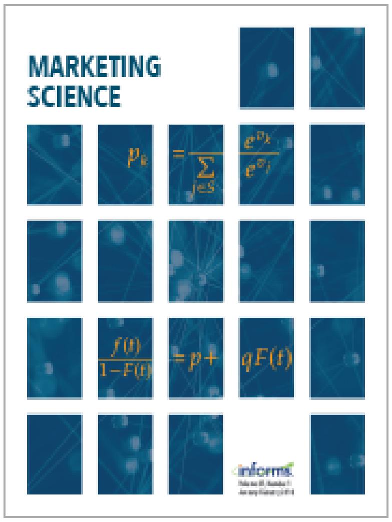

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Advertising Effectiveness, Digital Video Recorders, and Product Market Competition

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With increasing fragmentation of media markets and recent advances in technology, loss of advertising effectiveness has been a great concern for marketers. For consumers, the digital video recorder (DVR) offers the possibility to fast-forward through live programming. Whereas the DVR thus benefits consumers by reducing nuisance from commercials, industry observers believe that it may diminish advertisers' profits by rendering commercials ineffective. We use a model of informative advertising to study the effect of DVR penetration on competing advertisers' strategies and profits. We find that the overall effect of DVRs depends on the trade off between loss of advertising effectiveness and reduction in competition between firms. The latter effect arises because DVR penetration may increase the ratio of partially informed to fully informed consumers. We identify conditions under which an increase in DVR penetration counterintuitively leads firms to increase advertising levels and enjoy higher profits. Interestingly, we find that greater DVR penetration is beneficial for firms when the share of DVR owners in the population is above—rather than below—a threshold level. We also study the impact of different fast-forwarding ("zipping") behaviors on product market competition.

Key words: advertising; game theory; competitive analysis; marketing strategy; advertising avoidance technologies
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1. Introduction

The digital video recorder (DVR) technology has had a profound effect on the commercial broadcasting industry in recent years. A DVR allows viewers to record and fast-forward ("zip") through live programming, thereby avoiding exposure to commercials. According to a recent popular press article, 66% of DVR owners zip through advertisements, and a DVR owner is seven times more likely to skip advertisements than a nonowner (Steinberg 2007). The new technology benefits consumers by providing a better viewing experience of program content, but industry observers believe that zipping of advertisements and the related reduction of ad exposures diminishes profits of advertisers. This problem is likely to exacerbate as the number of DVR owners increases. Currently, DVR penetration is around 39% and by 2012 this number is estimated to grow to approximately 55%, with 65 million homes having such technologies at their disposal (Winslow 2009).

In the context of informative ads, we analyze the effect of ad avoidance technologies like DVRs on product market competition by examining the following research questions: How does DVR penetration and zipping of informative ads affect equilibrium prices, advertising levels, and profits of competing firms? How does the nature of the zipping behavior associated with DVR usage affect firms' strategies and profits?

We develop a model of informative advertising based on Soberman (2004) in which two firms compete for a market consisting of DVR owners and regular viewers. Firms simultaneously set prices and advertising reach. DVR owners have a positive probability of zipping an ad, whereas regular viewers watch all of the ads they receive. With respect to zipping behavior, we study two specifications. We consider naïve DVR owners whose decision to zip an ad is independent of their product preference. Subsequently, we also study the impact of selective DVR owners who zip ads based on product characteristics observed during the commercial.

Our principal findings are as follows. Given market conditions and type of zipping behavior, advertising levels and profits of competing firms could increase (or decrease) with DVR penetration. Advertising levels and profits crucially depend on the extent and composition of demand.[1] On the one hand, as commonly held, we find that DVRs and related ad zipping shrink the overall extent of demand by reducing the effectiveness of advertising. On the other hand, our results also suggest that DVR penetration may favorably change the composition of demand by increasing the ratio of partially informed to fully informed consumers. The latter effect relaxes competition between firms. The overall effect of DVRs depends on the relative size of these opposing effects. Interestingly, DVR penetration is beneficial when the share of DVR owners is above a threshold or when the cost of posting ads is low. Our results also suggest that the positive effects of DVRs are enhanced when consumers exhibit selective zipping behavior.

Our paper pertains to the relatively new literature on economics of television media markets. The television media market by nature is "two-sided," wherein the network broadcaster needs to attract both television viewers and advertisers to generate revenues.[2] In their pioneering article, Anderson and Coate (2005) find that, depending on the "nuisance cost" of ads, market provision of programs can lead to over or undersupply of programs and ads relative to the social optimum. In marketing, Wilbur (2008a) provides the first major empirical analysis of the two-sided television media market. Using a rich data set, he estimates demand on both sides of the media market—viewer demand for television programs and advertiser demand for viewers. He shows that viewers exhibit a strong aversion toward advertisements. In another paper, Wilbur (2008b) identifies various types of ad avoidance behaviors of a TV viewer and suggests that with greater penetration of DVR technologies, zipping behavior is likely to become more widespread than other forms of ad avoidance behaviors. We contribute to this literature by studying the effect of different zipping behaviors on firms' strategies and profits.

This paper also adds to the extant literature on informative advertising. The academic literature distinguishes two main functions of advertising, persuasion and information provision (Tirole 1988). Persuasive advertising is used to influence consumers' willingness to pay for a product or to change consumers' preference for a firm's versus its rival's product (Shaffer and Zettelmeyer 2004, Chen et al. 2009). Our paper is not concerned with such persuasive roles of ads and restricts itself to their informative role.

In the context of differentiated products, informative advertising has two opposing effects. First, informative ads create awareness about products such that consumers learn which products better fit their needs. This effect increases differentiation between firms, relaxing competition between them. Second, informative advertising creates more consumers who are fully informed about competing firms' products, increasing price competition between them. The existing literature on informative ads (Grossman and Shapiro 1984, Soberman 2004) has demonstrated that when products are not well differentiated, the second effect dominates the first. Therefore, in this scenario increasing ad levels escalates competition between firms leading to lower equilibrium prices. In this paper, whereas confirming the competition increasing effect of ads, we examine the choice of advertising strategy when the effectiveness of informative ads is mitigated by DVRs. We show that even if products are not well differentiated, increasing advertising levels may be accompanied with higher prices and higher profits for competing firms. Therefore, the presence of DVRs may be a blessing in disguise. Moreover, the literature on informative ads assumes that consumers are passive with respect to their viewing behavior so that if a firm reaches a consumer, she will automatically get exposed to the ad content. The presence of DVRs relaxes such an assumption. Specifically, a DVR conveniently allows consumers to view ads they prefer and to zip the ones they do not. The impact of consumer self-selection of ads on product market competition has not been studied in the context of informative ads.

Of course, this paper is related to the literature on ad effectiveness. For decades, researchers in marketing have developed empirical models to estimate the effect of advertising on sales. However, the results have been mixed. For example, Tellis and Weiss (1995) find that the effect of advertising on current sales of detergent is spurious. On the other hand, in a meta-analysis of split cable TV advertising experiments, Lodish et al. (1995) show that TV advertising for new products is positively correlated with sales. More recently, by explicitly modeling consumer responsiveness to ads, Chen et al. (2009) analyze the effects of combative advertising in a competitive market. They show that such advertising can either intensify or mitigate competition depending on consumer responsiveness to advertising. In particular, if consumers are responsive, overall price competition decreases and profits are enhanced. We add to the literature on ad effectiveness by highlighting that even if zipping

[1] We define *extent of demand* as the overall demand firms face from all informed consumers. Furthermore, *composition of demand* refers to the ratio of partially informed consumers (who are informed about the product of only one firm) to fully informed consumers (who are informed about both firms' offers).

[2] A two-sided market in general involves an intermediary whose revenue depends on bringing two entities on board. Classic examples for two-sided markets are nightclubs, shopping malls, and credit cards. For more on two-sided market economics, see Armstrong (2006).

of ads reduces their effectiveness, firms can derive higher profits under some conditions.

Althouth the focus of this paper is on DVR economics, many of the implications derived from our model can be more generally applied. In particular, our model can be used to study how the recent trend of increasing media fragmentation and related loss of advertising effectiveness may impact firm strategies and profits—an issue that is of great concern to marketers who consider cutting advertising budgets (Rust and Oliver 1994). Previous research (Grossman and Shapiro 1984) has suggested that loss of advertising effectiveness may lead firms to lower advertising levels. Our analysis alludes to market conditions wherein exactly the opposite may hold true. We find that under suitable market conditions, when ad exposure is mitigated, firms may counterintuitively be advised to advertise more. These results are consistent with Wilbur (2008a) who predicts that advertising levels increase with consumers' ad avoidance. Next, we outline our model.

2. Model

2.1. The Consumer Market

Our modeling framework is similar to Tirole (1988, p. 292) and Soberman (2004). We use the Hotelling (1929) model with two firms, denoted by subscripts A and B, located at the endpoints 0 and 1, respectively, on a line of unit length. Each firm offers a product to a continuum of consumers whose ideal values are uniformly distributed along the unit line. Consumers have a common reservation price, v, for the product and they incur a transportation cost, t, per unit of distance between their ideal values and the location of the firm.[3] In particular, a consumer located at a distance $x \in [0, 1]$ from firm A derives a net utility of $u_A = v - tx - p_A$ from buying the product of firm A and a net utility of $u_B = v - t(1-x) - p_B$ from buying the product of firm B, where p_A and p_B denote the prices charged by firms A and B, respectively. Consistent with the literature on informative ads, we assume that consumers do not ex ante know the characteristics and prices of the products. Instead, they learn this information by watching ads on television, and these ads are the only source of product information.[4] For simplicity and without loss of generality, we assume that consumers are informed about the product's attributes and price after the first viewing of an ad. Consumers only consider purchasing products whose characteristics and prices they know. Last, advertising is purely informative and has no persuasive role. Thus ads have no effect on the consumer's base value, v, for the product.

The consumer market is segmented on the basis of DVR ownership. Specifically, we assume that the market consists of a share of α DVR owners and $1-\alpha$ regular consumers. The share of DVR owners, α, is exogenously specified in our model. In reality, DVR penetration may be a function of the overall ad clutter and therefore a general equilibrium set up appears to be more appropriate. However, we present a partial equilibrium analysis for two reasons. First, overall ad clutter depends on competition in many industries rather than the one that is the focus of our analysis. Second, assuming α to be exogeneous keeps our analysis tractable. Finally, a DVR allows its owner to zip through a commercial that she receives, thereby limiting both the nuisance she experiences from the interruption of the program and the amount of information she absorbs from the commercial. In the following section we elaborate more on our assumptions with respect to the ad viewing behavior of consumers.

2.2. Advertisement Viewership Behavior

Throughout this paper we assume that regular consumers view all ads they receive.[5] To the contrary, consistent with the empirical observation in Wilbur (2008b), we assume that DVR owners zip through a percentage of ads. Furthermore, consumers do not retain any product-related information from a zipped exposure. We analyze two types of zipping behaviors. First, we consider a "naïve consumer model," wherein DVR owners consist of two segments of consumers who zip ads randomly. One segment comprises a share of S consumers, henceforth called "independent zippers," whose probability of zipping is independent across ads. The remaining share of $(1-S)$ consumers randomly zips blocks of ads at a time. These consumers watch all or none of the ads they receive, and hence we refer to them as "block zippers." Both types of zipping behavior are consistent with observations from past research (Cronin and Menelly 1992). Technically speaking, an independent zipper watches an ad aired by firm i, with $i = A, B$, with probability Pr_i (and zips it with probability $(1-\mathrm{Pr}_i)$), and a block zipper watches all ads she

[3] The locations of the firms are tantamount to the characteristics of their products in our model.

[4] In a different specification of our model, we assume that DVR owners learn only of the existence of the product through exposure to a zipped commercial and make purchase decisions based on imperfect information about product attributes obtained through search. Interestingly, we find that the presence of such "quasi-informed" consumers can increase competition between firms. This analysis is available from the authors.

[5] Alternatively, one could assume that all viewers engage in other types of ad avoidance behavior such as physical zapping or multitasking (Wilbur 2008b). However, a DVR owner would still have a lower probability of viewing an ad than a regular viewer. Our assumption is tantamount to normalizing the probability of avoiding ads through ways other than zipping to 0.

receives with probability $\Pr_{\text{Block}}$ (and zips them with probability $1 - \Pr_{\text{Block}}$).[6] The analysis of the naïve consumer model is shown in §3.

Second, in §4 we present a "selective consumer model" in which DVR owners zip ads based on their taste preferences. Findings from experimental research (Stout and Burda 1989) suggest that zipping consumers absorb some product-related information as a result of a state of heightened attention and hence may switch modes from zipping to viewing an ad if they feel sufficiently interested in the advertised product. Recent survey research conducted by Forrester Research found that 30% of DVR owners sometimes or frequently rewind ads they have zipped (Bernoff 2004). More importantly, in the same study more than 30% of respondents indicated that their reason for rewinding the commercial and viewing it at regular speed was that they "were interested in the product." Similarly, a DVR owner who is watching an ad may decide to zip, thereby switching modes from viewing to zipping. Technically speaking, in our model we assume the probability that a consumer watches an ad depends on her location $x \in [0, 1]$ on the Hotelling line. In particular, a selective DVR owner who is located at $x \in [0, 1]$ has a probability $\Pr_i(x)$ of watching an ad from firm $i = A, B$, where $\Pr_A(x)$ is linearly decreasing in x and $\Pr_B(x)$ is linearly increasing in x. In essence, this formulation captures the idea that a selective consumer has a greater probability of watching an ad featuring a product closer to her preference because her expected value from purchasing such a product is higher. We give more details on our specification in §4. Finally, note that some consumers may have a different selection mechanism. For example, they may view ads that appear humorous. Such selection mechanisms, although pertinent, are not in the scope of this paper.

2.3. Firm Strategies

In our model, firms offer horizontally differentiated products of identical quality, and we assume that they incur an identical unit cost of production, c. Furthermore, firms simultaneously decide on the price, p_i, and advertising reach, ϕ_i. The assumption of setting ad reach is done following previous literature (Grossman and Shapiro 1984, Soberman 2004). In practice, firms buy gross rating points (GRP)[7] from network broadcasters expecting to reach target populations by advertising during specific programs. Although this expected reach may be somewhat different from actual reach, recent improvements in data mining techniques ensure that firms have a fairly good idea about program viewership. Thus for parsimony we assume that expected and actual reach are equal and that firms have direct control over the latter. Furthermore, following previous literature, firms incur a cost for advertising and this cost is convex in ad reach, implying that it is increasingly hard to reach some target consumers.[8] In particular, we assume that firm i incurs a cost of $\theta\phi_i^2$ if it decides to reach ϕ_i of the market, where $\theta > 0$ is an advertising cost parameter. Note our formulation implies that the unit cost of advertising is independent of ad viewership and thus DVR penetration. We restrict θ so that firm i's ad reach ϕ_i is less than 1. Finally, advertising is not localized; i.e., all consumers receive the message with probability ϕ_i from firm i, where $i = A, B$.

2.4. Firm Demands and Profits

After firms send ads and DVR owners engage in ad zipping, consumers can have various information sets about the products. First, a consumer can have product and price information from both firms. Such a "fully informed" consumer makes her purchase decision after comparing the attractiveness of both products on the basis of product attributes and prices. Second, "partially informed" consumers have product- and price-related information only from one of the two firms. Thus they will purchase the product as long as its net utility is positive. Finally, "uninformed" consumers do not have any product information and thus do not consider purchasing either product. Furthermore, we assume that a consumer receives a utility of 0 from not purchasing.[9]

In the following we describe the demand for firm i where $i, j = A, B$ with $i \neq j$. Firm i gets its demand from both DVR owners and regular consumers, where

[6] Note that the difference between block and independent zippers would disappear if competing advertisers could avoid placing ads in the same "commercial break" (perhaps because of category exlusivity arrangements with network broadcasters). To see this, note if firms A and B post ads in the same break, a block zipper, when zipping, will zip both their ads. However, if firms post ads in different breaks, the probability of zipping an ad from firm A is essentially decoupled from the probability of zipping an ad from firm B, and hence they are independent.

[7] GRP is calculated as the product of frequency and percentage reach.

[8] Trying to expose hard-to-reach consumers to ad content may lead to a waste of ad expenditures because in the process an increasing number of "nontarget" consumers are exposed to the ad. This leads to a lower "bang for the buck" for each dollar spent on ads at greater levels of ad spending, which is consistent with the convexity of the ad cost function.

[9] Under our conceptualization, $u_{FI} \geq u_{PI} \geq u_{UI} = 0$, where u_{FI}, u_{PI}, and u_{UI} are the utilities for fully informed, partially informed, and uninformed consumers, respectively. In other words, more information is always better from the consumer's point of view because it gives her the opportunity to acquire a product that better fits her needs (Grossman and Shapiro 1984). Despite the apparent advantage of more information for consumers, DVR owners zip ads because of the implicit nuisance cost of ads in our model.

α is the share of DVR owners in the market. Among DVR owners a share of S consumers watches an ad received from firm i with probability Pr_i.[10] Moreover, a share of $(1-S)$ of DVR owners watches all ads they receive with probability $\mathrm{Pr}_{\mathrm{Block}}$. Firm i has local monopoly over two subgroups of DVR owners who are partially informed: (a) consumers who are reached by firm i, watch the ad, and are not reached by firm j—a fraction of $(S\,\mathrm{Pr}_i+(1-S)\,\mathrm{Pr}_{\mathrm{Block}})\phi_i(1-\phi_j)$ of DVR owners; and (b) consumers who are reached by both firms but skip the ad aired by firm j – a fraction of $S\,\mathrm{Pr}_i(1-\mathrm{Pr}_j)\phi_i\phi_j$ of DVR owners. Among regular viewers, a fraction $\phi_i(1-\phi_j)$ is reached only by firm i and hence is partially informed. The three partially informed groups of consumers buy from firm i as long as $u_i>0$. Therefore, the demand from this segment is $x_i=(v-p_i)/t$.[11] Additionally, firms compete for a proportion of $(S*\mathrm{Pr}_i\,\mathrm{Pr}_j+(1-S)*\mathrm{Pr}_{\mathrm{Block}})\phi_i\phi_j$ of DVR owners and a proportion of $\phi_i\phi_j$ of regular consumers. These fully informed consumers compare the net values of the two offers, and a proportion $y_i=(p_j-p_i+t)/2t$ of them buys from firm i.

Given the demand information above, the total demand Q_i and profit Π_i of firm i as a function of prices p_i and p_j is given as follows:

$$\begin{aligned}Q_i=\alpha(S*((&\mathrm{Pr}_i\phi_i(1-\phi_j)+\mathrm{Pr}_i(1-\mathrm{Pr}_j)\phi_i\phi_j)x_i\\&+\mathrm{Pr}_i\mathrm{Pr}_j\phi_i\phi_j y_i)\\&+(1-S)*\mathrm{Pr}_{\mathrm{Block}}(\phi_i(1-\phi_j)x_i+\phi_i\phi_j y_i)\\&+(1-\alpha)(\phi_i(1-\phi_j)x_i+\phi_i\phi_j y_i))\end{aligned}\tag{1}$$

$$\Pi_i=Q_i(p_i-c)-\theta\phi_i^2\tag{2}$$

We analyze a simultaneous move game where firms decide upon prices and levels of advertising reach. Subsequently, consumers who have viewed ads make purchase decisions. We determine the symmetric subgame perfect Nash equilibrium in pure strategies. Next, we present our analysis of the naïve consumer model.

3. Naïve Consumers

For model parsimony we assume that $\mathrm{Pr}_i=\mathrm{Pr}_{\mathrm{Block}}$. Substituting $\mathrm{Pr}_A=\mathrm{Pr}_B=\mathrm{Pr}_{\mathrm{Block}}=\beta$ in Equation (1) above, it is straightforward to derive the demand and profit functions for firms A and B, where β is denoted as the viewing rate. Consistent with Grossman and Shapiro (1984) and Soberman (2004), we assume that the market for partially informed consumers is fully served. This assumption helps us to focus attention on the market for which firms compete (Tirole 1988). Technically speaking, we restrict t such that $p<v-t$. Firms maximize profits with respect to prices and advertising reach. Table 1 shows the symmetric pure strategy equilibrium. We present detailed proofs and derivations in the electronic companion to this paper, which is available as port of the online version that can be found at http://mktsci.pubs.informs.org/.

Propositions 1 and 2 outline our main results and pertain to comparative statics around the stated equilbrium.

Proposition 1. *In the unique symmetric equilibrium, prices increase with the DVR penetration rate* α. *The equilibrium exists and is unique if* $\theta\in[\underline{\theta}_n,\bar{\theta}_n]$, $t\in[\underline{t}_n,\bar{t}_n]$, *and* $\beta\geq\underline{\beta}_n$. *The expressions for* $\underline{\theta}_n$, $\bar{\theta}_n$, $\underline{t}_n$, $\bar{t}_n$, *and* $\underline{\beta}_n$ *are given in Table* 1.

Note that demand from partially informed consumers is price inelastic given our assumption of market coverage for this market.[12] Therefore, the firms' pricing strategy depends only on the change in size of the fully informed market following an increase in DVR penetration, which, for a given ϕ, shrinks because fewer consumers watch ads from both firms. Thus firms have an incentive to raise prices consistent with softening of price competition. In a symmetric equilibrium, however, price has an effect neither on the composition nor on the extent of demand given our assumption of market coverage. To the contrary, the choice of advertising reach affects both the overall extent and the composition of demand. Thus changes in equilibrium profit are perfectly correlated with changes in equilibrium ad reach; therefore, choice of ad reach is crucial to firms. The next proposition outlines our result for the effect of a change in the DVR penetration rate on ad reach and profits. Note that we distinguish regions where equilibrium ad reach and profits are increasing, U-shaped, and decreasing with DVR penetration (also seeTable 2).

Proposition 2. *In the unique symmetric equilibrium,*

(i) *Ad reach and profits increase with the DVR penetration rate* α *for all* $\alpha\in[0,1]$ *when the cost of sending ads is low,* $\theta\leq\theta_n^*$, *and the size of independent zipping segment is positive,* $S>0$.

(ii) *Ad reach and profits decrease with the DVR penetration rate* α *for all* $\alpha\in[0,1]$ *when the cost of sending ads is very high,* $\theta>\bar{\theta}_n^*$, *and the size of independent zipping segment is small,* $0\leq S<S_n^*$.

(iii) *Ad reach and profits follow a U-shape with DVR penetration (decrease for* $\alpha<\alpha_n^*$ *and increase for* $\alpha\geq\underline{\alpha}_n^*$) *when (A) the cost of sending ads is very high,* $\theta\geqq\bar{\theta}_n^*$,

[10] Note that Pr_i takes a specific functional form depending on the viewing behavior—naïve or selective.

[11] The condition $0<(v-p_i)/t<1$ implies that some but not all partially informed consumers purchase.

[12] The mass of fully informed (FI), partially informed (PI), and uninformed consumers (UI) is, around the symmetric equilibrium, given by $FI=\phi^2(1-\alpha(1-\beta)(1+S\beta))$, $PI=2\phi(1-\phi-\alpha(1-\beta)(1-\phi-S\phi\beta))$, and $UI=1-FI-PI$.

Table 1 Equilibrium Results

Model type	Price (p^*)	Advertising reach(Φ^*)	Profit (Π^*)	Sufficient conditions
Naïve consumer model (§3)	$c+\frac{2\sqrt{\theta t}}{\sqrt{(1-\alpha(1-\beta)(1+S\beta))}}$	$\frac{2t(1-\alpha(1-\beta))}{t(1-\alpha(1-\beta)(1+S\beta))+2\sqrt{\theta t(1-\alpha(1-\beta)(1+S\beta))}}$	$\frac{4\theta t^2(1-\alpha(1-\beta))^2}{(t(1-\alpha(1-\beta)(1+S\beta))+2\sqrt{\theta t(1-\alpha(1-\beta)(1+S\beta))})^2}$	$\theta\in[\underline{\theta}_n,\bar{\theta}_n]$[a] $t\in[\underline{t}_n,\bar{t}_n]$, $\beta\geq\frac{2}{5}$
Selective consumer model (§4)	$c+\frac{2\sqrt{\theta t}}{\sqrt{(1-\alpha(1-\beta^2))}}$	$\frac{6t(1-\alpha(1-\beta))}{t(3-\alpha(3-3\beta^2+\varepsilon^2))+6\sqrt{\theta t(1-\alpha(1-\beta^2))}}$	$\frac{36\theta t^2(1-\alpha(1-\beta))^2}{\left(t(3-\alpha(3-3\beta^2+\varepsilon^2))+6\sqrt{\theta t(1-\alpha(1-\beta^2))}\right)^2}$	$\theta\in[\underline{\theta}_s,\bar{\theta}_s]$[b] $t\in[\underline{t}_s,\bar{t}_s]$, $\varepsilon\in[0,\bar{\varepsilon}_s]$ $\beta\geq\underline{\beta}_s$

[a] $\underline{t}_n=\frac{v-c}{5}$; $\bar{t}_n=\min\left\{\frac{(1-S(1-\beta))(v-c)}{2},\frac{(v-c)\sqrt{\beta(1-S(1-\beta))}}{(1+\sqrt{\beta(1-S(1-\beta))})}\right\}$; $\underline{\theta}_n=\max\left\{\frac{t}{4},\frac{t(1+S(1-\beta))^2\cdot\beta}{(4-4S(1-\beta))}\right\}$; $\bar{\theta}_n=\frac{(v-t-c)^2(1-S(1-\beta))\beta}{4t}$.

[b] $\underline{t}_s=\frac{3(v-c)\beta^2}{(15\beta^2-4\varepsilon^2)}$; $\bar{t}_s=\min\left\{\frac{6(v-c)(\sqrt{37}-7+5\beta(\sqrt{37}-6))}{(6(\sqrt{37}-9)+5(7\sqrt{37}-41)\beta)},\beta\left(\frac{v-c}{2}\right)\right\}$; $\bar{\theta}_s=\frac{(v-t-c)^2}{4t}\beta^2$; $\underline{\theta}_s=\frac{t(3(2-\beta)\beta+\varepsilon^2)^2}{36\beta^2}$; $\bar{\varepsilon}_s=\frac{12}{45+\sqrt{37}}$; $\underline{\beta}_s=\frac{1}{15}(3+\sqrt{9+60\varepsilon^2})$.

and the size of the independent zipping segment is large, $S\geq S_n^*$; or (B) the cost of sending ads is intermediate, $\theta_n^*\leq\theta<\bar{\theta}_n^*$, and the size of independent zipping segment is positive, $S>0$.

The equilibrium exists and is unique if $\theta\in[\underline{\theta}_n,\bar{\theta}_n]$, $t\in[\underline{t}_n,\bar{t}_n]$, and $\beta\geq\underline{\beta}_n$. The expressions for $\underline{\theta}_n$, $\bar{\theta}_n$, $\underline{t}_n$, $\bar{t}_n$, and $\underline{\beta}_n$ are given in Table 1, and the expressions for α_n^*, θ_n^*, $\bar{\theta}_n^*$ and S_n^* are given in Table 3.

To explain the result, we first highlight the effects of DVR penetration α on overall extent and composition of demand. For a given level of ad reach, ϕ, a marginal increase in α increases the mass of uninformed consumers. We refer to this effect as the demand contraction effect. To compensate for such demand contractions, firms may have an incentive to increase ad reach. However, more advertising creates more fully informed consumers, intensifying competition between firms (Grossman and Shapiro 1984). This effect, which operates via choice of ad reach, is an indirect effect of DVR penetration. Finally, because of ad zipping, a marginal increase in DVR penetration, α, increases the ratio of partially informed consumers to fully informed consumers. Because firms exert monopoly power over their partially informed consumers, this effect relaxes competition between firms. We call this the direct effect of DVR penetration.[13] In summary, whether DVR penetration is beneficial for firms depends on the trade-off between demand contraction caused by DVRs and the degree to which it softens competition between firms as measured by the relative sizes of the direct and indirect effects.

Having identified the general effects of DVR penetration, we examine its effect under specific market conditions. Note when advertising cost θ is low, $\theta\leq\theta_n^*$, compensating for demand contraction is inexpensive. Therefore, firms always find it optimal to increase ad reach and profits follow suit. However, if the advertising cost is very high, $\theta>\bar{\theta}_n^*$, increasing ad reach is expensive, making it harder to recover the demand contraction caused by DVRs. Additionally, if there are many block zippers, $S<S_n^*$, competition reducing benefits from DVR penetration are depressed. To see this, recall that block zippers either watch all or none of the ads they receive, which implies, at low S, any potential improvement in demand composition associated with DVRs is dissipated. As a response to lower ad effectiveness, firms decrease ad reach and profits decline.

However, in other scenarios the share of DVR ownership, α, influences the direction of the change in ad reach and profits as triggered by a marginal increase in DVR penetration. In particular, we find that at low levels of α, firms decrease ad reach with DVR penetraton, and at high levels of α, they increase ad reach with DVR penetration, resulting in a U-shaped response function. When there are few DVR owners in the market ($\alpha\leq\alpha_n^*$), the market comprises mostly regular consumers who view all ads they recieve. Such a market is akin to the low differentiation case analyzed by Soberman (2004), wherein the effect of advertising is largely competition enhancing. In our context this implies that any attempt to recover the lost demand by increasing ads is likely to impart a strong indirect effect. To avoid intensifying competition, firms advertise less and profits fall. Conversely, firms may benefit

Table 2 Relationship Between DVR Penetration (α) and Equilibrium Ad Reach (φ_n^*) & Profit (Π_n^*) as a Function of Ad Cost (θ) and Share of Independent Zippers (S)

S, θ	Low ($0<\theta\leq\theta_n^*$)	Intermediate ($\theta_n^*<\theta\leq\bar{\theta}_n^*$)	High ($\theta>\bar{\theta}_n^*$)
$S=0$	Decreasing	Decreasing	Decreasing
Low ($0<S<S_n^*$)	Increasing	U-shaped	Decreasing
High ($S_n^*\leq S\leq 1$)	Increasing	U-shaped	U-shaped

[13] Mathematically, if (PI/FI) denotes the demand composition the direct and indirect effects can be computed as

$$\frac{d(PI/FI)}{d\alpha}=\underbrace{\frac{\partial(PI/FI)}{\partial\alpha}}_{\text{Direct Effect}}+\underbrace{\frac{\partial(PI/FI)}{\partial\phi}\frac{d\phi}{d\alpha}}_{\text{Indirect Effect}}.$$

Table 3 Thresholds on Parameters (Propositions 2 and 4)

Model type	α	θ	S
Naïve consumer model (Proposition 2)	$\alpha_n^* = \frac{1}{2}\left(\frac{-(S\beta)^{3/2}\sqrt{t(4\theta+St\beta)}-(S\beta)^2 t+2\theta(1-S\beta)}{\theta(1-\beta)(1+S\beta)}\right)$	$\bar{\theta}_n^* = \frac{S^2 t(1-S(1-\beta))\beta}{(1-S(2-\beta))^2}$; $\theta_n^* = \frac{t(S\beta)^2}{(1-S\beta)^2}$	$S_n^* = \frac{1}{2-\beta}$
Selective consumer model (Proposition 4)	$\alpha_s^* = \frac{18\theta(1-\beta)^3 - t(3(1-\beta)\beta+\varepsilon^2)^2}{18\theta(1-\beta)^3(1+\beta)} - \frac{\sqrt{t}(3(1-\beta)\beta+\varepsilon^2)\sqrt{36\theta t(1-\beta)^2\beta + t(3(1-\beta)\beta+\varepsilon^2)^2}}{18\theta(1-\beta)^3(1+\beta)}$	$\theta_s^* = \frac{t(3(1-\beta)\beta+\varepsilon^2)^2}{9(1-\beta)^4}$	

from an increase in DVR penetration if $\alpha > \alpha_n^*$. Intuitively, at high α, the direct effect of DVR penetration is potent enough to mitigate overall competition between firms. Firms can leverage this competition-reducing effect of DVRs, and increase ad reach recovering any lost demand, which in turn increases profit. Interestingly, the threshold α_n^* strictly declines with the share of independent zippers, S. Firms prefer α_n^* to be as low as possible because the benefits from additional DVRs outweigh the costs when $\alpha > \alpha_n^*$. In other words, firms should prefer high S. Intuitively, when S is high, an increase in DVR penetration implies a strong direct effect on the composition of demand, enhancing the benefits from DVR penetration.

The preceding paragraphs explain why lower ad effectiveness as a result of DVRs may in some cases be preferable to firms. To further investigate this issue, we perform a comparative statics with respect to the viewing rate β for a given α. The parameter β may be rationalized as a direct measure of ad effectiveness associated with DVRs. Interestingly, we find that when a large share of DVR owners is independent zippers, advertising reach and profits decrease with β when the viewing rate is high. The reason is that at high viewing rates, even a marginal increase in β is severely competition enhancing because of a strong increase in the number of fully informed consumers. This forces firms to reduce their advertising levels, which leads to lower profits. In conclusion, this result confirms that in some cases high ad effectiveness may actually hurt firms and some ad zipping is beneficial.

In summary, the potential benefit from DVRs lies in mitigating competition. As in models of informative ads in the existing literature, advertising has dual but opposite effects—it extends overall demand but at the cost of increasing competition. We show that DVRs may mitigate the latter effect, which gives firms greater freedom to increase ad reach and enjoy higher profits. On the other hand, the costs associated with DVRs consist of lower ad effectiveness as a result of ad zipping. The overall effect of DVRs depends on the relative size of these two aforementioned effects. Up to this point we have considered the impact of DVRs when consumers zipped commercials randomly. However, consumers may exhibit selective zipping behavior, which we analyze in the next section.

4. Selective Consumers

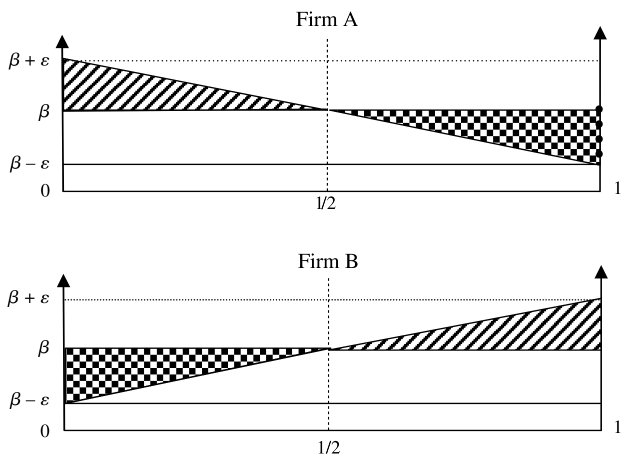
In this section we analyze how selective viewing of ads affects product market competition and how it moderates the effects of DVR penetration. For this purpose, it suffices to consider only one segment of consumers who engage in selective viewing; i.e., we assume $S = 1$ in our general modeling framework.[14]

Consider a DVR owner who begins to zip a commercial for television services such as HDTV programming. After processing some information in the pod, she realizes that the ad content pertains to cable television services. Now, if she has a preference for cable TV services, she may stop zipping the ad and watch the prerecorded commercial in full, obtaining all relevant information about the advertised service, including information about monthly subscription fees. On the other hand, if she prefers satellite television services, she may continue to zip the ad, precluding the advertised service from entering her consideration set.[15] Indeed, recent research findings (Bernoff 2004) show that DVR owners are inclined to watch commercials of products they are interested in, consistent with our example. Such selective ad viewing is possible as long as some product characteristics are visually salient to the consumer and is indicative of her state of heightened attention during the zipping process (Stout and Burda 1989, Wilbur 2008b).

[14] We extended the model to a two-segment formulation whereby one segment of size S selectively zips and a segment of size $(1-S)$ zips ads in blocks. Because the main results qualitatively remain the same for such a specification, we present the simpler model for ease of exposition. A detailed analysis for the two-segment selective consumer model is available from the authors.

[15] Analogously, a DVR owner who starts off viewing an ad may switch modes to zip the ad if the advertised product does not evoke her interests.

Figure 1 Viewing Probabilities in the Selective Consumer Model



Notes. Firm A is located at point 0 and firm B is located at point 1. DVR owners have a prior probability β of viewing an ad they receive. However, after observing some product characteristics, DVR owners may change their viewing mode. Because of this process, firms obtain additional demand from consumers located close to them (shown in the diagonally shaded triangles) but lose demand from consumers located farther away (shown in the checkered triangle).

Technically, in our model a selective DVR owner has a prior probability β of watching an ad but may adjust his viewing mode after he absorbs some product characteristics during the commercial. We assume that as a result of this process, a DVR owner located at $x \in [0, 1]$ watches an ad from firm A with probability $\Pr_A(x) = \beta + \epsilon(1 - 2x)$ and an ad from firm B with probability $\Pr_B(x) = \beta - \epsilon(1 - 2x)$ with $\beta \in (\epsilon, 1 - \epsilon)$, $\epsilon \in [0, \frac{1}{2})$.[16] In this formulation a DVR owner has a greater probability of watching an ad of a preferred product, and the parameter ϵ captures the degree of consumers' selectivity in ad viewing. We illustrate the consumer response to ads in Figure 1. Note that unless the ad selectivity, ϵ, is sufficiently high, there is a positive probability that a DVR owner will zip an ad from a firm close to her preference (or view an ad of a nonpreferred product). For example, a consumer located at point 0 still zips an ad from firm A with probability $(1 - \beta - \epsilon)$. In this sense, our model formulation accounts for "imperfect" ad selection.

Next, we outline the demand and profit functions for firm i based on our general modeling framework developed above (Equations 1 and 2), where $i, j = A, B$ and $i \neq j$. In doing so we find it helpful to distinguish between the demand generated from partially informed consumers, P_i, and fully informed consumers, F_i:

$$P_i = \alpha\left(\phi_i(1-\phi_j)\int_0^{x_i} \Pr_i(x)\,dx + \phi_i\phi_j\int_0^{x_i} \Pr_i(x)(1-\Pr_j(x))\,dx\right) + (1-\alpha)\phi_i(1-\phi_j)x_i, \tag{3}$$

$$F_i = \alpha\phi_i\phi_j\int_0^{y_i} \Pr_i(x)\Pr_j(x)\,dx + (1-\alpha)\phi_i\phi_j y_i, \tag{4}$$

$$\Pi_i = (P_i + F_i)(p_i - c) - \theta\phi_i^2. \tag{5}$$

Substituting $\Pr_A(x)$, $\Pr_B(x)$, $y_i = (p_j - p_i + t)/2t$, and $x_i = 1$ for $i, j = A, B$ and $i \neq j$ in Equation (5), we obtain the profit functions for firms A and B. Maximizing these profit functions with respect to price and advertising reach and solving first-order conditions, we obtain the equilibrium shown in Table 1. Both propositions below pertain to comparative statics around the stated equlibrium. Next, we summarize the effect of ϵ on ad reach and profits.

Proposition 3. *In the unique symmetric equilibrium,*
(i) *Prices do not change with ad selectivity.*
(ii) *Firms' choice of advertising reach and resulting profits increase with ad selectivity. The equilibrium exists and is unique if* $\theta \in [\underline{\theta}_s, \bar{\theta}_s]$, $t \in [\underline{t}_s, \bar{t}_s]$ $\epsilon \in [0, \bar{\epsilon}_s]$, *and* $\beta \geq \underline{\beta}_s$. *The expressions for* $\underline{\theta}_s$, $\bar{\theta}_s$, $\underline{t}_s$, $\bar{t}_s$, $\bar{\epsilon}_s$, *and* $\underline{\beta}_s$ *are given in Table* 1.

Ad selectivity has two opposing impacts on pricing. First, the number of fully informed consumers strictly decreases with ϵ, thereby reducing price competition. This is intuitive because consumers watch an ad from their preferred firm with a higher probability than an ad from their nonpreferred firm. This creates a greater number of consumers who are aware of only one product and not both. Second, with an increase in ad selectivity, ϵ, the mass of fully informed consumers gets more concentrated toward the center of the Hotelling line. These consumers exhibit less intense brand preference and have more elastic demands.[17] Therefore, competing for these fully informed consumers exerts a downward pressure on prices. Overall change in price is contingent on the relative strengths of the two effects that in our specific case cancel out.[18] The effect of selective viewing

[16] In a more general specification, a DVR owner located at $x \in [0, 1]$ watches an ad received from firm A with probability $\Pr_A(x) = \beta + \epsilon(\delta - x(1 + \delta))$ and an ad received from firm B with probability $\Pr_B(x) = \beta - \epsilon(\delta - x(1 + \delta))$, with $\beta \in (\epsilon, 1 - \delta\epsilon)$, $\epsilon \in [0, 1/(1 + \delta))$, and $\delta > 0$. In this formulation, δ measures the difference in the propensity to switch modes between ex ante zippers and ex ante viewers. In our specification we assume no difference; i.e., $\delta = 1$. A priori this assumption seems reasonable, at the same time making our analysis more tractable.

[17] We present a calculation of the price elasticity of demand in the electronic companion.

[18] The insentivity of prices to ad selectivity should be interpreted with caution. In our model we assume that "ex ante" zippers and viewers have the same propensity to switch modes. This assumption makes the two effects we allude to cancel out. If, for example, viewing consumers tended to be more ad selective than zipping consumers, then the first effect would dominate the second leading to softening of price competition. What is important to recognize is the two-part impact of ϵ on prices.

on ad reach is more straightforward to explain. Greater selectivity, ceteris paribus, creates more partially informed consumers dissipating the competition enhancing effect of advertising. In equilibrium, firms increase ad reach leading to greater profits. Next, we examine how selective ad viewing changes the effect of DVR penetration on firm strategies and profits.

Proposition 4. *In the unique symmetric equilibrium, when ad cost is low, $\theta < \theta_s^*$, ad reach and profits increase with the DVR penetration rate α for all $\alpha \in [0, 1]$. When ad cost is high, $\theta \geqq \theta_s^*$, ad reach and profits follow a U-shape with the DVR penetration rate α (decrease if α is low, $\alpha < \alpha_s^*$, and increase if α is high, $\alpha > \alpha_s^*$). Furthermore, α_s^* strictly declines with ϵ. The equilibrium exists and is unique if $\theta \in [\underline{\theta}_s, \bar{\theta}_s]$, $t \in [\underline{t}_s, \bar{t}_s]$ $\epsilon \in [0, \bar{\epsilon}_s]$, and $\beta \geq \underline{\beta}_s$. The expressions for $\underline{\theta}_s$, $\bar{\theta}_s$, $\underline{t}_s$, $\bar{t}_s$, $\bar{\epsilon}_s$, and $\underline{\beta}_s$ are given in Table* 1.

The effect of DVR penetration on advertising reach and profits with selective viewing are qualitatively similar to the results presented in Proposition 2. The marginal benefits of DVR penetration outweigh its marginal costs when DVR ownership is already high or if the cost of advertising is very low. It is interesting, however, to examine the effect of ϵ when ad costs are high, $\theta \geqq \theta_s^*$. In this case, firms find it harder to increase ad reach required to recover demand lost due to ad ineffectiveness. However, we find that ad selectivity curbs the negative indirect effects of DVR penetration and at the same time it enhances the favorable direct effect. This gives firms a greater freedom to increase ad reach and derive higher profits. In other words, the competition reducing benefits from DVR penetration are bolstered by ad selectivity of DVR owners. Mathematically, this is apparent because the threshold level of DVR ownership α_s^*, beyond which DVR penetration allows firms to increase advertising and profits, declines with ϵ. This result underscores the importance of encouraging "selective ad viewing" from the advertisers' standpoint. We discuss policy implications of our research, limitations, and directions for further research in the next section.

5. Conclusion and Summary

The increasing penetration of ad avoidance technologies such as DVRs is inevitable and growing. Conventional wisdom suggests that advertising becomes less effective when consumers have the ability to zip ads, leading to more uninformed consumers and lower demand and profits. In this paper, we observe this demand contraction effect of DVRs. However, we also uncover a surprising positive effect resulting from increased zipping of ads. DVRs may help generate more consumers who view ads from one firm and not both. Such partial awareness mitigates competition between firms. The overall impact of DVR penetration hinges on the trade-off between loss in advertising effectiveness and the aforementioned reduction in competition. Our analysis suggests that DVR penetration increases profits when the share of DVR owners in the population is high or when the cost of sending ads is low. Furthermore, our results also show that the benefits of DVR penetration are higher when there are more DVR owners who zip ads independently (as opposed to zippping blocks of ads). The latter finding has important managerial implications because it suggests that marketers should try to increase the possibility of partial exposure as facilitated by independent zipping. Thus, a straightforward policy implication may be that marketers should strive for category exclusivity inside a commercial break or channel in their contracts with broadcasters (Dukes and Gal-Or 2003). Such category exclusivity may enhance independent zipping rather than block zipping for a given category.

We also study a model where DVR owners are selective and change their ad viewing mode based on some product characteristics observed during the commercial. Our finding suggests that such selectivity improves the positive effects of DVR penetration. Therefore, firms may have an incentive to broadcast commercials that allow or encourage such selective zipping. Intuitively, firms should make relevant product characteristics visually salient during commercials so that even a zipping consumer can absorb these characteristics. For example, in markets where brand name is a relevant characteristic firms may make the ad creative "brand dominant" by making the brand name or logo central to the commercial for an extended period of time (Brasel and Gips 2008).

As mentioned earlier, we assume that the unit cost of advertising is independent of ad viewership and thus DVR penetration. This assumption is consistent with industry practice where firms predominately rely on Nielsen ratings of program viewership when determining advertising rates. However, more recently TiVo began to measure viewership of commercials and offers these data through its StopWatch ratings service (Crupi 2007). Potentially, advertisers could refuse to pay for zipped exposures to ads by TiVo users on the basis of this data. Although such practice is still uncommon, our model can readily be adjusted to consider the possibility that advertisers do not pay for a percentage of zipped exposures to ads. Whereas the unit cost of advertising decreases with DVR penetration in this scenario, our analysis of this more general model confirms the core finding of this paper that both equilibrium advertising reach and profits follow a U-shape with DVR penetration, as long as the share of TiVo users is below a threshold.[19] Given the relatively small share of TiVo users in the market it appears that the more parsimonious model presented in the paper is appropriate.[20]

Although our results are consistent with anecdotal evidence, there are several limitations and opportunities for future research. As mentioned earlier, we conduct a partial equilibrium analysis. A general equilibrium analysis where DVR penetration or viewing rate depends on the aggregate number of ads may be an area of future research. We assume that the market for partially informed consumers is completely served in equilibrium, which corresponds to the case of low differentiation between products (Soberman 2004). With higher differentiation the partially informed market is not covered and increasing ad reach may not be as competition enhancing. Thus, as more consumers acquire DVRs, firms can more easily increase ad reach to compensate for demand contraction caused by DVRs. Therefore, we conjecture that ad reach and profits increase at lower levels of DVR penetration when differentiation between products is high. However, a complete analysis for this case is quite cumbersome and left for future research. In our model advertising has no effect on the consumer's base value of the product. Although assuming such an effect would increase the incentive for firms to advertise, we conjecture that our qualitative insights regarding the effect of DVR penetration remain similar. However, it would be useful to verify this conjecture with the help of a model. Our paper implicitly assumes that firms reveal all relevant information about the product in their ads. If a firm did not reveal all relevant product information, consumers would have to search for the missing product attributes before purchase or make purchase decisions based on incomplete information (see Eaton and Grossman 1986). Issues related to strategic information revelation in the presence of DVRs may be a fruitful area for future research. Our model assumes that TV is the sole method for disseminating ads. A possible alternative strategy for firms, not considered by our model, is to shift advertising dollars to other channels to improve ad effectiveness when DVR penetration increases—for example, to advertise on the Internet. Despite better efficiency and ability to target through Internet ads, firms face other challenges when advertising on the Internet, such as click fraud (Wilbur and Zhu 2009). Furthermore, we do not consider the active role of media firms in this paper and restrict ourself to analyzing the strategies of advertisers. However, in reality advertising rates are the outcome of a negotiation process between advertisers and media firms (Dukes and Gal-Or 2003). A fruitful area for future research is to analyze the impact of DVR penetration on the media market as a whole, considering the role of profit maximizing media firms. Last, our analysis does not account for a base-level awareness of products and assumes consumers only get information through informative ads. Adjusting our model to account for a base-level awareness (Gal-Or and Gal-Or 2005, Dukes and Gal-Or 2003) is another potential area for future work.

[19] The adjusted ad cost function for this more general model is $C(\phi) = [1 - \alpha\delta(1-\beta)]\theta\phi^2$, where δ represents the share of consumers who own a TiVo or equivalently the percentage of zipped exposures to ads that advertisers do not pay for. This analysis is available from the authors upon request.

[20] TiVo currently has 3.3 million subscribers, compared to a total of 45 million DVR owners (Winslow 2009).

6. Electronic Companion

An electronic companion to this paper is available as part of the online version that can be found at http://mktsci.pubs.informs.org/.

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