Title: **CUSTOMER DIRECTED ADVERTISING AND PRODUCT QUALITY**[1]

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Abstract: This paper studies the relationship between three key elements of the marketing mix, namely, price, product and promotion, in a model where a seller employs informative advertising to launch a new product. We propose a fairly general advertising technology for the study of three promotional strategies –mass, imperfectly targeted and customer directed advertising (CDA). We find that both the private and the social incentives to use distinct advertising strategies are aligned, and that sales are likely to be promoted through CDA. Compared to mass advertising, with CDA the social planner reduces quantity and downgrades quality whereas the seller sometimes upgrades it. Our model of targeting with endogenous product quality provides some new insights into the way the transition from mass to specialized advertising can affect market outcomes. Quality distortions imply that (*i*) even if CDA increases the market price, the degree of market power need not increase, and (*ii*) CDA may yield a welfare loss even if it leads to a lower market price.

1 Introduction

One of the key elements of the marketing mix is advertising which, with the advent of the information era, has undergone significant technological changes. Until recently, firms launching new products could only reach their potential consumers by inserting ads in the mass media. Nowadays sellers have a vast range of different advertising means at their disposal, including an array of cable and satellite radio stations and televisions, specialized magazines and newspapers, classified Internet homepages, electronic newsgroups, etc.[2] These media are characterized by distinct audiences as well as by different advertising costs and efficiency. As a result, firms can select the best advertising means to reach the target market accurately. Since a successful marketing mix involves a well blended price, product and advertising strategy (Jobber, 2004), the question is how the *pricing* and the *design* of new products are influenced by various *advertising strategies.*

To study the interaction between these three key variables of the marketing mix (product, price and promotion), we examine a market where a single seller launches a new product.[3] Consumers are initially unaware of the existence and characteristics of the product so the seller must advertise to promote sales.[4] Our first contribution is the formulation of a fairly general advertising technology which allows for the distribution of ads to specific target audiences. This technology makes it possible to implement three different promotional strategies: (i) mass advertising, in which the seller places ads in the general media; (ii) imperfectly targeted advertising, which arises when the seller distributes ads only to some fraction of the population who values the good more, and leaves the rest of the potential consumers uninformed;[5] and (iii) customer directed

[2] For instance, in the USA alone, there are currently about 9,000 radio stations, 1,000 TV channels, 11,000 magazines, and 17,000 newspapers. Only in 1998, there were about 1,000 new magazines launched. These magazines target specific niches like *B1G2* for black gay people, *Aqua* for divers or *Quince* for Hispanic female teenagers (Kotler, 2002 and Kotler and Armstrong, 1998).

[3] There is a fourth element in the marketing mix (also called fourth P) which is *place* and refers to decisions about which distribution channels to use and how to manage them appropriately.

[4] The model is consistent with the launching of a new product; in such a case, a new market is created and thus it seems reasonable to assume that a firm holds substantial market power.

[5] As noted in Esteban, Gil and Hernández (2001), the particular readership structure of special-interest magazines offers an example of advertising means which allow firms to target

advertising (CDA), in which the promotion is targeted on those consumers who are willing to buy the good at the advertised price. Given this technology, we study when it is optimal for the seller to use the various advertising strategies and how they relate to the optimal price and product quality.

The attractiveness of different promotional strategies hinges upon the interplay between advertising costs and effectiveness. This relationship can be captured by a simple property of the advertising technology which we call *strong economies of targeting* and which holds when advertising costs decrease and consumer audience increases with the move of ads from less to more specialized promotional means. If the opposite holds, we say that the advertising technology exhibits *strong diseconomies of targeting.* We find that CDA is the optimal choice of the seller under quite mild conditions, in particular, strong economies of targeting need not hold; by contrast, mass advertising only arises under conditions which are more stringent than strong diseconomies of targeting. These two results together, along with some empirical evidence that we report about the costs and effectiveness of advertising in special-interest magazines, give support to the stylized fact that, as advertising technologies evolve over time, the use of mass advertising is losing importance in favor of more targeted advertising.

We then explore how the type of advertising strategy influences price and product positioning. Under mass advertising, as well as under imperfectly targeted advertising, the price-quality choice of the monopolist equals that under the full information benchmark. By contrast, under CDA, the seller brings fewer units to the market and distorts both the quality and the price in a manner that hinges upon the nature of product quality. This result provides a theoretical foundation to the well-known argument in the marketing literature that the appropriate marketing mix for a product depends on the characteristics of the market segment on which it is targeted (see e.g. Kerin and Peterson, 2004). We distinguish two settings with respect to the nature of product quality: one arises when the willingness to pay for an extra unit of quality is higher for those consumers who have a higher valuation for the good and we refer to it as *high-end quality*; when the opposite holds we speak of *low-end quality.*[6]

their ads on the most eager consumers.

[6] We use the term *high-end quality* because such a relationship between willingness to pay

In the high-end quality case, the use of CDA leads the firm to reduce the size of the target market and to supply higher quality at a higher price. There are many real life examples which corroborate these theoretical predictions. For instance, the traditional offerings of the footwear firm Reebok were running shoes aimed at the general public. However, the firm located an untapped female segment, the aerobic fitness market, which could easily be reached by specialized advertising media. To exploit this target market, Reebok introduced a new line of high quality products specifically designed for aerobic exercises and a variety of fashionable casual sport shoes. In accordance with the predictions of our model, the firm decided on a premium pricing strategy aimed at the higher end of the market and designed a promotional program which included advertising in special-interest magazines (see Bovée and Arens, 1989).

In the low-end quality case, CDA results in quality downgrading instead; moreover, a noteworthy result is that the market price may decrease. A possible example occurs in the market for computers (see footnote 5). Firms often accompany their offerings to the general public with the supply of side services such as software installation, start-on tutorials or home delivery and installation. By means of highly specialized computer magazines, firms can reach high valuation consumers in which case it makes sense to reduce the provision of side services and reduce the price.

A fundamental issue is how these different marketing mix strategies affect the firm's ability to exercise market power. In the high-end quality case, the higher price tends to increase the firm's degree of market power but the supply of higher quality works in the opposite direction. We find that this results in a moderate (or no) increase in the firm's market power. By contrast, when quality is low-end the firm's degree of market power increases substantially due to the significant cut in quality, no matter whether the price rises or drops.

We finally conduct the welfare analysis of customer directed advertising. We show that the private and social incentives to use CDA are aligned, whereas the

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and quality probably holds in situations where extra quality means superior technical features. In the market for computers, the speed of operation of a microprocessor, the capacity of a hard disk or the size of a random access memory may well be examples of high-end quality. When extra quality means provision of side services such as operating system tutorials or home installation, we may expect the opposite relationship between willingness to pay and quality, to which we refer as *low-end quality*.

private and social incentives for quantity and quality provision are generally misaligned. In particular, compared to the full information setting, the social planner always reduces both quantity and quality when sales are promoted through CDA. This is inconsistent with the monopolist's decision, since quality upgrading occurs in the case of high-end quality. This misalignment between the private and the social incentives leads us to ask how the private adoption of CDA, rather than mass advertising, affects social welfare. Once again, this turns out to depend on the nature of product quality. We find that the use of CDA can occasionally cause a welfare loss, and that such a loss is more (less) likely in a setting with low-end (high-end) quality.

Our model is related to the economics literature on *informative advertising*.[7] Most of the work in this literature differs from ours in that it does not consider the existence of specialized advertising means that allow sellers to target ads on particular segments of the potential market. The papers most closely related to the present study are Hernández-García (1997), and Esteban, Gil and Hernández (2001), who also assume that a seller can target ads on high valuation consumers.[8] These two papers have compared the equilibrium price of a monopolist under mass and targeted advertising for a given product quality and for a particular advertising technology in the spirit of Grossman and Shapiro (1984), assuming, further, that the firm employs a set of advertising media with the same target audience. They show that the use of CDA always increases both the market price and the firm's degree of market power.

Our contribution to this body of work is twofold. First, we formulate a fairly general advertising technology which encompasses others in the literature and

[7] This literature has distinguished between advertising that is *directly* informative, i.e., that conveys 'hard' information (see e.g. Bester, 1995; Bester and Petrakis, 1995; Butters, 1977; Caminal, 1996; Grossman and Shapiro, 1984; Moraga-González, 2000; Robert and Stahl, 1993; Shapiro, 1980; Stahl, 1994 and Stegeman, 1991) and advertising that is *indirectly* informative, i.e., that functions as a signal of private information (see e.g. Bagwell, 1988; Bagwell and Ramey, 1990; Kihlstrom and Riordan, 1984 and Milgrom and Roberts,1986). Our paper deals with informative advertising that is directly informative and thus relates to the first strand of this literature

[8] There are also a number of related papers which have studied strategic coupon targeting in various segmented markets (see e.g. Bester and Petrakis, 1996; Moraga-González and Petrakis, 1999 and Shaffer and Zhang, 1996). In a way, these articles assume the existence of an array of advertising means that enable sellers to target discount coupons on the most price-sensitive consumers. Furthermore, in monopolized markets, Esteban, Gil and Hernández (2004) study endogenous targeted advertising based on the use of databases compiled by the seller.

allows for the study of distinct advertising strategies. This technology also enables us to examine the possibility that the firm uses multiple advertising media with different target audiences (*mixed targeting*). Interestingly, the conditions under which different advertising strategies arise are simple and seem empirically testable. Secondly, we use this general advertising technology to examine the optimal combination of three of the variables of the marketing mix, and we obtain the novel result that a firm's advertising strategy has a bearing on its product design strategy. Moreover, it turns out that the nature of quality plays a fundamental role in determining how the use of highly specialized advertising means affects a firm's degree of market power and the level of social welfare. Thus, our paper provides both a broader and, at the same time, more precise picture of how the evolution of advertising technologies can affect the market outcome vis-à-vis earlier work.

The rest of the paper is organized as follows. Section 2 describes the model. The different equilibria are characterized in Section 3. Section 4 is devoted to the welfare analysis. Section 5 closes the paper with a review of the main conclusions. An appendix contains all the proofs.

2 The model

Consider a single producer trying to sell a new good of quality s at price p in an imperfect information setting. Let $Q(p, s)$ be the (estimated) demand function for this product under perfect information and $P(q, s)$ the inverse demand function. As usual, assume that demand is twice differentiable, downward slopping and that quality is desirable, i.e., $P(q, 0) = 0$ and $P'_s(q, s) > 0$. Let $c(s)$ denote the marginal cost of producing one unit of a good of quality s. We assume that producing higher qualities is more costly, i.e., $c(0) = 0$ and $c'(s) > 0$.[9]

Consumers are initially unaware of the existence, the quality and the price of the good. This implies that a potential consumer cannot be an actual buyer unless the seller invests in advertising (Stahl, 1994). To specify the details of the advertising technology, it is useful to think of the demand function $Q(p, s)$ as stemming from a unitary mass of potential consumers represented by the

[9] We also assume that $P''_{qq} < 0, P''_{ss} < 0, c''(s) > 0$, which are necessary for the second-order conditions to be fulfilled.

unit interval $[0, 1]$; these customers buy at most a single unit of the good. Each consumer has a willingness to pay $x(s)$ for a product whose quality is s, with $x'(s) > 0$. Assume that, for a given quality s, consumers can be ordered according to the valuations they place on the good and that such valuations decrease as x increases. A monopolist would ideally like to target its ads on the consumers who are willing to pay more for the good (Bagwell, 2001); under our assumptions these consumers are located in the left part of the unit interval.

A general advertising technology:

The distinctive feature of our advertising technology is that it allows the seller to choose the *target* of the advertising campaign. In particular, we consider that for any t in the unit interval $[0, 1]$, there is at least one advertising medium that disperses ads on the set of consumers $[0, t]$. We refer to t as the target of the advertising campaign. Implicitly, we are assuming there is a continuum of advertising means; this gives us smoothness of profit functions and enables us to use a first-order conditions approach. For the sake of simplicity, in most of the paper we consider that the whole advertising budget is allocated to a set of advertising media with the same target audience. In Appendix 2 we extend the model to the case where the firm has a discrete number of media available and implements a mixed targeting strategy by inserting ads in multiple advertising means with different target audiences.

Given a price-quality pair (p, s) such that $1 > Q(p, s) > 0$, we distinguish among three different advertising strategies: (i) *mass advertising*, i.e., ads are sent to the entire population of potential consumers ($t = 1$); (ii) *imperfectly targeted advertising*, i.e., the firm uses specialized media to send messages to consumers with relatively higher valuations ($1 > t > Q(p, s)$); (iii) *customer directed advertising* (CDA), i.e., ads are targeted on those consumers who are willing to buy quality s at price p ($t \leq Q(p, s)$).[10]

[10] We note *first* that the modeling of targeting adopted here is consistent with frequently encountered structures of specialized advertising media in which the degree of media specialization is positively correlated with consumers' valuation of the good. Accordingly, in many real-world situations the use of targeted advertising enables the seller to concentrate ads only on the most eager consumers. *Secondly*, the specification adopted here rules out the possibility of sending different messages to disjunct sets of buyers. If this was possible, the seller would be able to practice third-degree (or even first-degree) price discrimination. *Thirdly*, we note that in our setting every customer directed ad returns a sale. This is, admittedly, unrealistic;

An advertising technology is described by a pair $\{A(n,t), r(n,t)\}$. The *first* element is the cost of the advertising campaign $A(n,t)$, which denotes the cost of placing n ads of target t. For a given target t, we assume that $A'_n(n,t) > 0$, i.e., advertising costs increase with the number of ads acquired. The *second* element of the advertising technology is the probability $r(n,t) \in [0,1]$ with which each consumer becomes informed about the existence, quality and price of the good when the seller acquires n ads of target t. In other words, $r(n,t)$ is the chance that a targeted consumer sees at least one advertisement. We assume that, given a target t, this probability increases with the number of ads n placed by the seller, i.e., $r'_n(n,t) > 0$.

So far we have not imposed any structure on how advertising costs A and advertising effectiveness r relate to the target t. We shall distinguish among advertising technologies based on the following properties.

Definition 1: *We say that an advertising technology $\{A(n,t), r(n,t)\}$ exhibits "economies of targeting" whenever, for any given number of ads n,*

$$\frac{d}{dt}\left(\frac{A(n,t)}{tr(n,t)}\right) > 0.$$

In words, economies of targeting means that, for a given number of ads, the advertising cost per informed consumer falls with the move from less to more specialized advertising media. If the opposite holds, then we say that the advertising technology presents *"diseconomies of targeting"*. Building on Definition 1, we now present a stronger property of an advertising technology.

Definition 2: *We say that an advertising technology $\{A(n,t), r(n,t)\}$ presents "strong economies of targeting" (SET) whenever, for any given number of ads n, (i) $A'_t(n,t) > 0$, and (ii) $r(n,t) + tr'_t(n,t) < 0$.*

In words, an advertising technology exhibits SET when, for a given number of ads, advertising costs decrease and consumer awareness increases, as we move ads from less to more specialized advertising media. If conditions (i) and (ii) hold with the opposite sign, then we say that the advertising technology presents

however, we could assume, as in Grossman and Shapiro (1984), that the entire population of consumers has size $M > 1$ and that only a unit fraction of those customers are interested in the good. In this way, some of the ads could reach consumers who are not interested in the product.

"strong diseconomies of targeting" (SDT).[11]

We conclude this section by relating the advertising technology $\{A(n,t), r(n,t)\}$ formulated above to a number of specific advertising technologies that have appeared in the industrial organization literature. This literature has typically modelled advertising via a cost of message production. Imposing a particular structure on $A(\cdot)$ and $r(\cdot)$, our general advertising technology can encompass these advertising cost functions.

Examples:

(i) Grossman and Shapiro (1984) present an advertising cost function that generalizes the specification in Butters (1977). In their paper, a seller has no ability to target ads on particular segments of the potential market. Therefore $t = 1$, and the per firm expenditure needed to reach a fraction ϕ of the consumers is $A(\phi)$, with $A'_\phi > 0$. To establish a connection between this advertising technology and $\{A(n,t), r(n,t)\}$, we note that in our model $r(n,t)$ is monotone in n. As a result, we can obtain the number of ads to be placed in the mass media so that a consumer sees an ad with probability r, i.e., $n = h(r,1)$. Substituting n in $A(n,1)$ yields $A(h(r,1),1) = A(r)$. Setting $r = \phi$, the equivalence follows. An advertising cost function of this kind has also been used in Caminal (1996), Moraga-González and Petrakis (1999), Robert and Stahl (1993) and Stahl (1994).

(ii) A number of these papers have used specific functional forms to derive explicit solutions. A commonly used family of advertising cost functions is the polynomial: $A(\phi) = k\phi^\beta$, with $\beta > 1$, which presents constant-elasticity. Our advertising technology $\{A(n,t), r(n,t)\}$ accommodates this family of advertising cost functions by considering that the cost per ad of target t is $a(t)$, and that the cost of sending n ads of target t is linear, i.e., $A(n,t) = na(t)$. Then, setting $r(n,t) = n^\alpha f(t)$ we obtain

$$A(r^{-1}(r,t),t) = a(t)\left(\frac{r}{f(t)}\right)^{\frac{1}{\alpha}}.$$

Setting $a(1) = k$, $\beta = 1/\alpha$ and $r/f(1) = \phi$, the equivalence follows.

(iii) *Special-interest magazines with nested readerships* (Esteban *et al.*, 2001).

[11] We note that an advertising technology which exhibits SET also presents economies of targeting; however, the converse is not true.

This distribution of media[12] assumes that for any $t \in [0,1]$ there are a large number of specialized magazines with readerships on the support $[0,t]$, in such a way that a seller can target high-valuation consumers by carefully selecting a set of these magazines. In this context, the per firm expenditure needed to target a proportion ϕ of the consumers whose valuations lie in the set $[0,t]$ is $A(\phi,t) = n(\phi,t)\ a(t)$, with

$$n(\phi,t) = \frac{\log(1-\phi)}{\log\left(1-\frac{z(t)}{t}\right)},$$

where $z(t)$ is the readership of a magazine with target t. Our advertising technology accommodates a distribution of magazines with nested readerships assuming that $A(n,t) = na(t)$ and $r(n,t) = 1 - \left(1-\frac{z(t)}{t}\right)^n$. Setting $\phi = r$, the equivalence follows.[13]

3 Analysis

The seller's problem consists of choosing a marketing mix $\{p, s, t, n\}$ to maximize profits. In this section we address two issues: *first*, we ask whether, and under what conditions, the different advertising strategies arise in equilibrium. *Second*, we analyze whether distinct advertising strategies have a bearing on the optimal price-quality choice of the firm and its ability to exercise market power.

Let (p^m, s^m) be the equilibrium price-quality pair under full-information, i.e., $(p^m, s^m) = \arg\max\{\pi(p,s) = (p - c(s))Q(p,s)\}$. Moreover, let $q^m = Q(p^m, s^m)$ and $\pi^m = \pi(p^m, s^m)$.

Proposition 1 *(i) The seller employs mass advertising if and only if* $\pi^m r'_t(n,t) - A'_t(n,t) > 0$ *and imperfectly targeted advertising if and only if there exists*

[12] Specialized magazines often have *nested* readerships. For instance, there are magazines containing general information on sports, medicine, computers, family matters, etc., as compared to those specializing in particular sports (soccer, basketball, golf, etc.), medical specialities (surgery, radiology, dermatology, etc.), computer issues (video-games, Internet, etc.), or leisure activities (fitness, decoration, gardening, etc.).

[13] In fact, the advertising technology of this paper can be interpreted more broadly. For example, we can consider a nested distribution of magazines with only one magazine available for each target t. In this alternative framework, n should be interpreted as the advertising *effort* exerted in a single magazine –e.g. the number of ads inserted in the magazine, the size and color of the ad, etc.–. Finally, our model accommodates other types of specialized advertising media, such as cable television or radio. These media might not be nested, in such a way that the ads could be distributed in any interval in the set $[0,t]$.

$t \in (q^m, 1)$ such that $\pi^m r_t'(n,t) - A_t'(n,t) = 0$. (ii) The seller's price-quality choice under both mass and imperfectly targeted advertising is equal to (p^m, s^m). (iii) Under an advertising technology of constant-elasticity, imperfectly targeted advertising is more intense than mass advertising.

We now elaborate on some aspects of this result. We *first* note that the optimal target of the advertising campaign depends on the properties of the advertising technology. In particular, we observe that $A_t'(n,t) < 0$ and $r_t'(n,t) > 0$ suffice for mass advertising; the condition $A_t'(n,t) < 0$ holds if there are SDT whereas the condition $r_t'(n,t) > 0$ is *stronger* than SDT. Thus, we find that SDT need not lead to mass advertising.

Secondly, the price-quality choice of the monopolist under both mass and imperfectly targeted advertising maximizes the full information profit. The reason is that, under these advertising strategies, a marginal change in either the advertising intensity or the target of the campaign does not affect the difference between marginal revenue and marginal cost. As a result, neither the equilibrium price nor the quality level depend on the advertising strategy. We note that this result does not imply that mass advertising and imperfectly targeted advertising necessarily lead to exactly the same market outcomes. The difference between these advertising strategies is the intensity with which the seller promotes sales. The third part of Proposition 1 suggests that the relatively higher effectiveness of imperfectly targeted advertising will typically lead the firm to acquire more ads under this strategy than under mass advertising. Taking into account that, from a social perspective, a monopolist always undersupplies informative advertising (Shapiro, 1980), it follows that the use of imperfectly targeted advertising is, in fact, welfare improving.

We now turn to analyze the case in which the seller employs customer directed advertising to promote its sales. Let (q^d, p^d, s^d) denote the equilibrium quantity, price and quality of the seller under CDA. Then:

Proposition 2 *(i) Under customer directed advertising $t = Q(p,s)$. (ii) If $A_t'(n,t) > 0$ and $r_t'(n,t) < 0$, the monopolist employs customer directed advertising to promote sales. (iii) Under customer directed advertising the optimal price-quality choice of the monopolist is such that:*

(a) $q^d < q^m$,

(b) $s^d < s^m$ *if and only if* $P''_{sq} > 0$.

(c) If $P''_{sq} < 0$, *then* $p^d > p^m$.

We note that the existence of SET suffices to observe CDA. However, the seller will use this advertising strategy under conditions that are *weaker* than those in Definition 2; in particular, CDA can arise even in the presence of SDT. This suggests that this advertising technology is likely to be observed in most real world situations.[14] To substantiate this claim, we now present some empirical evidence which reveals that the conditions stated in Proposition 2 (ii) seem to hold in real markets.

We examine the advertising technology of special-interest magazines with nested readerships for the cases of medicine magazines, which are read by the health care community, and computer magazines. The 'Handbook of the Dutch Press and Publicity (2001)' (Handboek van de Nederlandse Pers en Publiciteit, 2001) provides readerships and advertising fees (in Euros) for a very large set of magazines; these magazines are classified according to the field, subject or topic they treat. The different contents of various magazines can therefore be seen as distinct degrees of specialization. Thus, moving ads from general medicine magazines to more specialized ones, for instance those specialized in cardiology, is interpreted in our context as concentrating the ads on a particular segment of the market. Similarly, in the market for computers, inspection of the Handbook reveals that there are general computer magazines and magazines specialized in Atari computers, Macintosh computers, the Nintendo 64 console, the Wordperfect word processor, the Internet, etc.

The empirical evidence reported in Table 1 indicates that moving an advertising campaign from less to more specialized magazines yields a cost saving, i.e. $A'_t(n,t) > 0$.[15] This constitutes evidence against the existence of strong diseconomies of targeting. Regarding $r'_t(n,t)$, the derivations above in Section 2 show that the sign of $r'_t(n,t)$ equals that of $z'_t(t)t - z(t)$, where $z(t)$ is the

[14] In Appendix 2 we discuss how the results of Proposition 2 extend to the case of mixed targeting. The intuition we provide below also holds there as long as mixed targeting involves customer directed advertising.

[15] For details about how we have computed the sign of $A'_t(n,t)$ and $r'_t(n,t)$ see our Tinbergen Institute Discussion Paper TI 2001-099/1.

readership of magazines of target t. The empirical evidence in Table 1 suggests that $r_t'(n,t) < 0$. This means that a monopolist should typically choose customer directed advertising to promote sales.[16] This evidence is consistent with the fact that nowadays mass advertising only accounts for less than 30 percent of total advertising expenditures (Kotler and Armstrong, 1998).

Magazines	**Av. Ad price** $a(t)$	**Readership** $z(t)$	**Target** t	$\mathbf{a'(t)}$	$\frac{z'(t)t}{z(t)} - 1$
General Medicine	3,100.75	12,673	21,240		
Cardiology	2,599	2,150	2,500	0.0267	-0.347
Neurology	1,992.3	1,542	1,875	0.0572	-0.301
Buccal Health	2,217	1,850	1,850	0.0455	-0.442
Logopedia/Phonetics	1,840	4,903	4,903	0.0770	-0.524
Midwifery	440	2,600	2,600	0.1427	-0.459
Oncology	2,301.5	2,177	3,355	0.0446	-0.096
Psychiatry	2,225.75	2,364	3,800	0.0501	-0.049
General Computers	8,103.75	119,976	187,499		
Macintosh	3,600	21,000	21,000	0.0270	-0.472
Atari	2,500	20,000	20,000	0.0334	-0.403
Games	6,370.4	51,954	74,772	0.0153	-0.132
Microsoft	5,445	51,954	40,000	0.0180	-0.457
WordPerfect/Corel	4,300	40,000	25,000	0.0234	-0.415
Windows	5,350	25,000	40,000	0.0186	-0.457
Nintendo64	4,250	18,000	18,000	0.0227	-0.398

Table 1. Empirical Evidence on Dutch Magazines: $A_t'(n,t), r_t'(n,t)$

To sum up, our results, along with this empirical evidence, suggest that firms are likely to use CDA and so the key issue is how this advertising technology affects market performance. In this regard, Proposition 2 shows that the use of CDA has implications for other variables of the marketing mix, i.e., for price/quantity and quality provision. To the best of our knowledge, the fact that advertising strategy has a bearing on product design strategies is novel in the literature. We now elaborate on the economic intuition behind the nature of this relationship.

[16] We also analyzed the data reported in the 'Spanish Guide to the Communication Media' (1999) (*Guía de los Medios de Comunicación de España*, 1999). Similar insights obtained.

Under CDA, any variation in the seller's price-quality choice modifies the size of the target segment $t = Q(p, s)$, which, in turn, has a bearing on advertising costs. This is the fundamental feature of CDA: it establishes a direct linkage between the size of the potential demand and the cost of the advertising campaign. This linkage gives the seller incentives to deviate from the profit maximizing price-quality choice under full information. In particular, as the firm decreases the quantity put in the market, the advertising campaign must be placed in more specialized media, which leads to a higher profit due to the lower cost and/or higher efficiency of the media. As a result, a monopolist who employs CDA amplifies the typical quantity distortion by bringing fewer units to the market.

For a given level of quality, this *quantity effect* translates immediately into a higher price, which explains why Esteban *et al.* (2001) find that targeting always leads to a higher market price. However, our model of targeting with *endogenous product quality* reveals that the market outcome can be quite different. In particular, we note that the quantity effect indirectly provokes a change in the level of quality supplied by the firm, and that this has a fundamental impact on both the price and the firm's degree of market power. To examine the nature of this distortion, we distinguish between two cases. When the willingness to pay for an extra unit of quality is higher for those consumers who have higher valuations for the good (*high-end quality*), i.e., when $P''_{sq} < 0$, then, relative to the full information benchmark, quality is distorted upwards, i.e., $\frac{ds^d}{dq} < 0$. By contrast, when the willingness to pay for an extra unit of quality is higher for those consumers who have lower valuations (*low-end quality*), i.e., when $P''_{sq} > 0$, then quality is distorted downwards, i.e., $\frac{ds^d}{dq} > 0$. To understand the economic intuition behind this result, note that the incentives of the seller to invest in quality provision are related to the willingness to pay for an extra unit of quality of the marginal consumer. Since the quantity put in the market under CDA is lower than the full information quantity, when $P''_{sq} < 0$ the marginal buyer under CDA has a higher willingness to pay for quality than the marginal buyer under full information, which leads the monopolist to increase the supply of quality. By contrast, when $P''_{sq} > 0$ the opposite holds and the seller downgrades quality. Given that $\frac{\partial P}{\partial s} > 0$, in the former (later) case, this *quality effect*, translates immediately into a higher (lower) price.

To account for price distortions, we must take into account both the quantitative and the qualitative implications of CDA. Thus, the impact of this advertising strategy on the price is given by:

$$\frac{dP^d}{dq} = \frac{\partial P}{\partial q} + \frac{\partial P}{\partial s}\frac{ds^d}{dq}. \tag{1}$$

If $P''_{sq} < 0$, both terms in this equation work in the same direction and CDA results in a negative *price-effect*, i.e., $dP^d/dq < 0$. By contrast, when $P''_{sq} > 0$, the quantity and the quality effects work in opposite directions and the sign of dP^d/dq is ambiguous.

Regarding the impact of CDA on the firm's market power, we note that the *quality effect* also changes the marginal cost of production, $c(s)$, which, in turn, affects the value of the Lerner index, $L = 1 - c(s)/p$. Thus, *for a given price*, if $P''_{sq} < 0$ $\left(P''_{sq} > 0\right)$, CDA increases (decreases) $c(s)$, thus reducing (increasing) the firm's market power. Therefore, the overall impact of CDA on market power is given by:

$$\frac{dL^d}{dq} = \frac{\partial L}{\partial P}\frac{dP^d}{dq} + \frac{\partial L}{\partial s}\frac{ds^d}{dq}. \tag{2}$$

Given that $\frac{\partial L}{\partial P} > 0$ and $\frac{\partial L}{\partial s} < 0$, the two terms in equation (2) can work in the same direction only if P''_{sq} and dP^d/dq have opposite signs. However, from equation (1) we know that $\frac{ds^d}{dq} < 0$ implies $\frac{dP^d}{dq} < 0$ and, therefore, the sign of $\frac{dL^d}{dq}$ is *unambiguously* determined *only* if $P''_{sq} > 0$ and $dP^d/dq < 0$. In this case, and as compared to the full information benchmark, the firm offers fewer units of lower quality at a higher price and so CDA increases the firm's degree of market power.

The above discussion raises two interesting questions, namely, whether or not CDA will *necessarily* increase the firm's market power, and whether this advertising strategy can lead to a lower market price. The only way we have found to address these issues is by solving our model for particular functional forms. Obviously, this type of analysis rests generality to our work but, in exchange, sheds further light on how CDA can affect the market outcome.

We have chosen to solve our model for a particular family of demand and cost functions that encompasses models often employed in the literature and that captures the distinction between high-end and low-end quality. We now present the details of these specifications.

Demand function: Demand stems from a unit mass of buyers characterized by a taste parameter θ uniformly distributed in the unit interval. A consumer's utility is $U = \theta + f(s) - \theta g(s) - p$, when he buys a good of quality s at price p, with $f(s) \geq 0$, $f(s) - \theta\ g(s) \geq 0$, and $f'(s) - \theta\ g'(s) > 0$, and zero otherwise. The economic interpretation of this utility function is as follows: (*i*) Since $\theta > 0$, buyers enjoy the good *per se*; (*ii*) $f(s) \geq 0$ indicates that buyers may attach value to quality *per se*, independent of the taste parameter; finally, (*iii*) $f(s) - \theta\ g(s) \geq 0$ together with $f'(s) - \theta\ g'(s) > 0$ imply that buyers always prefer higher qualities.[17] As mentioned earlier, this model of vertical product differentiation encompasses others in the literature.[18] Standard derivations yield a demand function $Q(p, s) = 1 - (p - f(s)) / (1 - g(s))$. We now consider that $f(s) = s - 1/s^{k-1}$ and $g(s) = 1 - 1/s^{k-1}$, which satisfy the above conditions for all $\theta \in [0, 1]$ when $k \geq 0$ and $s > 1$. This implies that $Q(p, s) = s^k\,(1 - p/s)$. Note that $k < 1$ captures *high-end quality*, i.e. $P''_{sq} < 0$, whereas $k > 1$ reflects *low-end quality*, i.e. $P''_{sq} > 0$ (the case $k = 1$ can be regarded as quality being *neutral*).

Advertising and production cost functions: Let $\{A(n, t), r(n, t)\} = \{na(t),\ n^{\alpha} f(t)\}$. This advertising technology encompasses the family of polynomial advertising cost functions with constant elasticity. We further assume that $f(t) = t^{-\alpha}$ and $\alpha = 1/2$. For simplicity, let $a(t) = a(1) = a$.[19] Finally, let marginal production costs be quadratic in quality, i.e. $c(s) = bs^2/2$.

Under these market conditions, we obtain the equilibrium price, quality and

[17] We note that this specification allows for the valuation of quality to be positively or negatively related to the taste parameter, i.e., we do not place any restriction on the sign of $g(s)$.

[18] In particular, setting $f(s) = 0$ and $g(s) = 1 - s$ yields $U = \theta s - p$ (Mussa and Rosen, 1978). Moreover, setting $f(s) = g(s) = s$ leads to $U = \theta + (1 - \theta)\ s - p$ (Tirole, 1988, p. 104).

[19] This assumption is in line with the empirical evidence reported above, where it is found that a is rather insensitive to t. Note that this advertising technology exhibits diseconomies of targeting. However, with this specification it holds that $A'_t(n, t) = 0$ and $r'_t(n, t) < 0$, which are sufficient for CDA.

advertising intensities under mass advertising and CDA:

$$p^m = \frac{2\ (1+k)(2+k)}{b(3+k)^2},\ s^m = \frac{2\ (1+k)}{b(3+k)},\ r^m = \frac{2^k\ (1+k)^{1+k}}{ab^{1+k}(3+k)^{3+k}},\ n^m = \frac{4^k\ (1+k)^{2+2k}}{a^2b^{2+2k}(3+k)^{6+2k}}$$

$$p^d = \frac{2\ (k^2+6k+8)}{b(5+k)^2},\ \ s^d = \frac{2\ (2+k)}{b(5+k)},\ \ r^d = \frac{2(2+k)}{ab(5+k)^2},\ \ n^d = \frac{2^{2+k}\ (2+k)^{2+k}}{a^2b^{2+k}(5+k)^{5+k}}$$

On the basis of these results, we can compute the impact that moving from mass advertising to CDA has on the firm's market power. Table 2 displays the percent changes in price, quality and degree of market power for reasonable values[20] of the parameter k.

	k=0	k=0.5	k=1	k=2	k=3	k=4
$\frac{p_d-p_m}{p_m}$	+44%	+21%	+11%	+2%	−1.5%	−3.2%
$\frac{s_d-s_m}{s_m}$	+20%	+6%	0%	−4.8%	−6.2%	−6.7%
L_m	+50%	+40%	+33%	+25%	+20%	+16%
$\frac{L_d-L_m}{L_m}$	0%	+11%	+20%	+33%	+44%	+50%

Table 2. Simulation Results

This table reveals a number of interesting issues. Consider that quality has a high-end nature ($0 \leq k < 1$). In such circumstances, we can note that the mass advertising Lerner index L_m increases as k falls. Moreover, CDA leads to larger price increases as k falls but, at the same time, also results in greater investments in quality provision. The interesting point is that, when $k = 0$, the quality-effect *entirely* offsets the price-effect, which yields the noteworthy result that when consumers do not value quality *per se*, CDA *does not* increase the firm's market power. By contrast, when $0 < k < 1$, the price effect dominates the quality effect and thus CDA increases the firm's market power.

When quality has a low-end nature ($k > 1$), as argued above, the possibility that the quantity effect leads to a price fall is open. This possibility is confirmed in Table 2 for $k \geq 3$, and so the second noteworthy result of this analysis is that CDA can indeed lead to a lower market price, i.e. $dP^d/dq > 0$. This raises the question of whether in this scenario the value of the Lerner index can fall. In this regard, we noted earlier that when $P''_{sq} > 0$, the firm always downgrades

[20] These values have been calibrated so that they generate an advertising cost-to-sales ratio ranging from 8% to 25%, which is consistent with the stylized fact that when a firm launches a new product, it usually incurs an average advertising cost of about 20% of sales (Kotler and Armstrong, 1998).

quality, and so the second term in the RHS of (2) is negative. Interestingly, in Table 2 we observe that the quality-effect is much stronger than the price-effect and so, in spite of the price fall, the use of CDA leads to a substantially greater firm's market power.[21]

In summary, the above analysis shows that the impact of CDA on the firm's market power depends crucially on the nature of product quality. Indeed, our model of targeting with endogenous product quality reveals an unusual relationship between the market price and the level of market power. Under high-end quality, the transition from mass advertising to CDA raises the price substantially, but this gives rise to a moderate (or no) increase in the firm's market power. By contrast, when CDA leads to a lower market price, the level of market power increases substantially. Finally, we should also point out that consumers might end-up purchasing fewer units of lower quality at a higher price when the seller uses customer directed advertising. This, of course, has a negative impact on consumers surplus, which calls for an examination of the welfare implications of this advertising strategy.

4 Welfare

In this section we examine the optimal choice of marketing mix by a social planner. In particular, we address three issues. The first pertains to the conditions under which a social planner uses CDA to promote sales. The second compares the social incentives for quantity and quality provision under customer directed advertising and the full information benchmark. Finally, we examine how the private adoption of CDA affects the level of social welfare.

As a welfare measure, we take the usual expression of gross consumer surplus

[21] It may also be the case that $P''_{sq} = 0$ $(k = 1)$. In this case, there is no quality-effect and thus the price effect is unambiguously negative. As a result, CDA always increases the firm's market power.

minus production and advertising costs:[22]

$$W(q,s,n,t) = \int_0^q P(\mu,s)\ d\mu\ r(n,t) - c(s)\ r(n,t) - A(n,t).$$

Let (q^*, s^*) be the optimal quantity and quality put in the market by a social planner under full information. Likewise, denote (q_d^*, s_d^*) as the quantity and quality socially optimal under CDA.

Proposition 3 *(i) If* $A_t'(n,t) > 0$ *and* $r_t'(n,t) < 0$*, the planner employs customer directed advertising to promote sales. (ii) Under CDA, the socially optimal quantity-quality choice satisfies* $q_d^* < q^*$ *and* $s_d^* < s^*$*.*

Proposition 3 shows that the social incentives to choose CDA are somewhat aligned with the private incentives. However, incentives for quantity and quality provision of the planner differ from those of the monopolist. A social planner who uses CDA *always* restricts the quantity and downgrades the quality of the product. The first effect is in line with the monopolist's decision; by contrast, the monopolist may upgrade quality in some cases. This misalignment between the private and the social incentives to alter quality arises because, while the seller only cares about the willingness to pay for an extra unit of quality of the marginal consumer, the social planner is concerned with the aggregate willingness to pay for an extra unit of quality.

These remarks lead us to ask whether the current proliferation of specialized advertising technologies may lead to a deterioration of social welfare. To offer a general answer to this question is difficult, and so we will limit ourselves to examining whether the private adoption of CDA lowers social welfare for the functional forms used in the previous section. In Table 3 the set Ψ indicates the range of values of the cost parameter b for which the seller's profit maximization problems have interior solutions that satisfy $q < 1$ and $s > 1$. Further, the sets Θ and Ω represent the values of b for which consumer surplus and social welfare decrease, respectively.

[22] Our specification of welfare follows the tradition in this literature and takes advertising costs as a loss (see Butters, 1977; Grossman and Shapiro, 1984); however, as pointed out by a referee, in a general equilibrium framework the whole of the advertising costs cannot be treated as a welfare loss.

	k=0	k=0.5	k=1	k=2	k=3	k=4
Ψ	$[0; 0.66]$	$[0.07; 0.85]$	$[0.25; 1]$	$[0.53; 1.14]$	$[0.73; 1.25]$	$[0.87; 1.39]$
Θ	$\varnothing$	$[0.07; 0.19]$	$[0.25; 0.42]$	$[0.53; 0.69]$	$[0.73; 0.86]$	$[0.87; 0.98]$
Ω	$\varnothing$	$[0.07; 0.08]$	$[0.25; 0.28]$	$[0.53; 0.56]$	$[0.73; 0.75]$	$[0.87; 0.89]$

Table 3. Welfare Results

We observe that the welfare implications of CDA are sensitive to the quality attributes of the product. In particular, on average, the size of the sets Ω and Θ relative to the set Ψ is greater for $k > 1$ than for $k < 1$. This implies that consumer surplus and welfare decrease under a larger set of parameters for low-end quality than for high-end quality. The case $k = 0$ deserves special attention. We know that the use of CDA does not increase the firm's market power, and so this advertising strategy results only in a higher advertising efficiency. As a result, in this case CDA is *always* welfare improving. This result contrasts with that in which quality is fixed (Esteban *et al.*, 2001), given that, in this scenario, CDA *always* increases the firm's market power and thus, for some parameter values, this technology causes a welfare loss.

We finally note that the size of the set Ω relative to Ψ is generally quite small. This suggests that, even though the possibility that CDA leads to a welfare fall cannot be excluded in this model, the likelihood of occurrence is small.

5 Conclusions

This paper has analyzed how distinct elements of the marketing mix are inter-related in a market where a seller launches a new product and uses informative advertising to promote sales. We have formulated a general advertising technology which allows for three possible advertising strategies: mass advertising, imperfectly targeted advertising and customer directed advertising. The seller's choice of advertising strategy is intimately related to the properties of the advertising technology. Under mild conditions, the monopolist promotes sales through CDA. In such a case, compared to the market allocation under full information, the seller puts fewer units in the market and distorts the quality and the price in a manner that is sensitive to the quality attributes of the product.

Further, we have seen that the nature of product quality plays a fundamental role in determining how targeted advertising affects both the market price and the firm's market power. Under high-end quality, the transition from mass to CDA raises the price substantially, but this results in a moderate (or no) increase in the firm's market power. By contrast, under low-end quality, CDA can lead to a lower market price, although the level of market power increases substantially. Finally, we find that mass advertising, as well as imperfectly targeted advertising, have no impact on the market outcome.

We have also compared the social and private incentives to use CDA and the incentives for quantity and quality provision. The incentives of the social planner to use CDA are somewhat in line with those of the seller. However, while the social planner always restricts quantity and quality, the monopolist may upgrade quality. This potential misalignment of incentives may lead to a welfare loss when the seller uses CDA instead of mass advertising. We have seen that this potential welfare loss is less likely in a setting of high-end quality.

An interesting extension of our model consists of analyzing advertising targeted to customers in an oligopoly setting. Further, our paper has a number of practical implications which are now pending more thorough empirical confirmation. However, the limited availability of good data on advertising and quality, particularly at the firm level, makes it difficult to address this issue, at least for the moment.

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Appendix 1

Proof of Proposition 1: (i) and (ii) For any p, s, the profits of the monopolist are given by

$$\Pi(\cdot) = (p - c(s)) \min\{Q(p,s), t\} r(n,t) - A(n,t) \tag{3}$$

Assume, for the moment, that $\min\{Q(p,s), t\} = Q(p,s)$. We note that the price-quality pair that maximizes $(p-c(s))Q(p,s)$ also maximizes $(p-c(s))Q(p,s)r(n,t) - A(n,t)$. Therefore, $p = p^m$ and $s = s^m$. Differentiating (3) with respect to t yields

$$\Pi'_t(\cdot) = \pi^m r'_t(n,t) - A'_t(n,t). \tag{4}$$

mass advertising arises in equilibrium if and only if the sign of (4) is positive, which holds when $A'_t(n,t) < 0$ and $r'_t(n,t) > 0$. But $t = 1$ is indeed greater than $Q(p^m, s^m)$, which completes the proof for the mass advertising case.

From the argument above, it follows that, for any $t > Q(p,s)$, the price-quality pair that maximizes seller's profits is (p^m, s^m). Differentiating (3) with respect to t yields

$$(p^m - c(s^m))q^m r'_t(n,t) - A'_t(n,t) = 0. \tag{5}$$

The monopolist uses imperfectly targeted advertising to promote sales only if equation (5) has an interior solution; the result follows.

(iii) Let $\widehat{t}$ be the solution to equation (5). Differentiating profits with respect to n yields

$$(p^m - c(s^m))q^m r'_n(n,t) - A'_n(n,t) = 0. \tag{6}$$

We now show that $dn/dt < 0$ for all $t \in (\widehat{t}, 1)$. To obtain dn/dt, we differentiate equation (6) totally:

$$\pi^m [r''_{nt}(n,t)dt + r''_{nn}(n,t)dn] - A''_{nt}(n,t)dt - A''_{nn}(n,t)dn = 0.$$

Isolating dn/dt yields

$$\frac{dn}{dt} = -\frac{\pi^m r''_{nt}(n,t) - A''_{nt}(n,t)}{\pi^m r''_{nn}(n,t) - A''_{nn}(n,t)}. \tag{7}$$

The denominator of this expression is negative (assuming second order conditions hold). Thus, the sign of dn/dt is equal to the sign of $\pi^m r''_{nt}(n,t) - A''_{nt}(n,t)$.

For a constant-elasticity advertising technology, we have that $r'_t(n,t) = n^\alpha f'(t)$, $A'_t(n,t) = a'(t)n$, $r''_{nt}(n,t) = \alpha n^{\alpha-1} f'(t)$, $A''_{nt}(n,t) = a'(t)$. Therefore, $r''_{nt}(n,t) = \alpha r'_t(n,t)/n$, and $A''_{nt}(n,t) = A'_t(n,t)/n$. Thus, the sign of (7) equals the sign of

$$\frac{1}{n}\left[\pi^m \alpha r'_t(n,t) - A'_t(n,t)\right] < \frac{1}{n}\left[\pi^m r'_t(n,t) - A'_t(n,t)\right] < 0,$$

where the last inequality follows from the fact that $t \in (\widehat{t}, 1)$. The proof is now complete. ■

Proof of Proposition 2: (i) By way of contradiction, assume that $Q(p,s) > t > 0$. Then, the profits of the monopolist are given by $\Pi(\cdot) = (p - c(s))tr(n,t) - A(n,t)$, which decrease monotonically with s. Therefore, in equilibrium, any $t < Q(p,s)$ should be accompanied by $s = 0$. However, $Q(p,0) = 0 < t$ for any t, which constitutes a contradiction.

(ii) We note that if $A'_t(n,t) > 0$ and $r'_t(n,t) < 0$, then $(p - c(s))Q(p,s)r'_t(n,t) - A'_t(n,t) < 0$. But this implies that the first derivative of the seller's profit function with respect to t is always negative. Consequently, $t = Q(p,s)$.

(iii) It is useful to employ the inverse demand function to write the problem of the monopolist under CDA as follows:

$$Max_{\{q,s,n\}}[P(q,s) - c(s)]qr(n,q) - A(n,q) \tag{8}$$

The first order conditions of this problem are:

$$[P(q,s) + P'_q(q,s)q - c(s)]r(n,q) + [P(q,s) - c(s)]qr'_q(n,q) - A'_q(n,q) = 0 \tag{9}$$

$$P'_s(q,s) - c'(s) = 0 \tag{10}$$

$$[P(q,s) - c(s)]qr'_n(n,q) - A'_n(n,q) = 0 \tag{11}$$

Note first that the optimal quality choice does not depend directly on the number of ads acquired n. Let us denote the solution of (10) as $s = s^d(q)$. Using CDA implies that $[P(q,s) - c(s)]qr'_q(n,q) - A'_q(n,q) < 0$. Therefore, a solution to equations (9) and (10) must satisfy $P(q,s^d(q)) + P'_q(q,s^d(q))q - c(s^d(q)) > 0$. Note that, for a given quantity q, the quality choice under perfect information $s^m(q) \equiv s^d(q)$. Then, it must hold that $P(q,s^d(q)) + P'_q(q,s^d(q))q - c(s^d(q)) = P(q,s^m(q)) + P'_q(q,s^m(q))q - c(s^m(q)) > 0$. Since $P(q^m,s^m(q^m)) + P'_q(q^m,s^m(q^m))q^m - c(s^m(q^m)) = 0$ and $P(q,s(q)) + P'_q(q,s(q))q - c(s(q))$ is a decreasing function of q (second order conditions), it follows that $q^d < q^m$. This proves (a).

(b) From (10) it follows that $s^d = s(q^d)$ satisfies $P_s'(q^d, s^d) = c'(s^d)$. Similarly $s^m = s(q^m)$ is the solution to $P_s'(q^m, s^m) = c'(s^m)$. Since $q^d < q^m$, $P_s'(q^d, s^m) - c'(s^m) > 0$ if and only if $P_{sq}'' < 0$. Maximization requires that the second order conditions are satisfied, i.e., $P_{ss}''(\cdot) - c''(\cdot) < 0$. This implies that $P_s'(q^d, s) - c'(s)$ declines with s and, therefore, that there exists $s^d > s^m$ such that $P_s'(q^d, s^d) - c'(s^d) = 0$. The other case is proved similarly.

(c) Notice that $dP(q, s(q))/dq = P_q' + P_s' s_q'$. Since $P_{sq}'' < 0$ implies $s_q' < 0$, the result follows. ■

Proof of Proposition 3: (i) The planner uses CDA if and only if

$$\int_0^q [(P(\mu, s) - c(s)]\, d\mu\; r_t'(n,t) - A_t'(n,t) < 0, \tag{12}$$

which holds if $A_t'(n,t) > 0$ and $r_t'(n,t) < 0$.

(ii) Under full information, the first order conditions with respect to q and s are

$$[(P(q,s) - c(s)] = 0 \tag{13}$$

$$\int_0^q P_s'(\mu, s)\; d\mu - c'(s) = 0, \tag{14}$$

respectively. Under CDA, $t = Q(p, s)$ and the first order conditions with respect to q and s are

$$[(P(q,s) - c(s)]\;\; r(n,q) + \int_0^q [(P(\mu, s) - c(s)]\, d\mu\; r_q'(n,q) - A_q'(n,q) = 0 \tag{15}$$

$$\int_0^q P_s'(\mu, s)\; d\mu - c'(s) = 0, \tag{16}$$

respectively. If $s^*(q)$ and $s_d^*(q)$ are solutions to (14) and (16), respectively, then it follows that $s^*(q) \equiv s_d^*(q)$. Thus, substituting (14) into (13) yields $P(q^*, s^*(q^*)) = c(s^*(q^*))$ or, equivalently, $P(q^*, s_d^*(q^*) - c(s_d^*(q^*)) = 0$. Moreover, since (12) holds under CDA, equation (15) implies $P(q_d^*, s_d^*(q_d^*)) - c(s_d^*(q_d^*)) >$

0. Since $P(q,s)-c(s)$ is a decreasing function of q (second order conditions), it follows that $q_d^* < q^*$. Finally, applying the implicit function theorem to (14), we obtain the nature of the relationship between quality and quantity:

$$\frac{ds}{dq} = -\frac{P_s'(q,s)}{\int\limits_0^q P_{ss}''(\mu,s)d\mu - c''(s)} > 0$$

where the inequality follows from the conditions above. Since $q_d^* < q^*$, it follows that $s_d^* < s^*$. ■

Appendix 2

In this Appendix we extend the model to the case where the firm has a discrete number of media available and implements a mixed targeting strategy by inserting ads in multiple advertising means with different target audiences. Our focus is on the conditions under which the firm finds it optimal to employ mixed targeting and on the relationship between three of the variables of the marketing mix.

Consider that there are m magazines, labelled $j = 1, 2, ..., m$ of target t_j. Let $t_1 > t_2 > ... > t_m$ without loss of generality. Under the assumptions above, the payoff to the seller can be written as follows:

$$\pi = [P(q,s)-c(s)]\left[\min\{q,t_1\}r(n_1,t_1) + \sum_{j=2}^{m}\min\{q,t_j\}r(n_j,t_j)\prod_{\ell=1}^{j-1}(1-r(n_\ell,t_\ell))\right] - \sum_{j=1}^{m}A(n_j,t_j).$$

Let us assume that the conditions in Proposition 2 hold, i.e., that moving ads from higher target magazines to lower target magazines reduces costs and increases consumer awareness:

$$A(n,t_{\ell+1}) < A(n,t_\ell); \text{ and } r(n,t_{\ell+1}) > r(n,t_\ell). \tag{17}$$

These conditions imply the following. Let t_k and t_{k+1} be defined such that $t_k > q > t_{k+1}$. Then, the firm will not use magazines j, such that $t_j > t_k$, i.e., $n_j = 0$ for all $j > k$. This is basically a result similar to that in Proposition 2, but we still need to show that there exists another magazine ℓ such that $t_\ell = q$, i.e., that the seller will adjust q in such a way.

Under condition (17), the profit can be written as follows:

$$\pi = [P(q,s) - c(s)] \left[qr(n_k,t_k) + \sum_{j=k+1}^{m} t_j r(n_j,t_j) \prod_{\ell=k}^{j-1} (1 - r(n_\ell,t_\ell)) \right] - \sum_{j=k}^{m} A(n_j,t_j).$$

Let us now see when the firm will choose q in such a way that q equals some t_ℓ, say t_{k+1}. Note that a decrease in q, accompanied by a reallocation of the advertising budget from magazine k to $k+1$, reduces the profits made just on a fraction of those consumers attracted by the last magazine k, while it increases the profits made on all other consumers (attracted by all other magazines). In analytical terms, the first effect leads to a profit loss of $[P(q,s) - c(s)]\ (q - t_{k+1})\ r(n_k,t_k)$. Regarding the second effect, we note that the reallocation of the advertising budget from t_k to t_{k+1} implies that all the targeted consumers are willing to pay a higher price $P(t_{k+1},s) > P(q,s)$. Further, if we define $\widehat{n}_{k+1}$ as the solution of

$$A(\widehat{n}_{k+1},t_{k+1}) = A(n_{k+1},t_{k+1}) + A(n_k,t_k),$$

the higher advertising effort in the magazine with target t_{k+1} will increase consumer awareness in $[0,t_{k+1}]$ by[23]

$$[r(\widehat{n}_{k+1},t_{k+1}) - r(n_{k+1},t_{k+1})] \left[t_{k+1} - \sum_{j=k+2}^{m} t_j r(n_j,t_j) \prod_{\ell=k+2}^{j-1} (1 - r(n_\ell,t_\ell)) \right].$$

Under mild conditions (such that the number of magazines is large so that q does not need to fall much) the first effect is of second-order and so the firm will use CDA, i.e. $q = t_{k+1}$. In analytical terms, CDA arises if

$$[P(t_{k+1},s) - c(s)]\,[r(\widehat{n}_{k+1},t_{k+1}) - r(n_{k+1},t_{k+1})] \left[t_{k+1} - \sum_{j=k+2}^{m} t_j r(n_j,t_j) \prod_{\ell=k+2}^{j-1} (1 - r(n_\ell,t_\ell)) \right] +$$
$$+ [P(t_{k+1},s) - P(q,s)] \left[t_{k+1} r(n_{k+1},t_{k+1}) + \sum_{j=k+2}^{m} t_j r(n_j,t_j) \prod_{\ell=k+1}^{j-1} (1 - r(n_\ell,t_\ell)) \right] >$$
$$> [P(q,s) - c(s)](q - t_{k+1}) r(n_k,t_k).$$

[23] The following expressions use the convention $\sum_{j}^{j-i} (\cdot) = 0$ and $\prod_{j}^{j-i} (\cdot) = 1$.

Under this condition, the seller must choose a $q = t_{k+1} \in \{t_1, t_2, t_3, ..., t_m\}$ to maximize:

$$\pi = [P(q,s) - c(s)] \left[qr(n_{k+1}, q) + \sum_{j=k+2}^{m} t_j r(n_j, t_j) \prod_{\ell=k+1}^{j-1} (1 - r(n_\ell, t_\ell)) \right] - A(n_{k+1}, q) - \sum_{j=k+2}^{m} A(n_j, t_j),$$

and so the connection between advertising, marginal revenue and marginal costs is established, as in Proposition 2. Therefore, the results described there will carry over to this case of multiple magazines.

The question now is whether the firm will indeed use a single magazine, t_{k+1}, or multiple magazines (mixed targeting). Let q^d, s^d be the optimal quantity and quality choice of the monopolist, respectively. The first-order conditions with respect to advertising intensities $\{n_{k+1}, ..., n_m\}$ for an interior equilibrium are:

$$[P(q^d, s^d) - c(s^d)] \left[q^d - \sum_{j=k+2}^{m} t_j r(n_j, t_j) \prod_{\ell=k+2}^{j-1} (1 - r(n_\ell, t_\ell)) \right] r'_{n_{k+1}}(n_{k+1}, q^d) - \\ - A'_{n_{k+1}}(n_{k+1}, q^d) = 0, \qquad (18)$$

$$[P(q^d, s^d) - c(s^d)] \left[t_h \prod_{\ell=k+1}^{h-1} (1 - r(n_\ell, t_\ell)) - \sum_{j=h+1}^{m} t_j r(n_j, t_j) \prod_{\substack{\ell=k+1 \\ \ell \neq h}}^{j-1} (1 - r(n_\ell, t_\ell)) \right] r'_{n_h}(n_h, t_h) - \\ - A'_{n_h}(n_h, t_h) = 0, \qquad h = k+2, ..., m. \qquad (19)$$

From these equations, we can see that the use of several magazines with different target audiences depends on the second derivatives A''_{nt} and r''_{nt}. Given that it seems reasonable to assume that $A''_{nt} > 0$ and $r''_{nt} < 0$, the use of more specialized magazines allows the firm to achieve higher advertising efficiency. However, at the same time, the term in parenthesis in equation (19) will generally get smaller as the target increases, thus lowering profits. This occurs because the use of increasingly specialized media leads to both a worse fit between the potential market and the target of the magazine, and a higher extent of ad duplication. As a result, the firm will use a single magazine, $k+1$, if and only if the set of first order conditions $h = k+2, ..., m$ hold with negative sign.

In summary, in this Appendix we have formulated a model of targeting with a discrete number of advertising media, in order to show that CDA is compatible with the use of mixed targeting, and that the main results of the paper hold under this type of advertising. Finally, we should note that mixed targeting can also be explained on the basis of strategic interaction. In this respect, recent work by Galeotti and Moraga-González (2004) and Esteban and Hernández (2004) claim that in an oligopolistic framework, a simultaneous move game of pricing-targeted advertising does not have a *pure strategy* Nash equilibrium, and so the use of specialized advertising must involve mixed targeting.