain A is further divided into subdomains A_1 to A_6, as discussed below). In domain A the conformity effect is below average, $\gamma < \frac{1}{2}$, while in domain D this effect is above average. Products for which a conformity effect is especially important are situated in the latter domain. In domain B the dividing line between groups is drawn for a value of the intrinsic utility parameter that is above average, $\phi_s > \frac{1}{2}$. This means that a small group 2 with a higher than average intrinsic utility comes into existence. For example, the shift of children from (very) wealthy families toward private schools is modelled best with parameter values in this domain. In domain C on the contrary, the split takes places in the lower part of the intrinsic utility range, resulting in a small group 1. In this case, one can think of firms introducing a product to the main category of quite interested potential buyers, while there is a small fraction of the population that has scarcely interest in the good.

The following property can be derived in a straightforward way:[8]

Property 3 *Imposing Assumption 1, in stage 2 total equilibrium demand $D(p)$ is described by:*

DOMAIN A. *For $\gamma < \min(\phi_s, 1 - \phi_s)$:*

(iA) If $p \leq \gamma \Rightarrow D(p) = 1$;

(iiA) If $\gamma \leq p \leq \phi_s \Rightarrow D(p) = 1 + \left(\frac{\gamma - p}{\phi_s - \gamma}\right)\phi_s$;

(iiiA) If $\phi_s \leq p \leq \phi_s + \gamma \Rightarrow D(p) = 1 - \phi_s$;

(ivA) If $\phi_s + \gamma \leq p \leq 1 \Rightarrow D(p) = \frac{(1-\phi_s-p)+\phi_s p}{1-\phi_s-\gamma}$;

(vA) If $1 \leq p \Rightarrow D(p) = 0$.

DOMAIN B. *For $1 - \phi_s \leq \gamma < \phi_s$:*

(iB) If $p \leq \gamma \Rightarrow D(p) = 1$;

[8] The proof is available upon request from the authors.

(iiB) If $\gamma \le p \le \phi_s \Rightarrow D(p) = 1 + \left(\frac{\gamma - p}{\phi_s - \gamma}\right)\phi_s$*;*

(iiiB) If $\phi_s \le p \le \phi_s + \gamma \Rightarrow D(p) = 1 - \phi_s$*;*

(ivB) If $\phi_s + \gamma < p \Rightarrow D(p) = 0$*.*

DOMAIN C. *For* $\phi_s \le \gamma < 1 - \phi_s$*:*

(iC) If $p \le \gamma \Rightarrow D(p) = 1$*;*

(iiC) If $\gamma < p \le \phi_s + \gamma \Rightarrow D(p) = 1 - \phi_s$*;*

(iiiC) If $\phi_s + \gamma \le p \le 1 \Rightarrow D(p) = \frac{(1-\phi_s-p)+\phi_s p}{1-\phi_s-\gamma}$*;*

(ivC) If $1 < p \Rightarrow D(p) = 0$*.*

DOMAIN D. *For* $\gamma \ge \max(\phi_s, 1 - \phi_s)$*:*

(iD) If $p \le \gamma \Rightarrow D(p) = 1$*;*

(iiD) If $\gamma < p \le \phi_s + \gamma \Rightarrow D(p) = 1 - \phi_s$*;*

(iiiD) If $\phi_s + \gamma < p \Rightarrow D(p) = 0$*.*

Property 3 states equilibrium demand in stage 2 for all relevant price intervals and all combinations of parameter values (γ, ϕ_s). Observe that only the following five types of equilibrium demand may occur: (a) demand is complete in both groups; (b) demand is incomplete in group 1 and complete in group 2; (c) demand is zero in group 1 and complete in group 2; (d) demand is zero in group 1 and incomplete in group 2; (e) demand is zero in both groups. In particular, it is not possible that equilibrium demand is incomplete in both groups.

4.2 The monopolist's pricing decision

Now, we want to derive the pricing decision for the monopolistic firm, given any γ and ϕ_s. To this purpose, a separated analysis is performed for each of the four domains A till D. For example for domain A, the optimal price is calculated in the following way. First, we calculate for all price intervals (iA) up to (vA) mentioned in Property 3 the optimal price, say $p^*_{iA}, \dots, p^*_{vA}$, and corresponding profits $(\pi(p^*_{iA}), \dots, \pi(p^*_{vA}))$ under the restriction that this price indeed is in the given interval. Second, the expressions for the maximum profits in the different price intervals are compared with each other. The price that globally maximizes profit in domain A is obtained as:

$$p^* = \arg\max\{\pi(p^*_{iA}), \dots, \pi(p^*_{vA}); \gamma, \phi_s\}, \tag{9}$$

and the corresponding profit is $\pi^* = \pi(p^*)$.

Deferring derivations to the Appendix, we present here the optimal price and corresponding profit for each of the domains. Doing so, we first introduce two threshold values for γ:

$$\underline{\gamma} = \frac{\phi_s(1-2\phi_s)}{1-\phi_s} \quad \text{and} \quad \bar{\gamma} = \frac{\phi_s}{\phi_s+1}. \tag{10}$$

Notice that $\underline{\gamma} < \bar{\gamma}$ since $\phi_s > 0$. It turns out that domain A must be divided into the following six subdomains for which the profit comparison is executed separately: $A_1 = \{(\gamma, \phi_s) \in A | \, \gamma \geq \bar{\gamma}$ and $\gamma > \frac{1}{2} - \phi_s\}, A_2 = \{(\gamma, \phi_s) \in A | \, \gamma \geq \bar{\gamma}$ and $\gamma \leq \frac{1}{2} - \phi_s\}, A_3 = \{(\gamma, \phi_s) \in A | \, \underline{\gamma} < \gamma < \bar{\gamma}$ and $\gamma > \frac{1}{2} - \phi_s\}, A_4 = \{(\gamma, \phi_s) \in A | \, \underline{\gamma} < \gamma < \bar{\gamma}$ and $\gamma \leq \frac{1}{2} - \phi_s\}, A_5 = \{(\gamma, \phi_s) \in A | \, \gamma \leq \underline{\gamma}$ and $\gamma > \frac{1}{2} - \phi_s\}$ and $A_6 = \{(\gamma, \phi_s) \in A | \, \gamma \leq \underline{\gamma}$ and $\gamma \leq \frac{1}{2} - \phi_s\}$. The division of domain A into the six subdomains is depicted in Figure 1. We remark that on the curve d_1 the equality $\gamma = \underline{\gamma}$ holds, on the curve d_2 the equality $\gamma = \bar{\gamma}$ holds, on the straight line d_3 we have $\gamma = \frac{1}{2} - \phi_s$, and on the straight line d_4 we have $\gamma = 1 - \phi_s$. (The curve γ_3 - γ_4 in Figure 1 is explained in Section 5.)

INSERT FIGURE 1 ABOUT HERE

It further turns out that, depending on the values of γ and ϕ_s, in equilibrium there are four possible expressions for the optimal price and corresponding profit. We introduce the following notation for these four combinations:

$$\begin{array}{llll} p^I & = \frac{1}{2}; & \pi^I & = \frac{(1-\phi_s)}{4(1-\phi_s-\gamma)}; \\ p^{II} & = \phi_s + \gamma; & \pi^{II} & = (1-\phi_s)(\phi+\gamma); \\ p^{III} & = \frac{\phi_s - \gamma(1-\phi)}{2\phi_s}; & \pi^{III} & = \frac{[\phi_s-\gamma(1-\phi_s)]^2}{4\phi_s(\phi_s-\gamma)}; \\ p^{IV} & = \gamma; & \pi^{IV} & = \gamma. \end{array} \tag{11}$$

Now we are able to present the following property.

Property 4 *Imposing Assumption 1, the profit-maximizing equilibrium price p^* and corresponding profit $\pi^* = \pi(p^*)$ are described by:*

(a) For $(\gamma, \phi_s) \in A_2, A_4, A_6 \Rightarrow \quad p^* = p^I; \quad \pi^* = \pi^I;$

(b) For $(\gamma, \phi_s) \in A_1, A_5 \Rightarrow \quad p^* = p^{II}; \quad \pi^* = \pi^{II};$

(c) For $(\gamma, \phi_s) \in A_3:$

if $\phi_s \leq \frac{2}{3}$ *and* $\gamma \in [\gamma_1, \gamma_2] \Rightarrow \quad p^* = p^{II}; \quad \pi^* = \pi^{II};$

if $\phi_s \leq \frac{2}{3}$ *and* $\gamma \notin [\gamma_1, \gamma_2] \Rightarrow \quad p^* = p^{III}; \quad \pi^* = \pi^{III};$

if $\phi_s > \frac{2}{3} \Rightarrow \quad p^* = p^{III}; \quad \pi^* = \pi^{III};$

(d) For $(\gamma, \phi_s) \in B$*:*

if $\gamma < \bar{\gamma} \Rightarrow \quad p^* = p^{III}; \quad \pi^* = \pi^{III};$

if $\gamma \geq \bar{\gamma} \Rightarrow \quad p^* = p^{IV}; \quad \pi^* = \pi^{IV};$

(e) For $(\gamma, \phi_s) \in C$*:*

if $\gamma \leq \frac{1}{2} - \phi_s \Rightarrow \quad p^* = p^I; \quad \pi^* = \pi^I;$

if $\gamma > \frac{1}{2} - \phi_s \Rightarrow \quad p^* = p^{II}; \quad \pi^* = \pi^{II};$

(f) For $(\gamma, \phi_s) \in D \Rightarrow \quad p^* = p^{IV}; \quad \pi^* = \pi^{IV}.$

Here $\bar{\gamma}$ *is defined in (10),* $p^I, \ldots, p^{IV}$ *and* $\pi^I, \ldots, \pi^{IV}$ *are defined in (11), and*

$$\gamma_{1,2} = \frac{\phi_s}{1 + 3\phi_s} \pm \frac{2\phi_s^2 \sqrt{(1 - \phi_s)(2 - 3\phi_s)}}{(1 - \phi_s)(1 + 3\phi_s)}.$$

Proof: See the Appendix.

In Figure 2 we depict the equilibrium fractions of buyers in both groups for the four possible outcomes given in Property 4. In this figure λ_1^I and λ_2^I denote the fractions of consumers that buy in equilibrium in, respectively, group 1 and group 2, in the area where the optimal profit is given by π^I. In a similar way, we define λ_1^{II} and λ_2^{II}, etcetera.

Note that the area where π^I is maximal is in the lower left corner of Figure 2, where both the bandwagon effect γ is relatively small and the value ϕ_s at which the original population is split is small. The latter implies that group 1 is relatively small here, whereas group 2 is relatively large. Figure 2 shows that below the line d_3, only a fraction of the consumers in group 2 (those with the higher intrinsic utility) buys and nobody in group 1. Intuitively, a higher γ helps the firm to win consumers for his product. Since in the lower left corner, both the intrinsic utility of the consumers in group 1 (and, thus, the size of this group) and the value of γ are low, it is not profitable for the firm to lower prices to induce individuals in group 1 to buy. Moreover, the low value of γ also prohibits the firm from selling to all members of group 2. At points at the line d_3, all individuals in group 2 buy, even the person with the lowest intrinsic utility ϕ_s. The message this line contains is that it is profitable for the firm to sell to the person with lowest intrinsic utility ϕ_s in group 2, even as (starting from a point on d_3) the value of ϕ_s decreases, as long as this decrease is compensated by an accompanying increase in the bandwagon effect γ. Notice that due to this increase in the bandwagon effect, the firm does not have to decrease prices to induce the marginal group 2 member to buy (on d_3 the equilibrium price always equals $\frac{1}{2}$).

INSERT FIGURE 2 ABOUT HERE

In the middle part of Figure 2, π^{II} is optimal. The figure shows that in this case the equilibrium price is such that the monopolist captures all members of group 2 as customers and none of group 1: the segmentation of the population into buyers and non-buyers coincides with the segmentation into peer groups. Again, the low intrinsic utility of the potential buyers in group 1 makes it unattractive for the firm to sell to them. However, the value of γ is high enough to win all members of group 2 for the product. In the next section, we discuss that in this area, given ϕ_s, a stronger bandwagon effect leads to strongly increased prices. However, once the border denoted by d_4 is crossed, it pays to decrease prices sharply in order to induce all individuals in group 1 to buy the product too. On the line denoted by d_4, $\pi^{II} = \pi^{IV}$.

In the upper left corner of Figure 2, the value ϕ_s is relatively high, which means that group 1 is relatively large and group 2 is relatively small. Moreover, the bandwagon effect is modest. In this area π^{III} is optimal, and all members of group 2 as well as some individuals of group 1 (those with the higher intrinsic utility) buy. In the next section we argue that the firm makes some price concessions to induce consumers in group 1 to buy the product. If we cross the curve denoted by γ_1 and γ_2 in upward direction, consumers in group 1 with the highest values of the intrinsic utility parameter are starting to buy the good. On curve d_2 in Figure 2 all members of group 1 buy, even the person with intrinsic utility equal to zero. If, starting from a point on d_2, the size of ϕ_s increases, then the price will increase (see p^{III}). The individual of group 1 with intrinsic utility equal to zero is just induced to buy if this increase in price is compensated by an accompanying increase in the bandwagon effect γ.

Finally, in the (upper) right part of Figure 2, π^{IV} is optimal. In this area all individuals will buy in equilibrium. The reason is that in this case, the size of the bandwagon effect prevails over the individual intrinsic utilities.

5 Effects of social subgroups on prices and profits

Properties 2 and 4 provide the equilibrium price and profit for the situation with one or two social groups, respectively. We can now compare the equilibrium prices and profits that are obtained before and after the formation of subgroups. Given the presence of a bandwagon effect, it is natural to think that splitting a population into smaller groups is beneficial for the firm, since smaller groups increase the possibilities to use the bandwagon effect to its advantage. Property 5 shows that this is only partially true. The property gives the exact combinations of γ and ϕ_s for which equilibrium profit is increased due to the presence of different social groups.[9]

Property 5 *Imposing Assumption 1, let π^0 be the equilibrium profit with one social group and π^* be the equilibrium profit with two social groups. We then have:*

$$
\begin{array}{ll}
\textit{(a) For } (\gamma, \phi_s) \in A_1, A_2, A_4, A_5, A_6 \Rightarrow & \pi^0 < \pi^*; \\
\textit{(b) For } (\gamma, \phi_s) \in A_3: & \\
\quad \textit{if } \phi_s \leq \frac{1}{2} \Rightarrow & \pi^0 < \pi^*; \\
\quad \textit{if } \frac{1}{2} < \phi_s \leq -\frac{1}{2} + \frac{1}{2}\sqrt{5} \textit{ and } \gamma \in (\gamma_3, \gamma_4) \Rightarrow & \pi^0 < \pi^*; \\
\quad \textit{if } \frac{1}{2} < \phi_s \leq -\frac{1}{2} + \frac{1}{2}\sqrt{5} \textit{ and either } \gamma = \gamma_3 \textit{ or } \gamma = \gamma_4 \Rightarrow & \pi^0 = \pi^*; \\
\quad \textit{if } \frac{1}{2} < \phi_s \leq -\frac{1}{2} + \frac{1}{2}\sqrt{5} \textit{ and } \gamma \notin [\gamma_3, \gamma_4] \Rightarrow & \pi^0 > \pi^*; \\
\quad \textit{if } \phi_s > -\frac{1}{2} + \frac{1}{2}\sqrt{5} \Rightarrow & \pi^0 > \pi^*; \\
\textit{(c) For } (\gamma, \phi_s) \in B: & \\
\quad \textit{if } \gamma < \frac{1}{2} \Rightarrow & \pi^0 > \pi^*; \\
\quad \textit{if } \gamma \geq \frac{1}{2} \Rightarrow & \pi^0 = \pi^*; \\
\textit{(d) For } (\gamma, \phi_s) \in C \Rightarrow & \pi^0 < \pi^*; \\
\textit{(e) For } (\gamma, \phi_s) \in D \Rightarrow & \pi^0 = \pi^*.
\end{array}
$$

Here

$$\gamma_{3,4} = \frac{1-\phi_s}{2} \pm \frac{1}{2}\sqrt{\frac{\phi_s(1-\phi_s^2-\phi_s)}{1-\phi_s}}.$$

Using Property 5, Figure 3 shows the (γ, ϕ_s)-combinations for which in equilibrium the profit in the case with two groups is, respectively, larger than, smaller than, or equal to the profit in the case with one group. In the lower left part of the figure profit is highest with two groups, in the upper left part profit is highest with one group, and in the right part profit is the same under one and two groups. The latter parallels a result by Grilo, Shy and Thisse (2001) who find in the context of a spatial duopoly model that a single firm is likely to capture the whole market when conformity is strong enough.

INSERT FIGURE 3 ABOUT HERE

We have calculated numerically for different combinations of γ and ϕ_s the percentage change in the equilibrium price, profit and demand if we compare the case with two groups versus the benchmark case with one group. We

[9]The proof is available upon request from the authors.

will not report all the details of our calculations here, but only make the following three observations. First, when group 2 with the consumers with a high intrinsic utility is relatively large (that is, ϕ_s is sufficiently small), the firm has the possibility to increase its profit by a maximum of about 18%, reached at point (γ, ϕ_s)=(1/3, 1/3). However, if group 2 is relatively small, and the value of γ is smaller than 1/2, the monopolist's profit decreases, with a maximal loss of about 8%, approximately when (γ, ϕ_s)=(0.3, 0.66).

Second, we have examined whether the changes in equilibrium profit are primarily caused by changes in prices or by changes in demand. It turns out that in the lower left part of Figure 3 there is a strong increase in price. Given a value of ϕ_s, prices increase sharply as the bandwagon effect becomes more pervasive, to a maximum increase of 100%. However, when the line d_4 is crossed, prices fall again to the same values as in the case without peer group segmentation. The reason is that then it is more profitable to capture the entire market instead of only group 2. In order to attract the group 1 consumers, the monopolist has to reduce prices.

Third, in the upper left corner of Figure 3, the price set by the monopolist is lower in the case with two groups than in the case with one group (the maximal reduction here is 23%). The reason is, that for values of γ and ϕ_s in this area, both group 2 is relatively small and consumers in group 1 with the highest intrinsic utilities have relatively high values of ϕ. Thus, the firm is eager to sell to at least some individuals in group 1. However, these individuals are not motivated by the buyers with higher intrinsic utility who now belong to group 2. A price reduction is needed to induce them to buy. The modest increase in demand that results is not sufficient to prohibit the monopolist from suffering a loss due to the presence of different social groups.

Finally, suppose for the moment that the monopolist has control over ϕ_s, what would then be his best response $BR(\gamma)$ to an exogenously given value of γ? The answer is that $BR(\gamma) = (1 - \gamma)/2$, a function that runs from point (0, 1/2) to (1, 0) in Figure 3 (not shown). All combinations of $(\gamma, BR(\gamma))$ are in the area with $\lambda_1^{II} = 0$ and $\lambda_2^{II} = 1$ (see Figure 2). This means that, when given the opportunity, the monopolist picks ϕ_s in such a way that a perfect segmentation in buyers and non-buyers is obtained, irrespective of the value of γ.

6 Conclusion

In this paper we explored the consequences of the presence of local consumption externalities, due to social groups within society, for the price-setting behavior of a profit-maximizing monopolist. The partition of society into small social groups does not inherently lead to increased market power of the monopolist. The sign and size of the change in prices and profits is dependent on both the strength of the conformity effect and on the specific social groups that are formed.

The formation of social groups is done on basis of the intrinsic tastes for the good. Though this implementation has an interpretation as a segmentation on basis of income, it is somewhat stylized and for this reason should be seen as a first attempt to model the consequences of social groups on price setting. In this study, we only consider the case with two groups. A natural future extension of the model would be to consider the effects of partitioning society into partially overlapping groups. Another modification would be to explicitly model the advertising decisions of the monopolist. A third possible extension is to allow for 'multiplicative preferences' under which the value that consumers attach to the local consumption externality is correlated with their intrinsic value for the good (see Ellison and Fudenberg for an example of this).

Appendix: Proof of Property 4

Since the analysis is rather extensive, we describe here the details for domain A only.[10] Recall that in domain A, we have $\gamma < \min(\phi_s, 1-\phi_s)$. First, we consider the pricing behavior for each of the price intervals (iA) to (vA) indicated in Property 3. For notational simplicity, we speak below about the intervals (i) to (v); that is, we omit the 'A'.

(i) $p \leq \gamma$ When the price is smaller than or equal to γ, demand is complete in both groups and the optimal price the monopolist can choose without leaving the price interval is choosing the price equal to the upper bound of this interval. That is, $p_i^* = \gamma$ and $\pi_i^* = \pi(p_i^*) = D(p_i^*)p_i^* = \gamma$.

(ii) $\gamma \leq p \leq \phi_s$ With demand given in Property 3, the following first-order condition for profit maximization can be derived:

$$1 + \left(\frac{\gamma - p}{\phi_s - \gamma}\right)\phi_s - \left(\frac{\phi_s}{\phi_s - \gamma}\right)p = 0.$$

Solving for p leads to the following expression for the corresponding price:

$$p_{ii} = \frac{\phi_s - \gamma(1-\phi_s)}{2\phi_s},$$

which is decreasing in γ since $\phi_s < 1$. Checking whether this price obeys the condition $\gamma \leq p \leq \phi_s$ results in:

$$p_{ii} \leq \phi_s \Leftrightarrow \gamma \geq \frac{\phi_s(1-2\phi_s)}{1-\phi_s} \equiv \underline{\gamma} \quad \text{and} \quad p_{ii} \geq \gamma \Leftrightarrow \gamma \leq \frac{\phi_s}{\phi_s + 1} \equiv \bar{\gamma}$$

Remark that $\underline{\gamma} < \bar{\gamma}$ as $\phi_s > 0$. Hence, for this price interval, one has to distinguish three cases with respect to the optimal price:

(ii^a) If $\gamma \geq \bar{\gamma}$, the optimal price is $p_{ii^a}^* = \gamma$ and $\pi_{ii^a}^* = \pi(p_{ii^a}^*) = \gamma$;

(ii^b) If $\underline{\gamma} < \gamma < \bar{\gamma}$, the optimal price is $p_{ii^b}^* = \frac{\phi_s - \gamma(1-\phi_s)}{2\phi_s}$ and $\pi_{ii^b}^* = \pi(p_{ii^b}^*) = \frac{[\phi_s - \gamma(1-\phi_s)]^2}{4\phi_s(\phi_s - \gamma)}$;

(ii^c) If $\gamma \leq \underline{\gamma}$, the optimal price is $p_{ii^c}^* = \phi_s$ and $\pi_{ii^c}^* = \pi(p_{ii^c}^*) = \phi_s(1-\phi_s)$.

Thus, when $\gamma \geq \bar{\gamma}$, demand is complete in both groups; when $\gamma \leq \underline{\gamma}$, demand is zero in group 1 and complete in group 2, and when $\underline{\gamma} < \gamma < \bar{\gamma}$, demand is incomplete in group 1 and complete in group 2.

[10] The analysis for domains B till D is similar, and available from the authors upon request.

(iii) $\phi_s \le p \le \phi_s + \gamma$ When price is within this interval, demand is zero in group 1 and complete in group 2. As in *(i)* the optimal decision for the firm is to choose price equal to the upper bound of the price interval, which is $\phi_s + \gamma$ in this case. Thus, $p^*_{iii} = \phi_s + \gamma$ and $\pi^*_{iii} = \pi(p^*_{iii}) = (\phi_s + \gamma)(1 - \phi_s)$.

(iv) $\phi_s + \gamma \le p \le 1$ When price is within this interval, demand is zero in group 1 and incomplete or complete in group 2. With demand given in Property 3, solving the first-order condition for profit maximization gives $p_{iv} = \frac{1}{2}$. This price satisfies the condition $\phi_s + \gamma \le p \le 1$ if and only if $\gamma \le \frac{1}{2} - \phi_s$. For this reason, one has to distinguish two cases:

(iv^a) If $\gamma \le \frac{1}{2} - \phi_s$, the optimal price is $p^*_{iv^a} = \frac{1}{2}$ and $\pi^*_{iv^a} = \pi(p^*_{iv^a}) = \frac{(1-\phi_s)}{4(1-\phi_s-\gamma)}$. In this case, if $\gamma < \frac{1}{2} - \phi_s$, demand is positive in group 2.

(iv^b) If $\gamma > \frac{1}{2} - \phi_s$, the optimal price is $p^*_{iv^b} = \phi_s + \gamma$ and $\pi^*_{iv^b} = \pi(p^*_{iv^b}) = (1 - \phi_s)(\phi_s + \gamma)$. In this case, demand is complete in group 2.

(v) $p \ge 1$ For prices larger than 1, demand is zero in both groups and profits are zero as well, $\pi^*_v = \pi(p^*_v) = 0$.

After this derivation of the optimal price and the corresponding profit for each of the five price intervals, the second step of the procedure is carried out. In this step, the maximum profits in the five price intervals are compared given any combination of (γ, ϕ_s) within domain A. The price p^* is chosen that maximizes overall profit $\pi(p; \gamma, \phi_s)$. Since for price interval *(ii)* and *(iv)* there are three, respectively, two, subcases – dependent on whether γ exceeds certain threshold values – domain A is divided into the six subdomains A_1 to A_6 introduced in section 4. For each of these subdomains maximum profits over the five different price intervals are compared, given a particular combination of (γ, ϕ_s). That price is deemed optimal that maximizes overall profits.

The relevant expressions of profit that have to be compared for the different subdomains are:

For A_1: $\pi^*_i, \pi^*_{ii^a}, \pi^*_{iii}, \pi^*_{iv^b}, \pi^*_v$;

For A_2: $\pi^*_i, \pi^*_{ii^a}, \pi^*_{iii}, \pi^*_{iv^a}, \pi^*_v$;

For A_3: $\pi^*_i, \pi^*_{ii^b}, \pi^*_{iii}, \pi^*_{iv^b}, \pi^*_v$;

For A_4: $\pi^*_i, \pi^*_{ii^b}, \pi^*_{iii}, \pi^*_{iv^a}, \pi^*_v$;

For A_5: $\pi^*_i, \pi^*_{ii^c}, \pi^*_{iii}, \pi^*_{iv^b}, \pi^*_v$;

For A_6: $\pi^*_i, \pi^*_{ii^c}, \pi^*_{iii}, \pi^*_{iv^a}, \pi^*_v$.

Observe that $\pi^*_{iv^b} = \pi^*_{iii} > \pi^*_{ii^a} = \pi^*_i > \pi^*_v = 0$ and $\pi^*_{iv^b} > \pi^*_{ii^c}$.

- **ad** A_1 From the above, it directly follows that for this subdomain

  $\pi^*_{iii} = \pi^*_{iv^b} > \pi^*_i = \pi^*_{ii^a} > \pi^*_v.$

Thus, the optimal price and profit when (γ, ϕ_s) is in subdomain A_1 are given by $p^*_{A_1} = p^*_{iv^b} = \phi_s + \gamma$ and $\pi^*_{A_1} = \pi^*_{iv^b} = (1-\phi_s)(\phi_s+\gamma)$.

- **ad** A_2 For A_2 a similar evaluation gives

  $\pi^*_{iii} > \pi^*_{ii^a} = \pi^*_i > \pi^*_v,$

such that only the expressions for π^*_{iii} and $\pi^*_{iv^a}$ have to be compared. Note that

$$\pi^*_{iv^a} \geq \pi^*_{iii} \Leftrightarrow 1 \geq 4(\phi_s+\gamma)(1-\phi_s-\gamma),$$

which is satisfied since $\phi_s + \gamma \leq \frac{1}{2}$ in subdomain A_2. Thus, $p^*_{A_2} = p^*_{iv^a} = \frac{1}{2}$ and $\pi^*_{A_2} = \pi^*_{iv^a} = \frac{(1-\phi_s)}{4(1-\phi_s-\gamma)}$.

- **ad** A_3 As for A_1, we know

  $\pi^*_{iii} = \pi^*_{iv^b} > \pi^*_i > \pi^*_v.$

What remains to be shown is for which (γ, ϕ_s)-combinations $\pi^*_{iv^b}$ maximizes overall profit and for which values (if any) $\pi^*_{ii^b}$. To this purpose, we solve the equation $\pi^*_{ii^b} = \pi^*_{iv^b}$, that is

$$\begin{aligned}
& \pi^*_{ii^b} = \pi^*_{iv^b} \\
\Leftrightarrow\quad & [\phi_s - \gamma(1-\phi_s)]^2 = 4\phi_s(\phi_s-\gamma)(1-\phi_s)(\phi_s+\gamma) \\
\Leftrightarrow\quad & \phi_s^2 - 2\gamma\phi_s(1-\phi_s) + \gamma^2(1-\phi_s)^2 = 4\phi_s(1-\phi_s)(\phi_s^2-\gamma^2) \\
\Leftrightarrow\quad & \gamma^2(1-\phi_s)(1-\phi_s+4\phi_s) - 2\gamma\phi_s(1-\phi_s) - 4\phi_s^3(1-\phi_s) + \phi_s^2 = 0 \\
\Leftrightarrow\quad & \gamma^2(1-\phi_s)(1+3\phi_s) - 2\gamma\phi_s(1-\phi_s) + \phi_s^2 - 4\phi_s^3(1-\phi_s) = 0.
\end{aligned}$$

Solving this equation for γ, we obtain

$$\gamma_{1,2} = \frac{\phi_s}{1+3\phi_s} \pm \frac{2\phi_s^2\sqrt{(1-\phi_s)(2-3\phi_s)}}{(1-\phi_s)(1+3\phi_s)}. \tag{A.1}$$

If $\phi_s \leq \frac{2}{3}$, then the square root in (A.1) is nonnegative. If $\phi_s > \frac{2}{3}$, then this root is imaginary, and $\pi^*_{ii^b} \geq \pi^*_{iv^b}$ for all values of γ. Thus:

- If $\phi_s > \frac{2}{3} \Rightarrow p^*_{A_3} = p^*_{ii^b} = \frac{\phi_s - \gamma(1-\phi_s)}{2\phi_s}$ and $\pi^*_{A_3} = \pi^*_{ii^b} = \frac{(\phi_s-\gamma(1-\phi_s))^2}{4\phi_s(\phi_s-\gamma)}$;
- If $\phi_s \leq \frac{2}{3}$ and $\gamma \in [\gamma_1, \gamma_2] \Rightarrow p^*_{A_3} = p^*_{iv^b} = \phi_s + \gamma$ and $\pi^*_{A_3} = \pi^*_{iv^b} = (1-\phi_s)(\phi_s+\gamma)$;
- If $\phi_s \leq \frac{2}{3}$ and $\gamma \notin [\gamma_1, \gamma_2] \Rightarrow p^*_{A_3} = p^*_{ii^b}$ and $\pi^*_{A_3} = \pi^*_{ii^b}$.

See Figure 1, where the roots γ_1 and γ_2 of (A.1) are depicted. The figure shows that γ_1 and γ_2 are indeed relevant since they overlap with subdomain A_3.

- **ad** A_4 From the preceding, we know that

$$\pi^*_{iv^a} \geq \pi^*_{iii} > \pi^*_i > \pi^*_v.$$

Thus, for (γ, ϕ_s) in A_4, the maximum profit $\pi^*_{A_4}$ is either $\pi^*_{ii^b}$ or $\pi^*_{iv^a}$. Solving $\pi^*_{ii^b} = \pi^*_{iv^a}$ leads to

$$\begin{aligned} & \pi^*_{ii^b} = \pi^*_{iv^a} \\ \Leftrightarrow \quad & [\phi_s - \gamma(1-\phi_s)]^2(1-\phi_s-\gamma) = (1-\phi_s)\phi_s(\phi_s-\gamma) \\ \Leftrightarrow \quad & -\gamma^3(1-\phi_s)^2 + \gamma^2(1-\phi_s)[2\phi_s + (1-\phi_s)^2] \\ & +\gamma\phi_s[(1-\phi_s) - 2(1-\phi_s)^2 - \phi_s] = 0. \end{aligned}$$

Solving for γ, one obtains $\gamma = 0$ or

$$\gamma_{1',2'} = \frac{(1-\phi_s)(1+\phi_s^2) \pm \sqrt{Discr}}{2(1-\phi_s)^2} > 0, \tag{A.2}$$

with $Discr = (1-\phi_s)^2[(1+\phi_s^2)^2 - 4\phi_s(1-2\phi_s(1-\phi_s))]$. Notice that in subdomain A_4, we have $Discr < (1-\phi_s)^2(1+\phi_s^2)^2$ since $1 - 2\phi_s(1-\phi_s) > 1-(1-\phi_s) > 0$. The latter follows from the fact that $\phi_s < \frac{1}{2}$ in subdomain A_4.

However, one can show that for each value of ϕ_s, the smaller root $\gamma_{1'}$ in (A.2) is larger than the corresponding value of $\bar{\gamma}$. In other words, both lines $\gamma = \gamma_{1'}$ and $\gamma = \gamma_{2'}$ are located at the right of line d_2 in (γ, ϕ_s)-space.

Since $\pi^*_{ii^b} < \pi^*_{iv^a}$ when $\gamma \notin (\gamma_{1'}, \gamma_{2'})$, the result is that $p^*_{A_4} = p^*_{iv^a} = \frac{1}{2}$ and $\pi^*_{A_4} = \pi^*_{iv^a} = \frac{(1-\phi_s)}{4(1-\phi_s-\gamma)}$.

- **ad** A_5 Since both

$$\pi^*_{iv^b} = \pi^*_{iii} > \pi^*_{ii^c} \quad \text{and} \quad \pi^*_{iv^b} > \pi^*_i > \pi^*_v,$$

we have that $p^*_{A_5} = p^*_{iv^b} = \phi_s + \gamma$ and $\pi^*_{A_5} = \pi^*_{iv^b} = (1-\phi_s)(\phi_s+\gamma)$.

- **ad** A_6 In this case, we have

$$\pi^*_{iii} > \pi^*_i > \pi^*_v, \pi^*_{iv^a} \geq \pi^*_{iii} \quad \text{and} \quad \pi^*_{iii} > \pi_{ii^c},$$

The fact that $\pi^*_{iv^a} \geq \pi^*_{iii}$ follows since $\phi_s + \gamma \leq \frac{1}{2}$ in subdomain A_6. It immediately follows that $p^*_{A_6} = p^*_{iv^a} = \frac{1}{2}$ and $\pi^*_{A_6} = \pi^*_{iv^a} = \frac{(1-\phi_s)}{4(1-\phi_s-\gamma)}$.

Summarizing results, statements (a), (b) and (c) of Property 4 follow directly by noting from (11) that $p^I = p^*_{iv^a}$, $\pi^I = \pi^*_{iv^a}$, $p^{II} = p^*_{iv^b}$, $\pi^{II} = \pi^*_{iv^b}$, $p^{III} = p^*_{ii^b}$ and $\pi^{III} = \pi^*_{ii^b}$.

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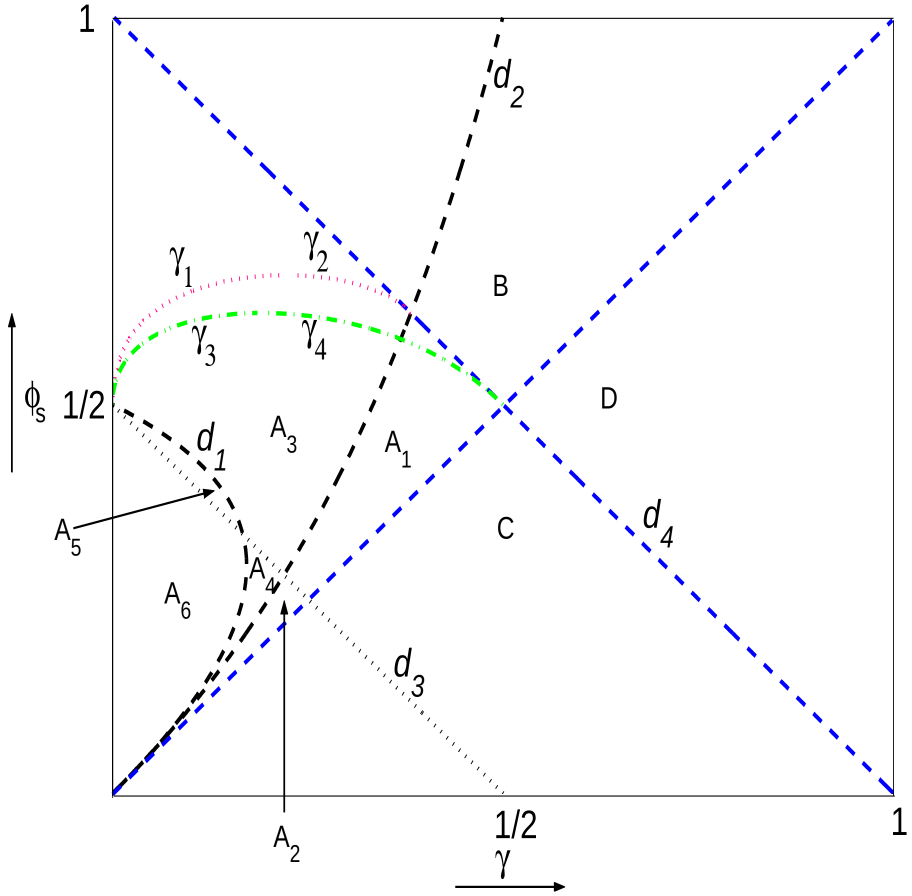

Figure 1: Partition of the (γ, ϕ_s)-space.

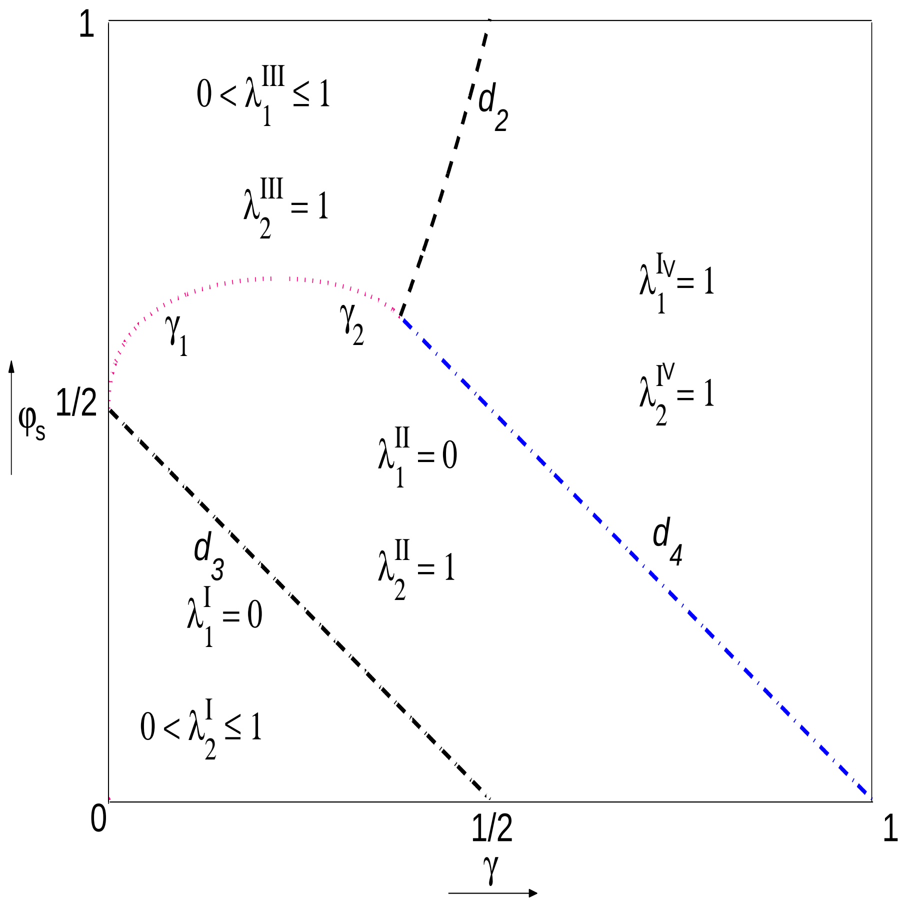

Figure 2: Equilibrium fractions of buyers for the different areas in (γ, ϕ_s)-space.

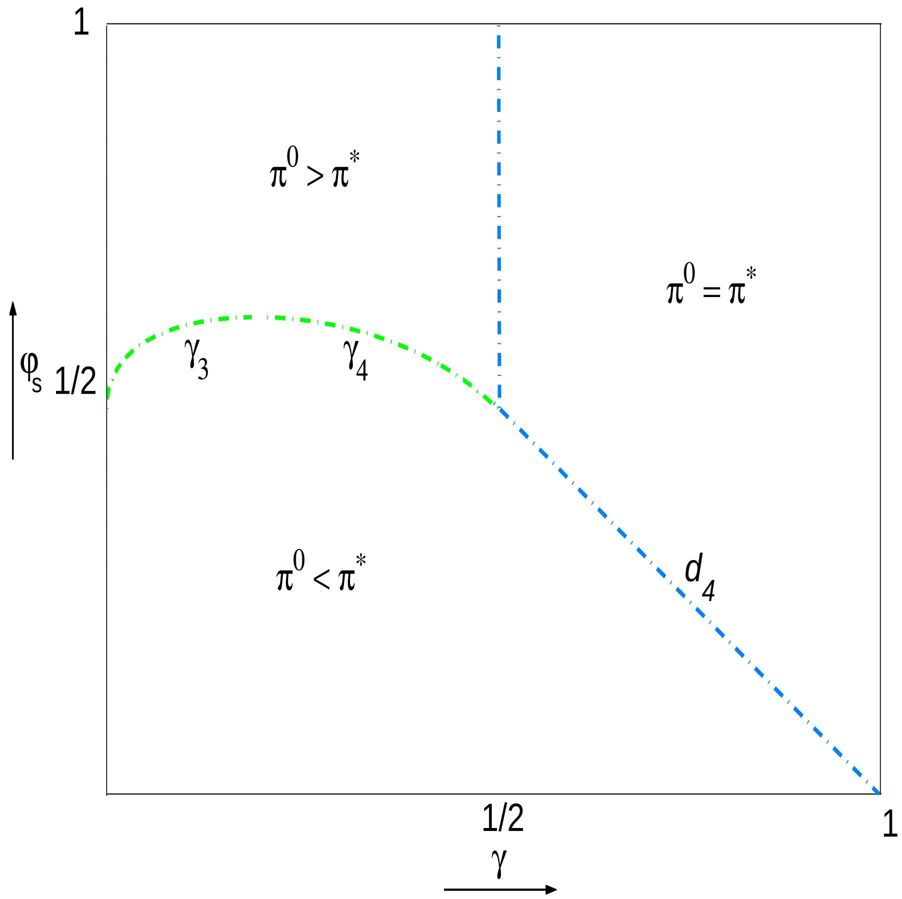

Figure 3: Profit comparison in the equilibria with one and two groups.