# Increasing Dominance - the Role of Advertising, Pricing and Product Design

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# Increasing Dominance - the Role of Advertising, Pricing and Product Design*

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**Abstract**

Despite the empirical relevance of advertising strategies in concentrated markets, the economics literature is largely silent on the effect of persuasive advertising strategies on pricing, market structure and increasing (or decreasing) dominance. In a simple model of persuasive advertising and pricing with differentiated goods, we analyze the interdependencies between ex-ante asymmetries in consumer appeal, advertising and prices. Products with larger initial appeal to consumers will be advertised more heavily but priced at a higher level - that is, advertising and price discounts are strategic substitutes for products with asymmetric initial appeal. We find that the escalating effect of advertising dominates the moderating effect of pricing so that post-competition market shares are more asymmetric than pre-competition differences in consumer appeal. We further find that collusive advertising (but competitive pricing) generates the same market outcomes, and that network effects lead to even more extreme market outcomes, both directly and via the effect on advertising.

**Keywords:** Increasing dominance, persuasive advertising, duopoly, network effects
**JEL:** D21, L11, L13, M37

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# 1 Introduction

Advertising investments represent one of the largest items in companies' financial budgets. It is estimated that advertising expenditure accounts for 1 percent of GDP worldwide and 3 percent of GDP in developed countries (*AdSpend Growth in 2006*, ZenithOptimedia). In the U.S. alone, firms spend US$ 150 billion on advertising-related services. For products as diverse as cosmetics, beer or consumer electronics, more than 20 percent of the profit margins are regularly re-invested in advertising-related activities (see *Advertising to Margin Ratios 2008*, Schonfeld & Associates).

The economics literature distinguishes between two main effects of advertising. First, advertising can create demand by informing consumers about existence, price and attributes of the product (Butters, 1977). It can also signal quality (Nelson, 1974), cost advantages (Linnemer, 1998) or economies of scale (Bagwell and Ramey, 1994; Clark and Horstmann, 2005). Following the informative view therefore, advertising carries information for potential consumers that will lead to purchases, thus increasing demand for an advertised product. Second, advertising can also change consumers' perceptions and preferences about the product and introduces a further source of (spurious) product differentiation (Dixit and Norman, 1978). The persuasive view on advertising thus argues that consumers' willingness to pay for a product is affected directly by the amount of advertising for it.

Although persuasive techniques such as celebrity endorsements or emotional appeal are a generic part of the marketer's everyday tool kit, the persuasive function of advertising is only slowly acknowledged in economic models of advertising competition.[1] Thus, the economic literature has been largely silent on many problems in concentrated advertising-intensive industries. Particularly, the effect of persuasive advertising on price competition and the resulting market structure is not yet fully understood.

This is especially surprising given the literature's existing focus on firm investment incentives in asymmetric market structures. In addition to the extensive (mostly empirical) literature on innovation incentives and market structure (Aghion et al., 2005; Kretschmer et al., 2009), research on increasing dominance studies markets in which ongoing investments by competing firms can serve to reinforce or weaken initial asymmetries in market structure. Such investments may involve setting low prices (Cabral and Riordan, 1994) or investing in high quality or low cost (Athey and Schmutzler, 2001), while additional sources of increasing dominance can be R&D risk choice (Cabral, 2002) or network effects (Arthur, 1989), among others. However, despite the obvious empirical relevance, the role of advertising has not been considered in such models.

Clearly, advertising is just one of many strategic variables firms choose when competing. Firms will run advertising campaigns with a clear expectation of their impact

[1] Bagwell (2007) gives a thorough overview over the theoretical and empirical literature on advertising.

on the pricing strategies they intend to use later on, and they will take product design outcomes from an earlier stage into account when deciding on advertising. In this paper, we propose a simple model of persuasive advertising and pricing with differentiated goods a la Hotelling (1929) and focus especially on the interdependencies between the outcome of the product design process and competition in advertising and prices. We find that differences originating from more or less successful product design will be amplified by firm advertising but reduced by pricing. In other words, products with larger initial appeal to consumers will be advertised more heavily while priced at a higher level - advertising and price discounts are strategic substitutes for products with asymmetric initial appeal to consumers. We find that the escalating effect of advertising dominates the moderating effect of pricing so that post-competition market shares are more asymmetric than the initial appeal to consumers given equal prices and advertising.[2] This is because the initially advantaged firm can charge higher prices *ceteris paribus*, so that it potentially gains more from an expansion of its customer base and thus has a greater incentive to advertise than its smaller rival. In a series of extensions, we find that collusive advertising (but competitive pricing) generates the same market outcomes, and that network effects lead to even more extreme market outcomes, both directly and via the effect on advertising.

Our work relates to models of persuasive advertising in a Hotelling setup without allowing for firm asymmetry. Von der Fehr and Stevik (1998) develop a framework for the classification of possible advertising technologies in such models. They distinguish three ways how persuasive advertising may affect demand: i) It may increase the willingness to pay, ii) increase perceived product differences or iii) change the ideal product variety. Ordoñez de Haro (1993), in a setup modeling option i), studies persuasive advertising as an entry barrier and finds that advertising will be employed excessively in equilibrium compared to the social optimum. Including ours, other research on persuasive advertising concentrated on changes in consumer preferences. Von der Fehr and Stevik (1998) conclude for this case that advertising will not affect prices and sales as the firms' advertising expenditures will be balanced in equilibrium. This result is due to the fact that they only consider symmetric firms (and employ an advertising technology similar to ours). Bloch and Manceau (1999) show that the degree of product differentiation - and thus the competitiveness of the market at the pricing stage - may decrease or increase when advertising alters the shape of the distribution of consumers' preferences on the Hotelling interval. They consider a general functional form which limits possible conclusions about firms' advertising incentives. In contrast, our parametrization of the advertising technology allows for a richer analysis of the advertising game while inevitably losing out on generalizability. Stressing the combative (i.e. business-stealing) aspect of persuasive advertising in a Hotelling model, Chen et al. (2009) consider the effect of advertising on the size of the

[2]Note that we think of increasing dominance in the sense of comparing post-investment to pre-investment market asymmetry rather than in a dynamic game.

respective segments of 'indifferent' and 'partisan' consumers in the pricing game. They find that if the initial distribution of preferences and the responsiveness to advertising are such that advertising increases the segment of partisan consumers who strongly favor one firm, competition in prices will soften. Conversely, if receiving advertisements from both firms creates a large segment of indifferent consumers, price competition will intensify. However, while studying the overall competitive effects with a flexible preference structure, the authors do not consider effects of persuasive advertising on the relative competitive positions of firms.

The only other work to our knowledge that allows for asymmetric market shares with persuasive advertising is by Doraszelski and Markovich (2007). In their model of a dynamic oligopoly market, firms build up goodwill that makes consumers more inclined to buy a certain brand. Their question is similar to ours in that they investigate the persistence and dynamics of initial advantages. However, the papers differ substantially with respect to the function of persuasive advertising they study: Goodwill advertising is more consistent with long-term investments in branding while our model concentrates on forms of advertising that take immediate effect on consumer preferences. Thus, where Doraszelski and Markovich consider the long-run effects of interaction in advertising and prices, we complement their work by looking at the implications of a setup equivalent to a one-shot product-specific campaign. This specification models a situation when decisions at the product design stage (still) strongly affect the demand of a newly introduced product. Despite these differences, the main finding of persuasive advertising as a force of increasing dominance is the same in both papers. However, while in their model a larger market and lower advertising costs have a deescalating effect, we find the exact opposite. The reason for this discrepancy is that in their model advertising has both market-share and market-size effects while we focus on the combative nature of advertising competition. Thus, in their model, the smaller firm may grow on market expansion and sidestep the competitive confrontation with the larger rival.

The way in which initial market share asymmetries enter the model is inspired by Grilo et al. (2001), who build their analysis of price competition with positive and negative network effects around the idea of locational advantage in a Hotelling model.

In our model, advertising is a costly device for location choices. Therefore, this work also relates to the literature on the choice of location in Hotelling models (e.g., Osborne and Pitchik, 1987; Anderson et al., 1997; Brekke et al., 2006; for a review see Anderson et al., 1992, Ch. 8). However, in contrast to models where firms choose location directly, in our model the distance between firms is fixed and the firms' locations are determined by the relative magnitudes of advertising by competing firms. We interpret advertising as an instrument for reacting to mistakes made in the product development phase due to uncertainty.

Our model can also be interpreted as one stage of a repeated market game in which firms make myopic (and uncertain) decisions on product design and subsequently choose advertising and pricing jointly and competitively. The initial asymmetry is then a result from prior iterations while the outcome forms the starting point for a new interaction.[3] As mentioned above, our work therefore also relates to the literature on increasing dominance (e.g., Cabral and Riordan, 1994; Athey and Schmutzler, 2001). In addition, our extension with network effects provides a new framework to study how different forces of increasing dominance interact. Given the concerns about inefficient market outcomes when network effects are present (e.g., Arthur, 1989; Besen and Farrell, 1994; Katz and Shapiro, 1994), studying the relative importance of network effects compared to strategies like advertising, quality and prices for competitive outcomes is an important task. Tellis et al. (2008) take a step in this direction by investigating the relative importance of quality and network effects for market dominance. They find that high quality was the most important driver of market success in the industries considered while the presence of network effects enhanced the quality effect. Our results suggest a similar relationship for advertising and network effects.

The remainder of the study is organized as follows. In the next section, we present the basic model. After that, we investigate the robustness of our results with two extensions. The implications and limitations of the results are discussed in the conclusion.

# 2 The Model

Our model is based on a Hotelling model of product differentiation: Two firms produce goods 0 and 1, which may differ in one dimension of their (exogenous) characteristics,[4] with constant marginal costs (normalized to 0). The difference in characteristics is given by their locations on the Hotelling line, $x_0 \in [0,1]$ and $x_1 \in [0,1]$. Without loss of generality we assume $x_0 \leq x_1$, that is, good 0 is located left of good 1.

Consumers have unit demand and are uniformly distributed with mass $N$ on the interval $[0,1]$. A consumer $j$'s position $\theta_j$ on the line gives her idiosyncratic preference for product characteristics. When buying product $i$ ($i = 0, 1$), she bears 'transport costs' $\tau$ ($\tau > 0$) multiplied by the squared distance between her own location and the location of the good she buys.[5]

Firms can advertise to alter consumers' perceptions about the ideal brand. More precisely, by investing in advertising they can shift the distribution of consumers horizontally so that after observing advertisements consumer $j$ decides as if his position was not $\theta_j$ but

[3] Note that we do not focus on the source of *ex ante* asymmetry, which could be due to luck, uncertain product innovation, or unknown consumer preferences. Instead, we focus on the effects such asymmetries have on competition in advertising and prices.

[4] We assume that firms cannot alter the fundamental product characteristics and take the *ex ante* location of the products as exogenous to concentrate on advertising and pricing decisions. For the choice of location see Gabszewicz and Thisse (1992).

[5] Quadratic transport costs ensure equilibrium existence in the pricing game (d'Aspremont et al., 1979).

$\theta_j - g(a_0, a_1)$ with $g(a_0, a_1) = \lambda(a_0 - a_1)$. This advertising technology has the following properties:[6]

- The sign of $g(\cdot)$ depends on the relative size of $a_0$ and $a_1$:
  $g(a_0, a_1) > 0$ for $a_0 > a_1$, $g(a_0, a_1) < 0$ for $a_0 < a_1$,
  and $g(a_0, a_1) = 0$ for $a_0 = a_1$.

- $g(\cdot)$ increases in $a_0$ and decreases in $a_1$:
  $\frac{\partial g(a_0,a_1)}{\partial a_0} > 0$, $\frac{\partial g(a_0,a_1)}{\partial a_1} < 0$.

- $g(\cdot)$ is symmetric in $a_0$ and $a_1$:
  $g(a, \bar{a}) = -g(\bar{a}, a)$ with $a, \bar{a} \in \mathbb{R}^+$ .

An important feature of our advertising technology is that firms cannot alter the distribution of consumers but only the position of the consumers' interval on the Hotelling line. Advertising thus does not lead to clustering of consumers around the advertised product but draws all of them towards one of the extremes of product space while maintaining a uniform distribution, so that the degree of consumer and firm heterogeneity is fixed.

The intuition for our advertising function is the following: Success in the advertising game means that consumers are convinced of the superiority of one brand's position over the other's for given prices. As we rule out targeting certain consumers, advertising shifts everyone's preferences, which is analogous to an increase in the reservation value for one product for all consumers. Consider the example of detergents differentiated along a Hotelling line capturing their 'gentleness'. A brand that is located closer (but not at) to the 'hard' (but effective) end of the line than its rival will advertise the benefits of effectiveness in general rather than the virtues of '2/3 hard, 1/3 gentle'. This untargeted advertising message eventually leads to all consumers preferring more effective detergents, i.e. the Hotelling line shifts towards the 'hard' end.

The effect of advertising on consumers' decision making is mediated through the transport costs: Consumer $j$'s post-advertising transport costs are $\tau(\theta_j - \lambda(a_0 - a_1) - x_i)^2$ instead of $\tau(\theta_j - x_i)^2$. Transport costs thus increase for the firm that advertises less. By using persuasive advertising firms can thus try to make their rival's brand less attractive ceteris paribus while at the same time enhancing the attractiveness of their own without altering fundamental product characteristics.

Advertising is costly for firms and displays decreasing returns (Simon and Arndt, 1980). We model this by assuming quadratic advertising costs with a scaling parameter $\phi_i > 0$:

$$C(a_i) = \phi_i \cdot a_i^2, \qquad i = 0, 1.$$

[6]With these properties, our advertising function is an application of the general functional form considered by von der Fehr and Stevik (1998) for advertising that changes the ideal product variety.

In our basic model, we assume that firms use the same advertising technology with equal costs so that $\phi_0 = \phi_1 = \phi$. The case of asymmetric costs will be discussed in the Appendix.

We now take a closer look at the consumer side of the model. Net surplus for a consumer $j$ with position $\theta_j$ when buying from firm $i$ ($i = 0, 1$) is

$$U_i(\theta_j) = V - \tau \cdot (\theta_j - \lambda(a_0 - a_1) - x_i)^2 - p_i, \tag{1}$$

where $V$ is the consumer's gross valuation and $p_i$ the price for good $i$. Assume that $V$ is large enough so that the market is always covered.

At this point it is useful to introduce the idea of locational advantage which helps us organize the discussion later on.

**Definition 1.** *If $x_0 + x_1 > (<) \, 1$, firm 0 (1) has an initial locational advantage.*

The intuition of the locational advantage is the following: For $x_0 + x_1 > 1$, good 0 lies closer than good 1 to the position of the median consumer $\bar{\theta} = \frac{1}{2}$ so that consumers' maximum travel distances are shorter for product 0. As a result, under a hypothetical assumption of equal prices and advertising, firm 0 would attract more consumers than firm 1. Consequently, in this case, firm 0 enters the game with an advantage. The analogous reasoning applies to firm 1 for $x_0 + x_1 < 1$. If the sum of the firms' positions $x_0$ and $x_1$ equals 1, goods are symmetrically located.

The initial locational advantage can originate from several sources. The most straightforward intuition would be that the firm with the locational advantage was more successful in designing the product to the median consumer's needs under uncertainty than its rival at a stage (not modeled here) prior to the game. This is not unrealistic as future demand is often hard to anticipate (e.g., Bayus, 1993; Krishnan and Bhattacharya, 2002). Alternatively, the advantage may stem from earlier iterations of the market game where one firm was able to build up goodwill with consumers (Doraszelski and Markovich, 2007). Our static setting can then be interpreted as a snapshot of a dynamic game with myopic firms.

The market game has three stages and is solved through backward induction. At the first stage, firms decide on advertising budgets $a_0, a_1 \geq 0$. Advertising costs are then sunk in the second stage, when firms choose price levels $p_0$ and $p_1$. At the third stage, consumers each select one of the products to buy after observing advertisements and prices.

# 3 Market Equilibrium

## 3.1 Third Stage: Consumer Choice

Equilibrium quantities corresponding to values of $(p_0, p_1)$ and $(a_0, a_1)$ at the third stage can be found by determining the indifferent consumer at $\hat{\theta} \in [0, 1]$. Solving $U_0 = U_1$ for the indifferent consumer's position yields

$$\hat{\theta} = \frac{1}{2}\frac{p_1 - p_0 + \tau(x_1 - x_0)(x_0 + x_1 + 2\lambda(a_0 - a_1))}{\tau(x_1 - x_0)}. \tag{2}$$

All consumers located on the interval $[\hat{\theta}; 1]$ buy product 1 while consumers located on $[0; \hat{\theta}]$ buy product 0. An increase in $p_1$ ($p_0$) shifts the position of the indifferent consumer closer towards the right (left) end of the line, thus increasing demand for firm 0 (1). Equation (2) also shows that demand increases with own advertising and decreases with advertising for the rival's product.

With market size $N$, quantities demanded for given price and advertising levels are $N \cdot \hat{\theta}$ for firm 0 and $N \cdot (1 - \hat{\theta})$ for firm 1. Note that for $\hat{\theta} \in [0, 1]$ we require:

$$\begin{aligned}\tau(x_1 - x_0)(x_0 + x_1 + 2\lambda(a_0 - a_1)) &< p_0 - p_1 \\ &< -\tau(x_1 - x_0)(2 - x_0 - x_1 - 2\lambda(a_0 - a_1)).\end{aligned} \tag{3}$$

Inequality (3) specifies combinations of advertising and price strategies for which firms share the market and market shares are determined by (2). Outside this area, one single firm captures the entire market.

## 3.2 Second Stage: Firms' Pricing Decisions

Having identified the behavior of consumers at the third stage of the game, we now turn to the pricing subgame at the second stage. We assume that at the time of the pricing decision advertising decisions have already come into effect and are observed by all agents. Consequently, advertising costs are sunk when prices are set. Firm $i$'s optimization problem at the second stage becomes thus

$$\max_{p_i} \quad p_i \cdot n_i(a_0, a_1, p_0, p_1),$$

where $n_i$ is the respective demand with $n_0 = N \cdot \hat{\theta}$ and $n_1 = N \cdot (1 - \hat{\theta})$.

Maximizing profit for given advertising levels under the assumption of market sharing and solving the resulting reaction functions yields prices

$$p_0^*(a_0, a_1) = \frac{\tau}{3}(x_1 - x_0)(2 + x_0 + x_1 + 2\lambda(a_0 - a_1)) \tag{4}$$

and

$$p_1^*(a_0, a_1) = \frac{\tau}{3}(x_1 - x_0)(4 - x_0 - x_1 - 2\lambda(a_0 - a_1)). \tag{5}$$

Equations (4) and (5) allow for several observations. Firstly, prices increase in own advertising and decrease in the advertising of the rival. Advertising and prices are thus complementary market strategies on the one hand and strategic substitutes in the market game on the other hand.[7] This is in line with the empirical results of Slade (1995), who finds that when advertising is combative, advertising and prices are strategic substitutes.

Further, our model reproduces the standard result that prices are positively correlated both with the degree of product differentiation measured by the product of the transport cost parameter $\tau$ and the distance between product locations $(x_1 - x_0)$. That is, when transport costs are relatively high or products very dissimilar, the intensity of competition between firms is low. In this case, the market will have higher overall price levels. Note that changes in the transport cost parameter $\tau$ affect the absolute competitive situation (i.e. intensity) in the pricing game while advertising affects the relative competitive situation.

Comparing (4) and (5) shows that the firm with the stronger relative position after advertising can charge a price premium. In particular, if $x_0 + x_1 + 2\lambda(a_0 - a_1) > 1$, firm 0 charges a higher price than firm 1. Analogously, firm 1 charges a premium if $x_0 + x_1 + 2\lambda(a_0 - a_1) < 1$. Note the strong resemblance of these expressions to the concept of locational advantage introduced earlier. We can hence rephrase our result in the following way:

**Remark 1.** *The firm with a* post-advertising *locational advantage charges a price premium over its rival.*

### 3.3 First Stage: Firms' Advertising Decisions

At the first stage, firms maximize profit taking into account advertising costs $C(a_i)$ as well as subsequent decisions. In particular, firm $i$ chooses its advertising level $a_i$ to maximize

$$\Pi_i = p_i^*(a_i, a_j) \cdot n_i(p_i^*(a_i, a_j), p_j^*(a_i, a_j), a_i, a_j) - \phi \cdot a_i^2.$$

Solving the reaction functions we obtain for the interior equilibrium advertising strategies

$$a_0^* = \frac{\lambda N \tau (x_1 - x_0)}{3\phi} \cdot \frac{3\phi(2 + x_0 + x_1) - 4\lambda^2 N \tau (x_1 - x_0)}{9\phi - 4\lambda^2 N \tau (x_1 - x_0)} \tag{6}$$

[7] Note that because of these features this game does not belong to the class of supermodular games studied by Milgrom and Roberts (1990), Vives (1990) and Tremblay (2004).

and

$$a_1^* = \frac{\lambda N\tau(x_1 - x_0)}{3\phi} \cdot \frac{3\phi(4 - x_0 - x_1) - 4\lambda^2 N\tau(x_1 - x_0)}{9\phi - 4\lambda^2 N\tau(x_1 - x_0)}. \tag{7}$$

Note how when firms are symmetrically located, these equations boil down to $a_0^* = a_1^* = \frac{\lambda N\tau(x_1 - x_0)}{3\phi}$. In other words, symmetrically located firms advertise the same so that symmetric market shares will persist.[8]. For asymmetric locations, conclusions from equations (6) and (7) hinge on the respective second term of the right hand side. We will make the following assumption throughout this section:

**Assumption 1.** *Advertising costs $\phi$ are not too low:*

$$\phi > \frac{4}{9}\lambda^2 N\tau(x_1 - x_0).$$

Assumption 1 states that advertising is sufficiently costly in relation to its effectiveness $\lambda$. It ensures that firms have to make a significant investment to be able to profit from a change in consumers' preferences. The inequality becomes stronger for larger markets ($N$) and higher degrees of product differentiation ($\tau$) indicating that the restriction on minimum advertising costs becomes more stringent with higher profit opportunities.

With Assumption 1 we can conclude from (6) and (7) that firm 0 advertises more than firm 1 if it has a locational advantage ($x_0 + x_1 > 1$), and less if $x_0 + x_1 < 1$. As a result, consumer preferences are drawn further towards the characteristics of the already leading product which amplifies the market asymmetry.

## 3.4 Subgame Perfect Equilibrium

We now complete our solution for an interior subgame perfect equilibrium of the game. Inserting (6) and (7) in equations (4) and (5), we obtain equilibrium price levels

$$p_0^* = \tau(x_1 - x_0)\frac{3\phi(2 + x_0 + x_1) - 4\lambda^2 N\tau(x_1 - x_0)}{9\phi - 4\lambda^2 N\tau(x_1 - x_0)} \tag{8}$$

and

$$p_1^* = \tau(x_1 - x_0)\frac{3\phi(4 - x_0 - x_1) - 4\lambda^2 N\tau(x_1 - x_0)}{9\phi - 4\lambda^2 N\tau(x_1 - x_0)}. \tag{9}$$

As above, a symmetric location of firms yields symmetric price strategies, $p_0^* = p_1^* = \tau(x_1 - x_0)$. For asymmetric locations, the firm with an initial locational advantage charges more than the price for symmetric locations while the firm with an initial disadvantage charges less. Hence, a firm with an initial disadvantage will concentrate on competitive pricing instead of trying to offset its position with large advertising efforts.

[8]Note that profits do not fall to zero as products are still differentiated unless $x_0 = x_1 = \frac{1}{2}$

Substituting $a_0^*$, $a_1^*$, $p_0^*$ and $p_1^*$ into (2) yields the position of the indifferent consumer:

$$\hat{\theta}^* = \frac{1}{2}\frac{3\phi(2 + x_0 + x_1) - 4\lambda^2 N\tau(x_1 - x_0)}{9\phi - 4\lambda^2 N\tau(x_1 - x_0)}. \tag{10}$$

When firm 0 has an initial locational advantage, $\hat{\theta}^*$ is located on the right side of the median consumer at $\theta = 1/2$ while it is located on his left side for an initial advantage of firm 1. The initially leading firm can thus translate its locational advantage into a higher equilibrium market share. The disadvantaged firm's lower price cannot compensate for the (advertising-enhanced) asymmetry in consumer preferences. The asymmetry in equilibrium market shares is more pronounced for larger markets and higher transport costs, indicating that higher profit opportunities benefit the initially leading firm most:

$$\frac{\partial \hat{\theta}^*}{\partial N} > (<)\, 0 \quad \text{and} \quad \frac{\partial \hat{\theta}^*}{\partial \tau} > (<)\, 0 \qquad \text{if } x_0 + x_1 > (<)\, 1.$$

At the same time, advertising costs and the market share of the initially leading firm are inversely related:

$$\frac{\partial \hat{\theta}^*}{\partial \phi} < (>)\, 0 \qquad \text{if } x_0 + x_1 > (<)\, 1.$$

Capturing market share hence becomes easier for the leading firm when advertising costs decrease. In other words, a negative shock in the costs for advertisements, for example during an economic recession, increases asymmetries in market shares *ceteris paribus* and may thus facilitate monopolization.

For $a_0^*, a_1^*, p_0^*, p_1^*$ and $\hat{\theta}^*$ to form an equilibrium they need to lie in their domain of definition, that is $a_0^*, a_1^* \geq 0$, $p_0^*, p_1^* \geq 0$ and $0 \leq \hat{\theta}^* \leq 1$. This is true if

$$\phi > \frac{4}{3 \cdot \min\{2 + x_0 + x_1, 4 - x_0 - x_1\}} \lambda^2 N\tau(x_1 - x_0). \tag{11}$$

The set determined by condition (11) is feasible under Assumption 1. Hence, as long as this inequality holds, equations (6)-(10) describe an interior subgame perfect equilibrium of the game. Our first proposition summarizes these results:

**Proposition 1a.** *The firm with an initial locational advantage advertises more than its rival while the disadvantaged firm charges a lower price. The firm with the initial advantage captures a larger share of the market.*

The advantage of the leading firm in the advertising game goes back to the way advertising and prices enter the profit functions. While prices are strategic complements, investments in advertising are strategic substitutes. Thus, the positive effect of advertising expenditure on own profits decreases with the amount spent by the other firm. This is in line with the results by Athey and Schmutzler (2001) who see the characteristic of strategic substitutes as one of the key conditions for increasing dominance.[9] In addition, the firm with the initial advantage will have a higher equilibrium margin than its rival because it can charge higher prices *ceteris paribus* due to its captive consumers. Since marginal costs of advertising are the same for both firms, the incentive to advertise is smaller for the initially disadvantaged firm.[10] The strategic advantage from the product design stage thus follows from considerations of cost and benefit of advertising.

We can also characterize what happens in corner solutions when (11) does not hold. In this case, $a_0^*, a_1^*, p_0^*$ and $p_1^*$ are no longer equilibrium strategies as at least one would be negative. Instead, one of the firms captures the entire market.

Let us first consider the case of $x_0 + x_1 > 1$ where firm 0 has an initial locational advantage. With Assumption 1 and equation (11), the critical parameter range is identified by

$$\frac{4}{9}\lambda^2 N\tau(x_1 - x_0) < \quad \phi \quad < \frac{4}{3 \cdot (4 - x_0 - x_1)}\lambda^2 N\tau(x_1 - x_0).$$

If this range is non-empty, the following outcome forms an equilibrium: At the third stage, all consumers buy from firm 0 and firm 1 leaves the market. Firm 0 charges the maximum price leading to monopolization as restricted by equation (3) while the advertising level is the profit maximizing investment for this price. The resulting equilibrium strategies are

$$\begin{aligned} p_0^* = \tau(x_1 - x_0)\frac{2\lambda^2 N\tau(x_1 - x_0) - \phi(2 - x_0 - x_1)}{\phi}, \qquad p_1^* = 0, \\ a_0^* = \frac{\lambda N\tau(x_1 - x_0)}{\phi} \quad \text{and} \quad a_1^* = 0. \end{aligned} \tag{12}$$

The intuition behind this result is that in the extreme cases where (11) does not hold, advertising is so cheap that the initially advantaged firm can corner the market through advertising. In this case, the rival firm cannot cut its prices further to attract consumers and must exit the market.

Note that this pressure from the leading firm on its competitor results from advertising, not fierce pricing. The ability of market cornering denotes an important difference between the effects of persuasive advertising and mere price cuts. In a setup without advertising, firms would always share the market. Only the introduction of the second strategic variable allows for monopolization through the leading firm.

Analogously, firm 1 may capture the market when it has a locational advantage and

[9]Note that we obtain increasing dominance although their other prerequisite, increasing returns to the investment, is not met.

[10]The incentive may be higher when the overall market size increases due to advertising (Doraszelski and Markovich, 2007).

advertising is not too costly:

$$\frac{4}{9}\lambda^2 N\tau(x_1 - x_0) < \quad \phi \quad < \frac{4}{3 \cdot (2 + x_0 + x_1)}\lambda^2 N\tau(x_1 - x_0).$$

Equilibrium strategies are then given by

$$\begin{aligned} p_0^* = 0, \qquad p_1^* &= \tau(x_1 - x_0)\frac{2\lambda^2 N\tau(x_1 - x_0) - \phi(x_0 + x_1)}{\phi}, \\ a_0^* = 0 \quad \text{and} \quad a_1^* &= \frac{\lambda N\tau(x_1 - x_0)}{\phi}. \end{aligned} \tag{13}$$

The following proposition summarizes these results:

**Proposition 1b.** *For sufficiently low advertising costs, the ex-ante advantaged firm captures the entire market.*

The fact that advertising can produce monopoly outcomes has important implications for product introduction and marketing. Assuming that the initial disadvantage stems from poor design at the product development stage, it shows that precisely when advertising is cheap, initial mistakes cannot be redressed through marketing efforts but may result in total failure. While this may seem counterintuitive at first glance, it becomes clearer when considering that the rival firm has access to the same cheap technology and can counteract all efforts from a more convenient position charging higher prices.

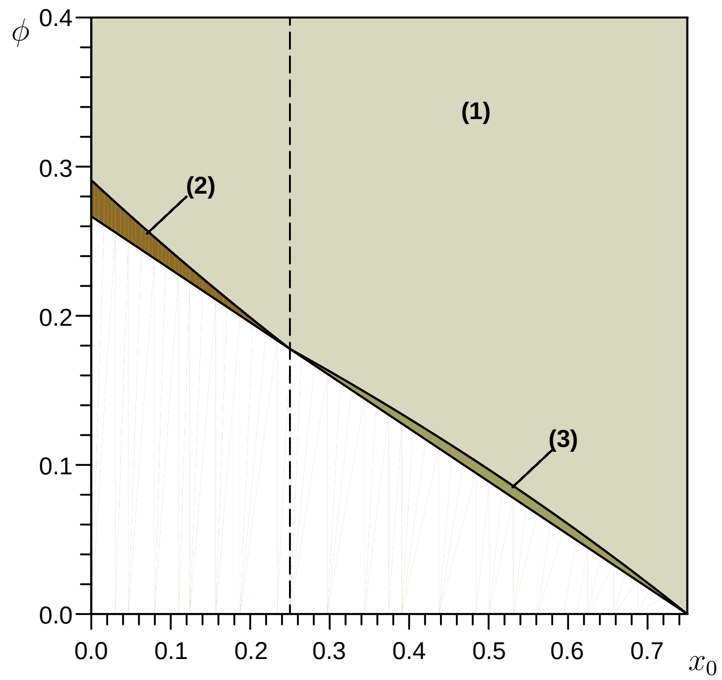


Figure 1: The effect of locational advantage and advertising costs on monopoly outcomes ($x_1 = 0.75$, $N = 1$, $\lambda = 1$, $\tau = 0.8$).

We illustrate the impact of advertising costs and locational asymmetry on monopolization graphically. Figure 1 exhibits areas of different market outcomes for one specific parametrization and combinations of advertising costs and location. The horizontal axis displays the location of firm 0's product on the Hotelling line and is restricted by the position of firm 1's product at $x_1 = 0.75$. The advertising cost parameter $\phi$ is shown on the vertical axis. For parameterizations in area *(1)* firms share the market. Monopolization occurs in areas *(2)* where firm 1 captures the market and *(3)* where firm 0 squeezes out its rival. Other parameterizations are excluded by Assumption 1.

## 3.5 Firms' Profit Levels

We consider now how our results translate into firms' profit levels. We first look at the relative profit level of firms. While the firm with a locational advantage benefits from its larger equilibrium market share and higher price, it also spends more on advertising than its rival. An analysis of equilibrium profits, however, confirms that the revenue effect dominates the cost effect so that a firm with an initial locational advantage earns higher profits than its rival, as expected:

$$\Pi_0^* > (<)\, \Pi_1^* \qquad \text{if } x_0 + x_1 > (<)\, 1.$$

A second aspect is how absolute profit levels are affected by the advertising technology.

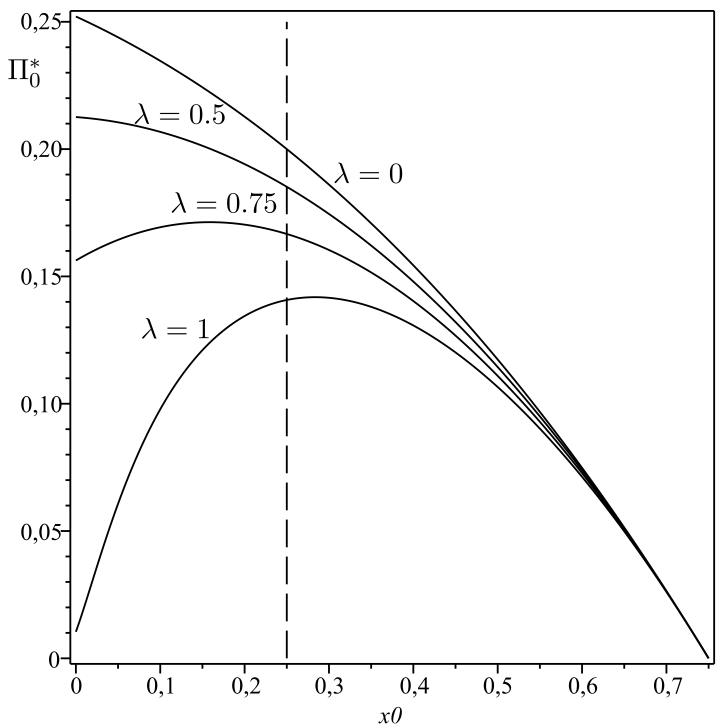


Figure 2: Firm 0's equilibrium profit for different levels of advertising effectiveness ($x_1 = 0.75$, $N = 1$, $\phi = 0.3$, $\tau = 0.8$).

Figure 2 shows profit levels of firm 0 plotted against its location for different levels of advertising effectiveness, $\lambda$.

$\lambda = 0$ characterizes a world without an effective advertising technology. Profits then decrease monotonically when the distance between products shrinks - the standard Hotelling result. In this case, a maximum level of product differentiation benefits a firm more than a locational advantage that goes along with a position closer to the other firm. When advertising is effective, the shape of the profit function changes to an inverse u-shape yielding highest profits in situations with intermediate degrees of product differentiation, i.e. for positions implying a locational advantage. The intuition for this result is that for intermediate degrees of product differentiation a locational advantage helps decide the advertising game in favor of the advantaged firm while consumers perceive the firms as sufficiently different. When firms are located closer to each other, it becomes harder to pull consumers away from the rival through advertising. We can also observe that for the underlying parametrization feasible profit levels decline when advertising becomes more effective. The reason is that advertising spending tends to increase for larger $\lambda$ resulting in the observed decline of overall profit levels. Even the leading firm may need to make investments so substantial that they are not balanced by potential gains. At the same time, it cannot forgo advertising as the rival firm would otherwise gain an advantage. This classical prisoners' dilemma situation arises for most parameterizations while for others at least the initially leading firm profits from advertising.[11]

# 4 Extensions

In this section, we discuss two extensions of our basic model and their implications for equilibrium outcomes.

## 4.1 Semi-Collusive Advertising

For a significant share of the parameter space, both firms would be better off if advertising was not available, but are willing to use the opportunity in the battle for market share. For symmetric firms, any investment in advertising at all is clearly wasted. We therefore reflect on how firms would act if they decided jointly on the implementation of advertising.[12] Semi-collusion on advertising may be attractive for firms when, for instance, antitrust authorities observe price levels more strictly than advertising levels.[13]

Collusion at the first stage of the game does not influence consumer and firm behav-

[11]Identifying the parameter ranges is not possible analytically. A numerical analysis is available from the authors on request.

[12]The case of full collusion or un-contested monopoly can not be analyzed in this framework as the assumption of full market coverage would imply the potential of unrestricted profits.

[13]See Wang et al. (2007) for empirical evidence on semi-collusion on advertising.

ior for any advertising level at the second and third stage. Consumer behavior is thus described by equation (2) while firms set prices at the second stage according to (4) and (5). At the first stage, firms maximize joint profit

$$\Pi^{coll} = p_0^*(a_0, a_1) \cdot n_0(p_0^*(a_0, a_1), p_1^*(a_0, a_1), a_0, a_1) \\ + p_1^*(a_0, a_1) \cdot n_1(p_0^*(a_0, a_1), p_1^*(a_0, a_1), a_0, a_1) - \phi \cdot (a_0 + a_1)$$

with respect to advertising levels $a_0$ and $a_1$. Solving the first order conditions for optimal levels of advertising gives

$$a_0 = \frac{-2\lambda N\tau(x_1 - x_0)(1 - x_0 - x_1)}{9\phi - 8\lambda^2 N\tau(x_1 - x_0)} \tag{14}$$

and

$$a_1 = \frac{2\lambda N\tau(x_1 - x_0)(1 - x_0 - x_1)}{9\phi - 8\lambda^2 N\tau(x_1 - x_0)}. \tag{15}$$

Note that for symmetric locations, none of the firms advertises. For interpreting equations (14) and (15), we require analogously to Assumption 1 that advertising costs do not lie below a certain threshold:

**Assumption 2.** *Advertising costs $\phi$ are not too low:*

$$\phi > \frac{8}{9}\lambda^2 N\tau(x_1 - x_0).$$

With this assumption, we can see that (14) and (15) yield negative advertising spending for the product that is initially disadvantaged. However, since advertising levels are restricted to the non-negative space, the first best solution is not feasible. Accordingly, firms will set advertising for the disadvantaged product equal to 0. Assume without loss of generality that firm 0 is the firm that is initially disadvantaged. We thus have

$$a_0^{*,coll} = 0. \tag{16}$$

Substituting this back into the profit maximization problem yields

$$a_1^{*,coll} = \frac{2\lambda N\tau(x_1 - x_0)(1 - x_0 - x_1)}{9\phi - 4\lambda^2 N\tau(x_1 - x_0)} \tag{17}$$

for optimal advertising spending for product 1. Comparison with equations (6) and (7) shows that the difference between advertising spending for the two products is the same, whether firms collude or compete at the third stage. As a result, the shift of the consumer interval is the same as well. Consequently, when firms set advertising collusively but compete in prices, the competitive results about market shares and prices are reproduced:

In the case of semi-collusion, the firm that advertises less in the competitive equilibrium does not advertise at all, while the other firm reduces its investment by the same amount. Market shares and prices are identical to the competitive case while profits for both firms increase due to savings in advertising expenditure.[14]

It is interesting to compare this finding with results from d'Aspremont and Jacquemin (1988) on Research Joint Ventures.[15] In a two-stage model where firms first choose R&D spending levels that maximize joint profit and compete in prices afterwards, they find that firms invest more in the first stage the higher the spillovers from R&D investment. The first stage then sees increased quantities on the product market and thus lower prices than in the fully competitive case while profits are higher. Our result thus follows from the assumption of no spillovers generated from advertising spending (i.e. pure business-stealing). In such cases,the colluding firms refrain from duplicating advertising investments and settle on the profit maximizing division of the market.

## 4.2 Network Effects

Demand-side externalities or network effects are a common feature especially in high-technology markets. (Arthur, 1989; Farrell and Klemperer, 2007). As the structure of markets for products with network effects is often characterized by asymmetries and extreme outcomes (Koski and Kretschmer, 2004), the starting point for strategic interactions is related in many ways to our basic setup.

By introducing network effects to our model, we shed more light on how firms' advertising decisions differ for goods with network effects compared to marketing traditional products. While some authors (Brekke et al., 2006; Pastine and Pastine, 2002) considered advertising functions uniquely applying to network markets, our setup lets us compare the worlds with and without network effects directly.

We follow an approach similar to Grilo et al. (2001) to incorporate network effects in our basic model with symmetric costs: Two incompatible networks are formed by the clients of the firms where each client profits from the size of the network he belongs to. This effect may be due to, e.g., an enhanced availability of complementary products or direct opportunities for interaction. Each consumer demands at most one unit of the good so that he has to decide which network to join exclusively. The network effect adding to his utility function when buying good $i$ ($i = 0, 1$) follows the existing literature and is defined as $\gamma \cdot n_i$ where $\gamma \geq 0$ and $n_i$ indicates the total number of buyers of good $i$.

[14]Note, however, that the collusive advertising levels do not form a Nash equilibrium as unilateral deviation would raise the firm's profit.

[15]Compared to advertising, the question of semi-collusion has been more extensively studied in the literature on R&D, see e.g., Kamien et al. (1992), Cabral (2000), and Lambertini et al. (2002).

Net surplus for a consumer $j$ with position $\theta_j$ buying from firm $i$ ($i = 0, 1$) is

$$U_i(\theta_j) = V - \tau \cdot (\theta_j - x_i - \lambda(a_0 - a_1))^2 + \gamma n_i - p_i. \tag{18}$$

With network effects different partitions of consumers $(n_0, n_1)$ can arise for equilibrium values of $(p_0, p_1)$ and $(a_0, a_1)$ at the third stage. For determining the corresponding equilibrium quantities, we need to identify the consumer for whom $U_0 = U_1$. Then, for consumers' expectations about network size to be fulfilled in equilibrium the following conditions must hold (Grilo et al., 2001):

$$n_0 = \hat{\theta} N \quad \text{and} \quad n_1 = (1 - \hat{\theta})N.$$

Solving $U_0 = U_1$ for the position of the indifferent consumer $\hat{\theta}$ yields

$$\hat{\theta} = \frac{1}{2} \frac{p_1 - p_0 + \tau(x_1 - x_0)(x_0 + x_1 + 2\lambda(a_0 - a_1)) - \gamma N}{\tau(x_1 - x_0) - \gamma N}. \tag{19}$$

Through what follows we will concentrate on network effects that are not too strong compared to the product differentiation parameter, so that

$$\tau(x_1 - x_0) - \gamma N > 0. \tag{20}$$

This assumption rules out equilibria with upward-sloping demand that yield multiple subgame perfect equilibria.[16]

Solving the extended game through backward-induction yields equilibrium strategies:

$$a_0^* = \frac{\lambda N \tau(x_1 - x_0)}{3\phi} \cdot \frac{3\phi\left[(2 + x_0 + x_1)\tau(x_1 - x_0) - 3\gamma N\right] - 4\lambda^2 N \tau^2 (x_1 - x_0)^2}{9\phi(\tau(x_1 - x_0) - \gamma N) - 4\lambda^2 N \tau^2 (x_1 - x_0)^2} \tag{21}$$

and

$$a_1^* = \frac{\lambda N \tau(x_1 - x_0)}{3\phi} \cdot \frac{3\phi\left[(4 - x_0 - x_1)\tau(x_1 - x_0) - 3\gamma N\right] - 4\lambda^2 N \tau^2 (x_1 - x_0)^2}{9\phi(\tau(x_1 - x_0) - \gamma N) - 4\lambda^2 N \tau^2 (x_1 - x_0)^2}, \tag{22}$$

$$p_0^* = (\tau(x_1 - x_0) - \gamma N) \frac{3\phi\left[(2 + x_0 + x_1)\tau(x_1 - x_0) - 3\gamma N\right] - 4\lambda^2 N \tau^2 (x_1 - x_0)^2}{9\phi(\tau(x_1 - x_0) - \gamma N) - 4\lambda^2 N \tau^2 (x_1 - x_0)^2} \tag{23}$$

and

$$p_1^* = (\tau(x_1 - x_0) - \gamma N) \frac{3\phi\left[(4 - x_0 - x_1)\tau(x_1 - x_0) - 3\gamma N\right] - 4\lambda^2 N \tau^2 (x_1 - x_0)^2}{9\phi(\tau(x_1 - x_0) - \gamma N) - 4\lambda^2 N \tau^2 (x_1 - x_0)^2}. \tag{24}$$

When firms are symmetrically located, equations (21) and (22) boil down to $a_0^* = a_1^* = \frac{\lambda N \tau(x_1 - x_0)}{3\phi}$, which is identical to the case without network effects. Advertising decisions

[16] For a discussion of upward-sloping demand in a Hotelling model see Grilo et al. (2001).

hence are only affected by network externalities when the market is characterized by an initial asymmetry. Note that, in contrast, price strategies always depend negatively on the size of the network externality as an additional consumer carries the added benefit of a larger network size.

Analogous to the other specifications, we require advertising costs to lie above a certain threshold:

**Assumption 3.** *Advertising costs are not too low:*

$$\phi > \frac{4}{9 \cdot (\tau(x_1 - x_0) - \gamma N)} \lambda^2 N \tau^2 (x_1 - x_0)^2.$$

We can infer from equations (21) and (22) that the firm with the initial advantage makes a larger investment in advertising while the disadvantaged firm charges a lower price. we now study how network effects interact with the locational advantage. It can be shown that the influence of the network effect on equilibrium advertising spending depends on the initial asymmetry between firms:

$$\frac{\partial a_0^*}{\partial \gamma} > (<)\, 0 \quad \text{and} \quad \frac{\partial a_1^*}{\partial \gamma} < (>)\, 0 \qquad \text{if } x_0 + x_1 > (<)\, 1.$$

Network effects thus escalate the difference between advertising spending of the two firms. In other words, the escalating forces of advertising and network effects do not work independently but interact with each other. The influence of network effects on the price differential, on the other hand, is ambiguous and depends on the parametrization. However, the insight from the basic model that the initially advantaged firm charges a higher price than its rival is also valid in the presence of network effects.

The position of the indifferent consumer can be derived as

$$\hat{\theta}^* = \frac{1}{2} \frac{3\phi\left[(2 + x_0 + x_1)\tau(x_1 - x_0) - 3\gamma N\right] - 4\lambda^2 N \tau^2 (x_1 - x_0)^2}{9\phi(\tau(x_1 - x_0) - \gamma N) - 4\lambda^2 N \tau^2 (x_1 - x_0)^2}. \tag{25}$$

Inspection shows that the market share of the initially advantaged firm will always be higher than its rival's. As in the basic setup, the products' difference with respect to their appeal to consumers cannot be overcome by price cuts. Comparative statics show that the existence of network effects deepens amplifies the asymmetry of market outcomes by shifting the indifferent consumer further away from the center of the line:

$$\frac{\partial \hat{\theta}^*}{\partial \gamma} > (<)\, 0 \qquad \text{if } x_0 + x_1 > (<)\, 1.$$

Network effects thus lead to more extreme market outcomes where one firm dominates a substantial part of the market.

The following proposition summarizes the results for the extension with network effects:

**Proposition 2.** *In interior equilibria, advertising spending increases (decreases) in network effects for the firm with (without) the initial locational advantage. The market share of the leading firm increases in network effects.*

As in the basic setup, there are also parameter values for which the strategies given above cannot form an equilibrium. In these cases, the initially advantaged firm may corner the market. In particular, firm 0 can drive firm 1 out of the market if

$$\phi < \frac{4}{3 \cdot [(4 - x_0 - x_1)\tau(x_1 - x_0) - 3\gamma N]} \lambda^2 N \tau^2 (x_1 - x_0)^2. \tag{26}$$

Note how the inequality becomes weaker for stronger network effects: As seen in the comparative statics for $\hat{\theta}^*$, the existence of network effects facilitates extreme market outcomes. At the same time, Assumption 1 is still required so that (26) is not always feasible.

Equilibrium strategies for cases covered by (26) are

$$p_0^* = \gamma N - \tau(x_1 - x_0)\frac{2\lambda^2 N\tau(x_1 - x_0) - \phi(2 - x_0 - x_1)}{\phi}, \qquad p_1^* = 0,$$
$$a_0^* = \frac{\lambda N \tau (x_1 - x_0)}{\phi} \quad \text{and} \quad a_1^* = 0.$$

For the sake of completeness, we also identify the parameter range for which firm 1 captures the market when it has a locational advantage:

$$\phi < \frac{4}{3 \cdot [(2 + x_0 + x_1)\tau(x_1 - x_0) - 3\gamma N]} \lambda^2 N \tau^2 (x_1 - x_0)^2. \tag{27}$$

In these cases, prices and advertising levels will be in equilibrium:

$$p_0^* = 0, \qquad p_1^* = \gamma N - \tau(x_1 - x_0)\frac{2\lambda^2 N\tau(x_1 - x_0) - \phi(x_0 + x_1)}{\phi},$$
$$a_0^* = 0 \quad \text{and} \quad a_1^* = \frac{\lambda N \tau (x_1 - x_0)}{\phi}.$$

Figure 3 illustrates how network effects and locational advantage interact with regard to market outcomes. Values on the horizontal axis represent firm 0's position on the Hotelling line. The vertical axis shows the extent of the network effect. Area *(1)* indicates parameterizations for which firms share the market while area *(2)* represents the space where firm 0 captures the entire market. Parameterizations outside these spaces are excluded by Assumption 3.

The Figure shows that firm 0 captures the market only if it has an initial locational advantage ($x_0 > 0.25$). Note that for this parametrization monopolization would never

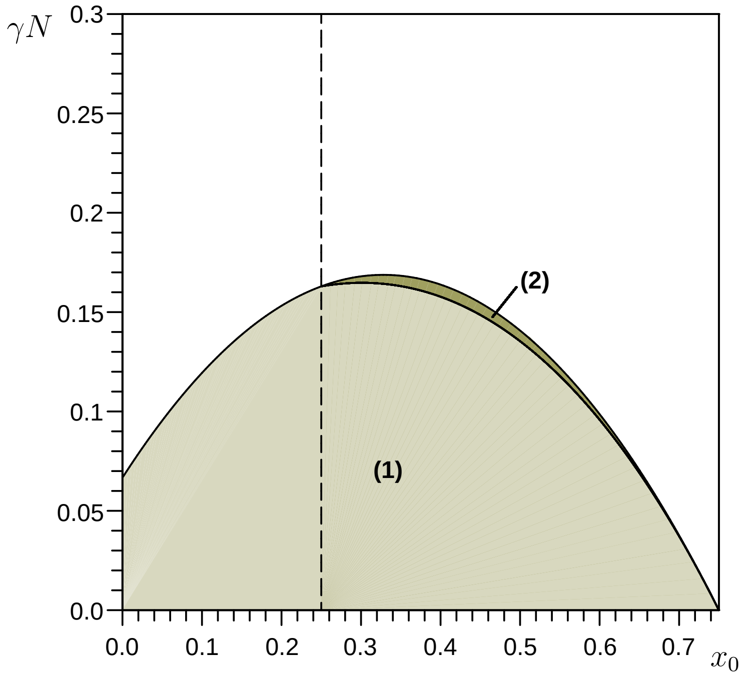


Figure 3: The effect of locational advantage and network effects on monopoly outcomes ($x_1 = 0.75$, $\phi = 0.3$, $N = 1$, $\lambda = 1$, $\tau = 0.8$).

occur without network effects. As in the other specifications of the model, the parameter space with monopoly outcomes is largest for medium values of $x_0$: When firm 0 is located closer to firm 1 and its locational advantage increases, it may capture the market only for small ranges of network effects. At the same time, the closer firm 0 is located to firm 1, the lower are the critical values of network effects that yield monopolization. Note also how the feasible parameter space shrinks for small distances between firms. Equilibrium existence thus hinges significantly on firms' distance in the case of network effects.

# 5 Discussion and Implications

Our model and its results have both theoretical and empirical implications. On a theoretical level, we find that asymmetry in terms of products' initial appeal to consumers can have important implications about the use and effect of specific strategic variables. Specifically, we find that while advertising would not change market shares and relative profits with symmetric firms, it amplifies initial asymmetries in product design if there are any. This result of increasing dominance is obtained without assuming differences in the effectiveness or cost associated with advertising. Further, standard sources for increasing dominance like scale economies or financial constraints are not necessary for this result.[17]

[17]Of course, our results on increasing dominance extend to other strategies designed to alter firms' relative competitive positions, e.g. cost-reducing investments. For cost-reducing investments, however,

We also find that firms choose different strategies for different strategic variables - *ex-ante* advantaged firms will compete more aggressively in advertising, *ex-ante* disadvantaged firms will offer higher price discounts. This insight stems from analyzing two strategic variables instead of keeping one of them constant. Finally, we also find that network effects affect post-competition market shares both directly (through favoring the firm with a larger consumer appeal) and indirectly (through encouraging (discouraging) advertising for *ex-ante* advantaged (disadvantaged) firms).

Note that by constraining $x_0$ and $x_1$ on $[0, 1]$, we exclusively considered the case of *ex-ante* horizontal product differentiation. In a model of vertical product differentiation, Tremblay and Martins-Filho (2001) show that the firm with the higher quality advertises more than its rival and charges a higher price. Thus, like in our model, an initial strategic advantage leads to higher investments in the advertising game. We also focus on untargeted advertising which changes all consumers' preferences in the same way. A model of targeted advertising, where consumers closer to the advertised product experience a greater increase in reservation value $V$ might generate different results similar to Chen et al. (2009) where the share of 'partisan' consumers increases in advertising.

Empirically, our results generate a number of predictions about advertising behavior in concentrated markets: First, we expect larger firms to advertise more heavily, but charge higher prices. Following the terminology of Fudenberg and Tirole (1984), this resembles a 'Fat Cat' effect in an entry game where overinvestment by an incumbent at the first stage accommodates entry by committing to less aggressive pricing at the second stage. While we do not look at incentives for entry here, we find for the larger firm an equivalent pattern of tough investment at the advertising stage followed by soft behaviour at the pricing stage. Second, we find in our model that in asymmetric markets advertising tends to exacerbate initial differences and that this tendency is more pronounced for lower advertising costs. Thus, if advertising costs differ across markets or time, we would expect different degrees of (ex-post) market concentration due to these differences in advertising cost. Regulatory interventions in advertising of controversial goods, e.g. tobacco, might thus provide researchers with a setting in which to test our prediction that advertising tends to amplify initial market share differences. Finally, in a cross-section of industries with and without network effects, we would expect a more uneven distribution of advertising expenditures (for equal post-competition market share distributions) in network industries.

Our model uses specific functional forms for the cost and effect of advertising. For empirical work in particular, the question if the parametrization we used is plausible is crucial as it will help us identify empirical settings in which our predictions can be tested. The cost of advertising represents decreasing net returns to advertising, which would seem plausible in most markets. Further, we restrict advertising efficiency to be symmetric

the dominant firm may end up advertising more and charging lower prices given their lower cost.

across firms for analytical convenience.[18] While the qualitative nature of our results remains unchanged with asymmetric advertising costs, firm effectiveness of advertising would need to be controlled for in empirical work. More importantly however, advertising has a pure business-stealing effect in our model. This means that in markets where advertising raises awareness (and therefore demand) for the product as such our model would not be appropriate.[19] Our model thus applies to mature markets with a largely fixed market size. Note also that in our model advertising works immediately and not via the building up of brand equity or goodwill. We therefore expect our model to be most useful when considering short-term advertising campaigns rather than long-term brand building campaigns (which would also arguably expand the market for the product). Thus, product-specific rather than firm-wide advertising over a limited time period (e.g. seasonal campaigns) would be the most appropriate empirical setting in which to test our model empirically.

# 6 Concluding Remarks

We considered a simple operationalization of persuasive advertising and analyzed its effect in a duopoly market where firms differ with respect to their ex ante appeal to consumers. To our knowledge, we are the first explicitly consider asymmetric firms' advertising decisions in a Hotelling framework. We showed that for symmetric advertising costs a firm with an initial advantage increases its lead by investing more in advertising than its rival. Due to lower advertising incentives, an initially disadvantaged firm, on the other hand, competes by setting low prices.

For a significant part of the parameter space, both firms would be better off if advertising was not available, but will advertise to capture market share. It is thus natural to reflect on how firms would act if they decided jointly on the implementation of advertising. Our results show that when firms set advertising collusively but compete in prices, the competitive results about market shares and prices are reproduced.

The welfare implications of our model are not straightforward. As it is generally not clear how to weigh consumers' initial perceptions against their post-advertising preferences, we can only argue in terms of qualitative results. Anderson et al. (1997) observe that the social optimum in games of spatial differentiation is generally reached when aggregate transport costs are minimized. For fixed distances and quadratic transport cost functions, this is given when firms are located symmetrically on the consumer interval. Instead of making the market more symmetric, however, advertising exacerbates market asymmetry in our model. Consumers may even switch from the initially closer product if

[18] In the Appendix we show that firms can compensate a disadvantage in product design by higher efficiency in advertising.

[19] In a model with both business-stealing and demand-creating advertising Doraszelski and Markovich (2007) obtain different predictions to ours on the effect of market size and advertising effectiveness.

the whole interval shifts through advertising. Advertising thus has the exact opposite effect than what would be socially desirable. The reason for the large discrepancy between the competitive and socially optimal outcomes lies in the assumption that the market is always covered. Aggregate demand is thus fixed and firms attend less to consumer surplus.

One could argue that our results depend strongly on the assumption of a one-shot game. For example, as the smaller firm is constrained to this period's budget, it can only invest as much in advertising as it earns at the product market. In reality, the firm may build up a savings stock over time or borrow money at the capital market to rectify earlier strategic choices. On the other hand, if the smaller firm had such an opportunity, so would the initial leader. It is not clear that the disadvantaged firm could really raise enough capital to compete head-to-head. In such a situation, the optimal timing of advertising spending and strategies such as pulsing would definitely become interesting issues to study.

Our extended model suggests that network effects do not change the quality of competition substantially but strengthen the observed escalating effects of advertising. Clearly, an empirical investigation of this issue would be of great value for the assessment of the scope of network effects' impact on competitive outcomes. The theoretical model, on the other hand, could be extended in a dynamic framework with installed bases that add to the network size. In such a setting, additional asymmetries in installed bases may shift more weight to network effects than in the present one-shot game.

One other avenue for future research is a model variant where aggregate demand is endogenous. In practice, marketers often aim at different functions of advertising, mixing informative and persuasive content. Incorporating informative aspects that determine the size of the potential market in the model will presumably widen the scope of overall advertising investments. However, there is no reason for expecting that in this case the disadvantaged firm could surpass its initially leading rival.

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# A Asymmetric cost structure

Consider now the case where advertising technologies differ with respect to their cost parameters $\phi_i$. The decision problem for firm $i$ at the third stage becomes

$$\max_{a_i} \quad p_i^*(a_i, a_j) \cdot n_i(p_i^*(a_i, a_j), p_j^*(a_i, a_j), a_i, a_j) - \phi_i \cdot a_i^2.$$

Profit maximization yields advertising levels

$$a_0^* = \frac{\lambda N \tau (x_1 - x_0)}{3} \cdot \frac{3\phi_1(2 + x_0 + x_1) - 4\lambda^2 N\tau(x_1 - x_0)}{9\phi_0\phi_1 - 2(\phi_0 + \phi_1)\lambda^2 N\tau(x_1 - x_0)} \tag{28}$$

and

$$a_1^* = \frac{\lambda N \tau (x_1 - x_0)}{3} \cdot \frac{3\phi_0(4 - x_0 - x_1) - 4\lambda^2 N\tau(x_1 - x_0)}{9\phi_0\phi_1 - 2(\phi_0 + \phi_1)\lambda^2 N\tau(x_1 - x_0)}. \tag{29}$$

Note that the cost asymmetry may result in varying advertising values also for symmetrically located firms. For (28) and (29) to yield profit maxima, we require minimum levels for advertising cost parameters:

$$\begin{aligned} \phi_0 &> \frac{2}{9}\lambda^2 N\tau(x_1 - x_0) \\ \phi_1 &> \frac{2}{9}\lambda^2 N\tau(x_1 - x_0). \end{aligned} \tag{30}$$

In addition and analogously to Assumption 1, we make the following assumption about overall advertising costs:

**Assumption 4.** *Advertising costs satisfy the following inequality:*

$$\frac{\phi_0\phi_1}{\phi_0 + \phi_1} > \frac{2}{9}\lambda^2 N\tau(x_1 - x_0)$$

Assumption 4 states that the sum of advertising costs cannot be too low. It implies that when one of the firms has very low advertising costs, we require the other to have relatively high costs. As in the case of Assumption 1, the restrictions to the parameter space avoid cases in which one firm can profit from shifts of the consumer interval without sacrificing anything.

Equations (28) and (29) show that the initially disadvantaged firm may gain on its rival when it can advertise at lower costs. The cost differential necessary for this opportunity depends on the extent of the initial locational asymmetry. In particular, we have

$$a_0^* > (<)\, a_1^* \qquad \text{if} \qquad \frac{\phi_1}{\phi_0} > (<) \frac{4 - x_0 - x_1}{2 + x_0 + x_1}.$$

A firm with a locational disadvantage may thus invest a higher amount in advertising than the initially advantaged rival when the locational asymmetry is counterbalanced by a cost advantage. When a firm is both advantaged with respect to location and advertising cost, it will always out-advertise the rival, thus further increasing asymmetries. This leads to the following proposition:

**Proposition 3a.** *For asymmetric advertising costs, a locational disadvantage can be offset by a less costly advertising technology so that a firm with an initial disadvantage advertises more than its rival and shifts the consumer distribution in its favor.*

The interior subgame perfect equilibrium is then described by (28) and (29) as well as

$$p_0^* = \phi_0\tau(x_1 - x_0)\frac{3\phi_1(2 + x_0 + x_1) - 4\lambda^2 N\tau(x_1 - x_0)}{9\phi_0\phi_1 - 2(\phi_0 + \phi_1)\lambda^2 N\tau(x_1 - x_0)}, \tag{31}$$

$$p_1^* = \phi_1\tau(x_1 - x_0)\frac{3\phi_0(4 - x_0 - x_1) - 4\lambda^2 N\tau(x_1 - x_0)}{9\phi_0\phi_1 - 2(\phi_0 + \phi_1)\lambda^2 N\tau(x_1 - x_0)} \tag{32}$$

$$\text{and } \hat{\theta}^* = \frac{1}{2}\frac{3\phi_0\phi_1(2 + x_0 + x_1) - 4\phi_0\lambda^2 N\tau(x_1 - x_0)}{9\phi_0\phi_1 - 2(\phi_0 + \phi_1)\lambda^2 N\tau(x_1 - x_0)}. \tag{33}$$

Equilibrium prices and market shares depend on the size of the advertising cost parameters. Differences in the cost of the advertising technology lead to asymmetric pricing and market outcomes even for symmetric firms. It may even be feasible to oust a locationally advantaged firm altogether: For

$$\phi_0 < \frac{4}{3(4 - x_0 - x_1)}\lambda^2 N\tau(x_1 - x_0), \tag{34}$$

firm 0 can advertise so cheaply that firm 1 can no longer counteract the effect with further price cuts. As a result, firm 0 captures the entire market. Note that in contrast to the case with symmetric costs, inequality (36) may also hold for cases where firm 0 is initially disadvantaged ($x_0 + x_1 < 1$). Initial market asymmetries may thus be offset completely by advertising cost differentials.

Equilibrium strategies for the parameter range restricted by (34) are

$$\begin{gathered} p_0^* = \tau(x_1 - x_0)\frac{2\lambda^2 N\tau(x_1 - x_0) - \phi_0(2 - x_0 - x_1)}{\phi_0}, \qquad p_1^* = 0, \\ a_0^* = \frac{\lambda N\tau(x_1 - x_0)}{\phi_0} \quad \text{and} \quad a_1^* = 0. \end{gathered} \tag{35}$$

Analogously, for

$$\phi_1 < \frac{4}{3(2 + x_0 + x_1)}\lambda^2 N\tau(x_1 - x_0), \tag{36}$$

firm 1 captures the entire market with

$$p_0^* = 0, \qquad p_1^* = \tau(x_1 - x_0)\frac{2\lambda^2 N\tau(x_1 - x_0) - \phi_1(x_0 + x_1)}{\phi_1},$$
$$a_0^* = 0 \quad \text{and} \quad a_1^* = \frac{\lambda N\tau(x_1 - x_0)}{\phi_1}. \tag{37}$$

While (34) and (36) do not depend on differentials but absolute cost levels, joint advertising costs must not be too low. By Assumption 4, own advertising cost that are so low that a disadvantaged firm is apt to monopolize the market require the rival's cost to be relatively high. The following proposition restates what was shown above:

**Proposition 3b.** *When its own advertising costs are very low, a firm that was initially disadvantaged can even capture the whole market.*

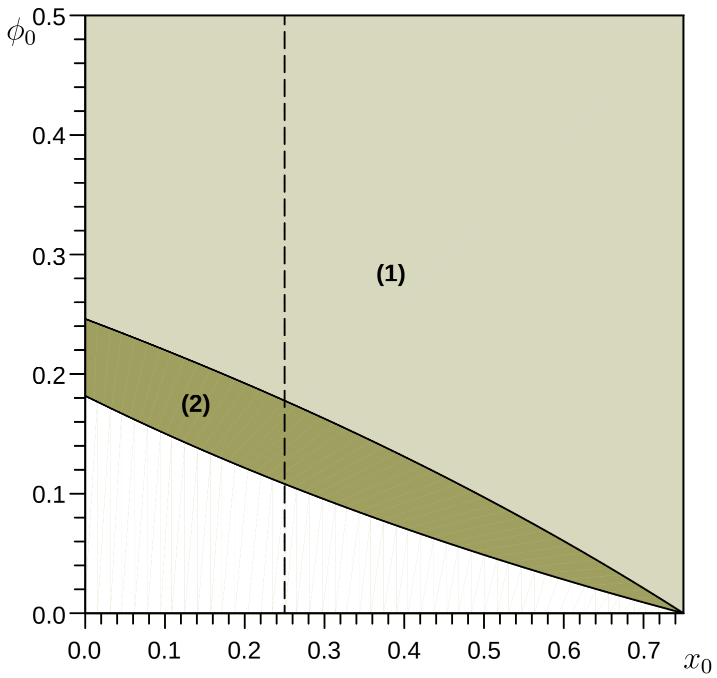


Figure 4: The effect of locational advantage and advertising costs on monopoly outcomes for asymmetric advertising cost ($x_1 = 0.75$, $\phi_1 = 0.5$, $N = 1$, $\lambda = 1$, $\tau = 0.8$).

Figure 4 illustrates the relationship between initial locational asymmetry and cost asymmetry with regard to market outcomes: Values on the horizontal axis represent firm 0's position on the Hotelling line. Firm 0's advertising cost parameter $\phi_0$ is depicted on the vertical axis. Its relation to the fixed cost parameter of firm 1, $\phi_1$, embodies the cost asymmetry. Again, area *(1)* indicates parameterizations for which firms share the market. For parameterizations in area *(2)*, firm 0 captures the entire market. For other parameterizations joint advertising costs are too low so that they are excluded because of Assumption 4.

We can see from Figure 4 that when firm 0 is located far from firm 1, the cost differential required for complete market capture is smaller than when firms are located more closely to each other. Put differently, the closer firm 0 is located to firm 1, the lower its advertising costs must be in order to be able to capture the entire market. The intuition behind this observation is that when firms' products are located closely to each other they look similar from a consumer's point of view. It is thus more difficult to displace the other firm as consumers who have preferences close to one brand do not need to travel far in order to buy the other product. By contrast, when firms are located far from each other, a smaller advertising investment is needed to make the own firm appealing and the other firm unattractive to a large share of consumers. In other words, advertising's effects are less extreme when firms are located closely to each other.

Note also how the notion of locational advantage becomes negligible in this setting: Firm 0 can capture the market even when it is initially disadvantaged ($x_0 < 0.25$) while the area of market capture shrinks with increasing locational advantage.