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Advertising versus pay-per-view in electronic media

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Abstract

Media providers frequently have to trade-off revenues from advertisers and subscribers. However, with contemporary electronic media, such as Internet websites, there exists the possibility of giving viewers of the same program the option to pay a higher price and view fewer advertisements, or pay a lower price but view more advertisements. With heterogeneous consumers, there will be some takers for both options, thereby allowing the media provider to derive the advantages of both subscription and advertising revenues. In this paper, we examine the number of options, the subscription price and the amount of advertising that should be offered to consumers. We find conditions where a pure advertiser-supported strategy or a pure pay-per-view strategy can be optimal. However, except under specified conditions, the optimal strategy is to charge a subscription price and have advertisements, but offer options to consumers.

Keywords: Advertising; Price discrimination; Media

1. Introduction

Advertising and media share a symbiotic relationship. Whereas advertising revenue sponsors media content, it is the content that makes the consumption of advertising palatable to consumers (Owen & Wildman, 1992). Television broadcasting, for example, has traditionally been wholly advertiser sponsored. The situation was encouraged by the technical difficulty of collecting revenues from subscribers while simultaneously denying access to nonpaying viewers (Kratenmaker & Powe, 1994; Owen & Wildman, 1992). However, media such as the Internet and cable-provided services have largely overcome this difficulty, resulting in a greater emphasis on subscriber generated revenues (Artzt, 1994).

The media provider has to balance the revenue from advertising and subscription. For any program, higher subscription prices result in fewer consumers and, consequently, in lower advertising revenue. On the other hand, the amount of revenue that can be raised from advertising is also limited since a large number of advertisements will turn off consumers. However, with contemporary electronic media, media providers can inexpensively design and offer several price-advertising choices to consumers, and the managerial decision

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is not restricted to setting a single price and advertising level. Consider the following examples:

> "The slack ad market and overall economic slump has forced many dot-coms and New Economy publications out of business... Some Internet magazines have tried to dodge a bullet by adopting subscription models or becoming increasingly flexible with their ad formats... Others have turned to paid ad-free services. In April, Salon launched a subscription service called Salon Premium, which lets customers choose an ad-free format. After 11 weeks the company said it had amassed more than 10,000 subscribers". (Olsen, 2001a)

> "Slashdot.org, the "news for nerds" web site popular among software developers and Linux fans, said this week that it plans to use larger ads and offer a subscription service. When Slashdot increases ad sizes, it plans to introduce a subscription service for people who want to pay for an ad-free version...The cost of the service has yet to be determined". (Mariano, 2001)

In these examples, advertising is used as a source of revenue and for segmenting the market into groups that differ in their utility for advertising-free programs. Segmenting the market offers two potential advantages. First, additional revenues are obtained by charging different prices to different customer segments. Second, advertisers may be willing to pay different advertising rates for advertising to different segments. Thus, the media provider can price discriminate on both the consumer side and the advertiser side.

By the term 'media provider', we refer to a variety of firms. Consider the following examples of electronic media and the ways in which they have applied the advertising-subscriber trade-off:

- Telephone: Mitchell (1997) reports the use of advertising sponsored telephone calls in Sweden. The subscribers of this service agree to have their long distance calls interrupted by commercials in exchange for making the call for free. In the US, a similar Seattle-based company, FreeFone, subsidizes or pays subscribers for listening to ads (Kalakota & Whinston, 1996, p. 479).
- Voicemail and e-mail services: In these, the customer is provided with a free service subject to being targeted or interrupted by ads while using the service.
- Internet: In 2001, online advertising spending was projected to be about \$6 billion (Olsen, 2001b). In Internet marketing, there are pay-as-you-go pricing schemes where customers are subsidized if they click on an advertisers' icon or fill out a questionnaire. For example, Cybergold and Netincentives offered merchandise coupons and cash to surfers who agreed to look at advertisements. Cybergold dollars could then be redeemed at participating merchant sites.[1] Two Cybergold advertisements are shown in Fig. 1.
- Video-on-Demand: Video-on-Demand is an interactive service that allows subscribers to order movies on their television but retain full video functionality such as rewind and fast-forward. A cable operator, Stargazer, offers discounts on video-on-demand if customers view advertisements or fill out personal information questionnaires at the beginning of the movie.

In all of these examples, there is a trade-off between the subscription price and the amount of advertising. The Internet example is particularly explicit. Taking advantage of the Internet as an interactive media, pay-as-you-go schemes allow viewers to select their own exposure to ads. By viewing from a large selection of ads, viewers can precisely determine their discount and, therefore, the price they pay.

Fig. 2 illustrates the two revenue sources for a media provider, advertising and subscribers, and shows the interrelationships that are common to all the preceding examples.

There are three relevant groups of decision makers. They are the consumers, the advertisers, and the media provider. Consumers maximize their utility by selecting from the options presented to them by the media provider. Advertisers decide whether to advertise or not advertise based on the advertising rates charged by the media provider. The media provider

[1] (Cybergold closed operations recently; other websites that pay for viewing ads include http://www.adsenger.com, http://www.spedia.net, http://www.clickdough.com, http://www.paybar.com, and http://www.adbroadcast.com.)

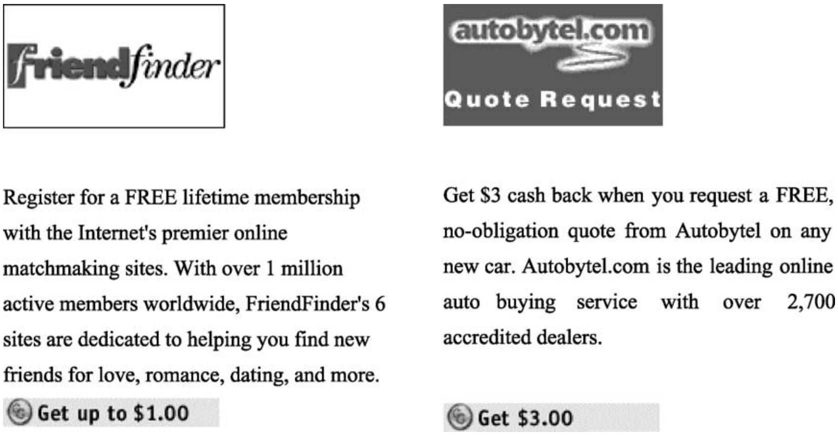

Fig. 1. Cybergold ads.

needs to consider the decisions of the others when making its own decisions. For the media provider, there are three types of decisions to make:

- Revenue issues: To what extent should the program depend on advertiser revenue versus subscriber revenue? When, if ever, is it optimal for a media provider to implement a pure pay-per-view strategy, or a pure advertiser-supported strategy?
- Subscriber market issues: How should the market be segmented and what choices of price-advertising levels should the media provider provide consumers?
- Advertiser market issues: At what rates should access to the segments be sold to advertisers?

The purpose of this paper is to develop an analytical model to establish normative guidelines for media managers facing these issues. The media provider's problem has not been examined in detail in the marketing literature. Historically, issues of advertiser and subscriber supported services have been studied by media economists in the context of the radio and television broadcast industries (Anderson & Coate, 2000; Beebe, 1977; Samuelson, 1964; Steiner, 1952). The main results from this literature are that a competitive market may not produce either sufficient diversity or a welfare maximizing supply of programming. This literature does not examine the role of advertising as a price discrimination mechanism.

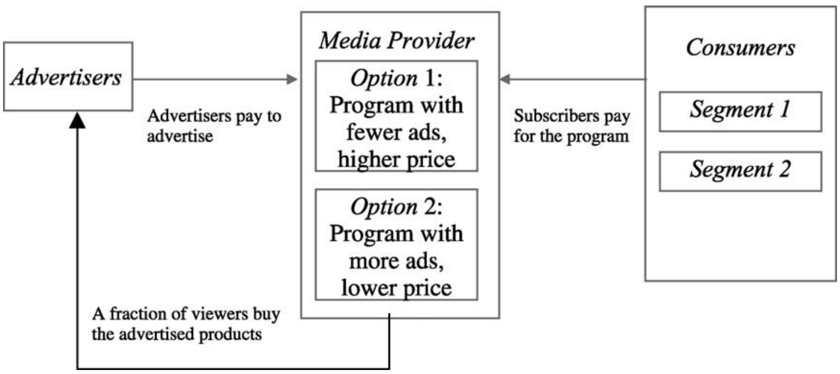

Fig. 2. Revenue sources for media provider.

The results of our study are particularly applicable to electronic media. However, one could argue that the idea of subsidizing media content is not really new. Traditional media also obtain revenues from advertisers and subscribers. Magazine publishers often sell subscriptions at very cheap rates. The price paid for many magazines and newspapers does not even cover their costs of printing and distribution. Obviously, these magazines make their money from advertising. However, electronic technology gives media managers a simple and inexpensive way to provide customers with a large number of price and advertising options, instantaneously if required, in comparison to traditional media such as newspapers and magazines. This feature is essential for incorporating the price discrimination strategies to be discussed shortly. In the extreme case, it is possible to mass-customize the amount of advertisements and price paid for the service on interactive media. Lack of these opportunities in traditional media perhaps explains why the problem has not been studied earlier. The present study is particularly relevant given the rapid growth of electronic media and the need for work in this area.

The rest of the paper is organized as follows: The next section lays out the conceptual underpinnings of the model. Sections 3 and 4 contain the model description and the analysis, respectively. Section 5 is a discussion of the results and Section 6 concludes.

2. Conceptual underpinnings

In this section, we obtain the demand functions of consumers and advertisers. In the next section, we will use these functions as input in the maximization program of the media provider.

2.1. Consumer model

For consumers, ads are an unwelcome intrusion. Consumer efforts at avoiding exposure to ads include zipping of commercials for programs that are recorded on video tapes, and zapping, i.e. changing channels when commercials are aired, or physically moving away (Stout & Burda, 1989). For a review of this literature, see Bellamy and Walker (1996). Zipping and zapping are clear indications of customer dissatisfaction with advertisements. Estimates of ads zipped on video playback range from 20% to 60% of all ads (Bellamy & Walker, 1996). It is therefore assumed that customers dislike advertisements to varying degrees.[2]

An explanation for avoidance of commercials is based on the viewers' opportunity cost of time (Krattenmaker & Powe, 1994; Narasimhan, 1984). Viewers are dissatisfied because they could have been doing something more worthwhile than watching ads. It is commonly assumed that income is a good proxy for opportunity cost. As Krattenmaker and Powe (1994, p. 41) note, a person who earns \$150 an hour would probably be willing to rent a 2-h video of a movie rather than watch a 2 1/2-h free presentation of the movie with commercials. A similar explanation is given by Narasimhan (1984) to explain the use of coupons as price discrimination devices. It is more likely that higher income customers have less advantage from cutting and managing coupons for their purchases, and therefore, low-income customers use coupons, whereas high-income customers pay the full price.

We consider two customer types,[3] high and low. Based on the arguments above, they correspond to high- and low-income customers, respectively. Although a stylized representation of heterogeneity, the two-segment assumption yields insights generalizable to many segments. (Furthermore, by making one segment of size zero, our results apply to a homogeneous audience. Homogeneity can occur in practice if the program is strongly targeted to a specific group of viewers). High-segment customers are those who are willing to pay more for an increase in program quality in comparison to low segment customers, where quality is defined as the intrinsic value of the programming content less the amount of advertising. Thus, quality is

$$q = T - a \tag{1}$$

where $a \geq 0$ is the amount of advertising and $T \geq 0$ is the useful programming content. We operationalize a

[2] We do not examine media such as TV shopping channels, classifieds and yellow pages where the advertising is the information and viewers willingly subject themselves to it. It is evident that in these cases, more advertising is always better. A similar logic extends to cases where viewers appreciate advertising up to a threshold and dislike it thereafter. Advertising should always be provided up to the threshold and the decision on incremental advertisements beyond that is then the subject of this study.

[3] The words 'type' and 'segment' are used interchangeably.

as the total number of advertisements. Each advertisement takes a unit amount of time or space as determined by the context. The content T is also converted into the same units. For example, if a cable television channel is showing a 90-min movie with 30 min of advertisements and each advertisement takes 30 s, it is straight forward to calculate that $a=60$, $T=180$ and $q=120$.

Consumers' utility functions are given by

$$U_i(q,p_{si}) = V_i(q) - p_{si}, \qquad i \in \mathrm{L,H}. \tag{2}$$

The i subscript denotes the two segments, low (L) and high (H). The function $V_i(q)$ is the valuation, or maximum willingness-to-pay, for program content of quality q. The subscription price customers are required to pay is denoted p_{si}. Quasi-linear utility functions are commonly seen in the literature due to desirable properties such as the absence of income effects (Fudenberg & Tirole, 1991). A linear specification for $V_i(q)$ is selected for analysis:

$$U_i(T-a,p_{si}) = \theta_i(T-a) - p_{si}, \qquad i=\mathrm{L,H} \tag{2a}$$

High-type customers value an improvement in programming quality more, therefore, $\theta_H > \theta_L$. The preference for advertising is illustrated graphically in Fig. 3.

2.2. Advertiser model

The advertisers' willingness to advertise depends on their value and cost from advertising to customers. Customer segments are of differential value to advertisers and, ceteris paribus, high-income customers tend to be preferred (Kalita & Ducoffe, 1995; Narasimhan, 1984). This is because high-income customers are more likely to have disposable income to spend on the advertised products.

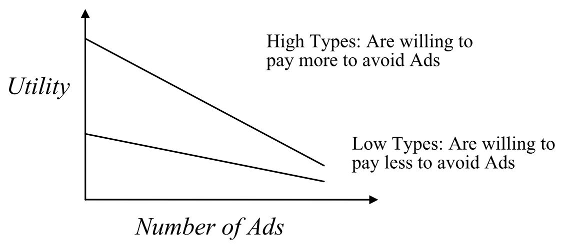

Fig. 3. Utility (Preference) for advertising for customer segments.

To obtain the advertising demand function, let us suppose there are M firms having products that they are potentially interested in advertising. We assume that the profit margin of each product is indexed by a parameter s drawn from a uniform distribution on $[0,\sigma]$. Thus, the density is given by $f(s)=1/\sigma$ and the distribution is $F(s) = \int_0^s f(x)\mathrm{d}x = s/\sigma$. Let N_H and N_L denote the size of high- and low-income viewers, respectively. For any product, it is assumed that high types are more likely to purchase the advertised product than low types. Specifically, for each product, a high-income viewer will purchase the product with probability w, whereas a low-income viewer will have a probability λw, where $\lambda < 1$ (Anderson & Coate, 2000). (However, note that although it is unlikely to be the case in practice, all the analysis will go through unchanged if $\lambda \geq 1$.) Given that the probability of purchase does not change with the number of advertisements, the number of advertisers is equal to the number of advertisements. This completes the description of the advertising market.[4]

A firm selling a product at profit margin s will be willing to pay sw to contact a high-type viewer and λsw to contact a low-type viewer. A firm that does not advertise gets a payoff of zero. The advertiser who is just indifferent between advertising and not advertising is denoted s^*, and can be identified by equating the expected profit from advertising against the cost of advertising, i.e. $N_H ws^* + N_L \lambda ws^* = (N_H + N_L)p_a$ where the advertising rate per person is denoted p_a. All firms with higher margins than the indifferent advertiser will advertise. The number of such firms is $M[1-F(s^*)]$. Inserting the value of s^*, we obtain the demand function:

$$a(p_a) = M\left[1 - \frac{p_a}{\sigma w\left[\frac{N_H+\lambda N_L}{N_H+N_L}\right]}\right] \tag{3}$$

Other than the indifferent advertiser who obtains zero surplus, the remaining advertisers obtain a pos-

[4] It is a straightforward extension to introduce additional parameters to capture additional factors that influence purchase probability w such as advertising effectiveness, zipping and zapping. Similarly, the quantity of purchases can be included in s. Since these factors are not our primary focus, we essentially assume that they are constant.

itive surplus from advertising. From Eq. (3), the amount of advertising decreases if the advertising rate per person, p_a, increases as we would expect. The advertising rate per person is:

$$p_a = \sigma w\left(1 - \frac{a}{M}\right)\left(\frac{N_H + \lambda N_L}{N_H + N_L}\right) \tag{4}$$

If segments view separate programs, then the advertising rates for access to the segments are different. The advertising rates per person for high- and low-income consumers are, respectively:

$$p_{aH} = \sigma w\left(1 - \frac{a}{M}\right) \tag{4a}$$

$$p_{aL} = \sigma w\lambda\left(1 - \frac{a}{M}\right) \tag{4b}$$

From $\lambda < 1$, it can be seen that $p_{aH} > p_{aL}$, i.e. advertisers pay a higher rate per person to access high-income customers. Furthermore, the advertising rate increases with the number of potential advertisers M. Having developed the consumers' and advertisers' models in this section, we can now turn our attention to modeling the media provider's problem.

3. Model

Observe that each consumer yields a profit equal to the sum of the subscription price he or she pays and the amount that advertisers are willing to pay for him or her. The total profit is obtained by adding the profits across all consumers. Costs in electronic media are mainly fixed costs such as the cost for buying or developing programming content. The variable cost of serving each additional consumer is negligible since duplication and transmission of content is both high quality and costless in electronic media.

We consider four strategies that the media provider might pursue. These are labeled limited access, free access, pooling and separating. The pooling and separating terminology is borrowed from the signaling literature but is also appropriate here. A pooling strategy is one where all customers accept the available option (p_s, a) where p_s is the subscription price and a is the amount of advertising. In a separating strategy, customers in the two segments choose different options (p_{sH}, a_H) and (p_{sL}, a_L). In limited access, the low-income segment does not participate because the media provider sets a very high subscription price, while in free access, the high types prefer not to participate due to the large amount of advertising contained in the program, even though the program is free or pays the viewers (hence the name 'free access'). The possible strategies and profit functions are shown in Table 1.

In a separating strategy, the media provider cannot identify and charge segments their maximum willingness-to-pay and achieve a 'first best' price discrimination. However, by designing an appropriate set of options, it can make customers self-select their preferred subscription price and advertising level (Moorthy, 1984). This self-selection feature is known as incentive compatibility (Fudenberg & Tirole, 1991). There is an extensive theoretical literature in marketing and economics on price discrimination (e.g. Dolan, 1987; Maskin & Riley, 1984; Moorthy, 1984; Narasimhan, 1984; Oi, 1971). A related literature focuses on methods for designing a product line (Dobson & Kalish, 1988; Moorthy, 1984; Reibstein & Gatignon, 1984) sometimes using conjoint methodology. The purpose of conjoint is to provide individual or segment level utilities, i.e. the value of the parameters in Eq. (2a). Thereafter, the design of the best list of options for the consumer to select from must be obtained using analytical results, as provided in this paper.

To analyze the problem requires finding an equilibrium, i.e. a situation in which consumers, advertisers and the media provider are all making the best decision given what the other players are doing. The profit functions listed in Table 1 have to be maximized by the media provider with respect to the decision variables and constrained by the reactions of the consumers and the advertisers.

Table 1
Alternative strategies

	Sell to one segment	Sell to both segments
Offer one option	Limited access: $\Pi_1 = N_H(p_s + p_{aH}a)$ Free access: $\Pi_2 = N_L(p_s + p_{aL}a)$	Pooling $\Pi_3 = (N_H + N_L)(p_s + p_a a)$
Offer two options		Separating $\Pi_4 = N_H(p_{sH} + p_{aH}a_H) + N_L(p_{sL} + p_{aL}a_L)$

4. Analysis

In this section, the optimal characterization of the four strategies discussed in the preceding section are obtained.

4.1. Limited access and free access

Limited access means that only the high-segment customers are provided access to the service through charging a high subscription price. A decision on the amount of advertising implicitly determines the advertising rate according to Eq. (4a). Thus, the profit function is:

$$\max_{p_s,a} \ \Pi_1 = N_H\left(p_s + \sigma w\left(1-\frac{a}{M}\right)a\right) \tag{5}$$

$$\text{s.t.} \quad IR_H: \ \theta_H(T-a) - p_s \geq 0 \tag{5a}$$

$$\text{and } M \geq a \geq 0 \tag{5b}$$

The constraint IR_H ensures that the high types participate. For the low segment to not participate and the high types to participate, i.e. $\theta_H(T-a) - p_s \geq 0 > \theta_L(T-a) - p_s$, it must be the case that $T>a$ since otherwise $\theta_L(T-a) \geq \theta_H(T-a)$. This imposes an upper bound on the amount of advertising that can be shown under limited access. Nonnegativity constraints on prices are not required since there is no limitation to prevent the media provider from paying subscribers and advertisers if that happens to be optimal. However, it can intuitively be seen that paying advertisers to advertise cannot be optimal because this decreases both advertising revenue and subscription revenue.

Since only the high types are served, they should be charged to the maximum extent they are willing to pay. Hence, we get

$$p_s = \theta_H(T-a). \tag{6}$$

Substituting Eq. (6) into (5) and maximizing the resulting profit function, we obtain the following proposition.

Proposition 1: *In the optimal 'Limited Access' strategy, the media provider offers subscription price and advertising level (p_s, a). The high-segment customers select this option and the low segment customers select the outside option. Where:*

(i) If $T > M(\sigma w - \theta_H)/2\sigma w$ then $p_s = \theta_H(T-a)$, where if $\sigma w \leq \theta_H$ then $a = 0$ and $\Pi_1 = N_H \theta_H T$, else if $\sigma w > \theta_H$, $a = M(\sigma w - \theta_H)/2\sigma w$ and $\Pi_1 = N_H\left(\theta_H T + \frac{M(\sigma w - \sigma_H)^2}{4\sigma w}\right)$.

(ii) If $T \leq M(\sigma w - \theta_H)/2\sigma w$ then $a \to T$ and $p_s \to 0$. The profit is $\Pi_1 = N_H \sigma w T(1 - T/M)$.

(All proofs in Appendix A).

Part (i) of the proposition, for programs of high intrinsic quality T, says that revenue should always be generated from subscription but that revenue from advertising may or may not be appropriate depending on the segment's dislike for advertising. If the dislike for advertising is sufficiently high, i.e. if θ_H is larger than σw, the media provider should rely on subscription revenue alone.

Part (ii) of the proposition considers the case where the optimal solution $a = M(\sigma w - \theta_H)/2\sigma w$ cannot be reached due to the necessity of $T>a$ to keep out the low types. Ideally, the media provider would like to increase advertising and then have a zero or negative subscription price. However, in this case, it is not possible to exclude the low types based on self-selection since they have less disutility for advertisements than high types and will be overcompensated by being paid to view the program. If external criteria such as demographics can be used to screen the types then self-selection is not required and one can offer special invitations to the high types only while blocking the participation of low types. As an example of this scenario, consider Free-PC. In 1999, a company, Free-PC, offered to give away PCs to selected Internet surfers who agreed to use the company's Internet service, share demographic information and agree to view targeted advertisements on their desktops.

When only the low-income segment participates, we have free access, a complement to the previous strategy when $T < a$. In this case, the objective is:

$$\max_{p_s,a} \ \Pi_1 = N_L\left(p_s + \sigma w \lambda\left(1-\frac{a}{M}\right)a\right) \tag{7}$$

$$\text{s.t.} \ IR_L: \ \theta_L(T-a) - p_s \geq 0 \tag{7a}$$

$$\text{and } M \geq a \geq 0 \tag{7b}$$

The results are given by Proposition 2:

Proposition 2: *In the optimal 'Free Access' strategy, the media provider offers subscription price and advertising level (p_s, a). The low-income segment selects this option and the high-segment customers select the outside option. Where:*

(i) If $T < M(\sigma w\lambda - \theta_L)/2\sigma w\lambda$ then $p_s = \theta_L(T - a)$ where $a = M(\sigma w\lambda - \theta_L)/2\sigma w\lambda$ and $\Pi_2 = N_L\left(\theta_L T + \frac{M(\sigma w\lambda - \theta_L)^2}{4\sigma w\lambda}\right)$.
(ii) If $T \geq M(\sigma w\lambda - \theta_L)/2\sigma w\lambda$ then $a \to T$ and $p_s \to 0$. The profit is $\Pi_2 = N_L \sigma w\lambda T(1 - T/M)$.

Several examples of this strategy that requires viewers to see a large number of advertisements in return for payment can be found on the Internet. They include payment for receiving and reading emails by advertisers (e.g. http://www.yoyomail.com, http://www.mintmail.com and http://www.Htmail.com), listening to radio ads (e.g. http://www.cashradio.com), and being paid to surf different websites (e.g. http://www.epipo.com, http://www.clickdough.com).

4.2. Pooling

In a pooling strategy, a single version of the program is once again offered but this time, it is targeted for consumption by both high and low segments. Using Eq. (4), the objective is:

$$\underset{p_s,a}{\text{Max}}\ \Pi_3 = (N_H + N_L)\left(p_s + \sigma w\left(1 - \frac{a}{M}\right)xa\right)$$

$$\text{where } x \equiv \left(\frac{N_H + \lambda N_L}{N_H + N_L}\right) \tag{8}$$

$$\text{s.t. } \mathrm{IR_H}:\ \theta_H(T - a) - p_s \geq 0 \tag{8a}$$

$$\mathrm{IR_L}:\ \theta_L(T - a) - p_s \geq 0 \tag{8b}$$

$$\text{and } M \geq a \geq 0 \tag{8c}$$

Observe that if $T > a$ and if the low types get more utility from participating, the high type will certainly participate as well. When $T < a$, as long as the high types participate, the low types will also participate. In setting the subscription price, the media provider will select the highest price at which both segments participate. Thus,

$$p_s = \begin{cases} \theta_L(T - a) & a < T \\ 0 & a = T \\ \theta_H(T - a) & a > T \end{cases} \tag{9}$$

The result that the participation constraint of either type may bind under the appropriate circumstances is new, since invariably in the mechanism design literature, the high types participate if the low types do. Consider what this result implies for the 'high' and 'low' terminology we use, since the high-type viewer does not have higher value for the program when $T < a$ since in this case $\theta_H(T - a) < \theta_L(T - a)$. However, the high types are willing to pay more for an improvement in program quality than are low types. This is known as the 'single-crossing' property and it is this property that defines high-type customers (Fudenberg & Tirole, 1991, p. 259).[5] This is consistent with our behavioral interpretation of high types having greater opportunity cost of time because reducing advertisements saves them higher costs.

Inserting Eq. (9) into (8) and solving, the results can be summarized by the following proposition.

Proposition 3: *An optimal pooling strategy exists where the media provider selects subscription price and advertising level (p_s, a) and both the high and low segment customers select this option. Where,*

(i) if $T > M(\sigma wx - \theta_L)/2\sigma wx$, then $p_s = \theta_L(T - a)$ where (a) if $\sigma wx > \theta_L$, then $a = M(\sigma wx - \theta_L)/2\sigma wx$ and $\Pi_3 = (N_H + N_L)[\theta_L T + M(\sigma wx - \theta_L)^2/4\sigma wx]$, and (b) if $\sigma wx \leq \theta_L$ then $a = 0$ and the profit to the media provider is $\Pi_2 = (N_H + N_L)\theta_L T$.
(ii) if $T < M(\sigma wx - \theta_H)/2\sigma wx$, then $p_s = \theta_H(T - a)$, where $a = M(\sigma wx - \theta_H)/2\sigma wx$. The profit to the media provider is $(N_H + N_L)[\theta_H T + M(\sigma wx - \theta_H)^2/4\sigma wx]$.

[5] Mathematically, $\theta_H > \theta_L \Rightarrow \left|\frac{\partial U_H/\partial q}{\partial U_H/\partial p_s}\right| > \left|\frac{\partial U_L/\partial q}{\partial U_L/\partial p_s}\right|$ where $\frac{\partial U_i/\partial q}{\partial U_i/\partial p_s}$, $i \in L, H$ is the marginal rate of substitution between quality and subscription price (or the slope of the customer's indifference curve in (q, p_s) space). Hence, a high type customer must be compensated more than a low segment customer for a given decrease in program quality.

(iii) else $p_s = 0$ and $a = T$. The profit to the media provider is $(N_H + N_L)T\sigma wx(1 - T/M)$.

Part (i) of the proposition describes the circumstances when a subscription price should be charged. There may or may not be advertising. The condition for no advertising is $\sigma wx \leq \theta_L$. For a value of x close to 1, e.g. if the advertisements are for necessities that people of all incomes are equally likely to purchase, it is less likely that we will observe a purely subscription based equilibrium. However, if x is close to 0, advertisers do not advertise and a pure subscriber supported strategy will be seen.

Fig. 4 illustrates the proposition graphically. Observe that subscription price can become negative as given by Proposition 3(ii). This is more likely if program quality is poor, advertisers greatly value customers, and there are a large number of firms ready to advertise.

Proposition 3(iii) describes the situation where the media provider should obtain all its revenue from advertising, there is no payment to the viewers, and neither segment is left with positive surplus. The profit here dominates that in Propositions 1(ii) and 2(ii). Consequently, those two cases can be safely ignored.

The best examples of the pooling strategy with pure advertiser support are broadcast television and radio. If pooling can be seen as the archetypical strategy of the traditional media, the next strategy represents the possibilities of the new electronic media.

4.3. Separating

In a separating strategy, two options (p_{sH}, a_H) and (p_{sL}, a_L) are offered to and accepted by the high types and the low types, respectively. To implement this strategy, the firm has to ensure that each customer type selects the option intended for its type. Knowing that cannibalization of the options can occur, constraints are needed to ensure that each type selects the option meant for it. These are known as incentive compatibility (IC) constraints. Using Eqs. (4a) and (4b), the objective is

$$\text{Max } \Pi_4 = N_H\left(p_{sH} + \sigma w\left(1 - \frac{a_H}{M}\right)a_H\right) + N_L\left(p_{sL} + \sigma w\lambda\left(1 - \frac{a_L}{M}\right)a_L\right) \qquad (10)$$

w.r.t. (p_{sH}, a_H) and (p_{sL}, a_L), subject to constraints $M \geq a \geq 0$ and:

$$\mathrm{IC_L}: \ \theta_L(T - a_H) - p_{sH} \leq \theta_L(T - a_L) - p_{sL} \qquad (10a)$$

$$\mathrm{IC_H}: \ \theta_H(T - a_H) - p_{sH} \geq \theta_H(T - a_L) - p_{sL} \qquad (10b)$$

$$\mathrm{IR_L}: \ \theta_L(T - a_L) - p_{sL} \geq 0 \qquad (10c)$$

$$\mathrm{IR_H}: \ \theta_H(T - a_H) - p_{sH} \geq 0 \qquad (10d)$$

Constraints (10a–d) ensure incentive compatibility for the low and high-income segments, and

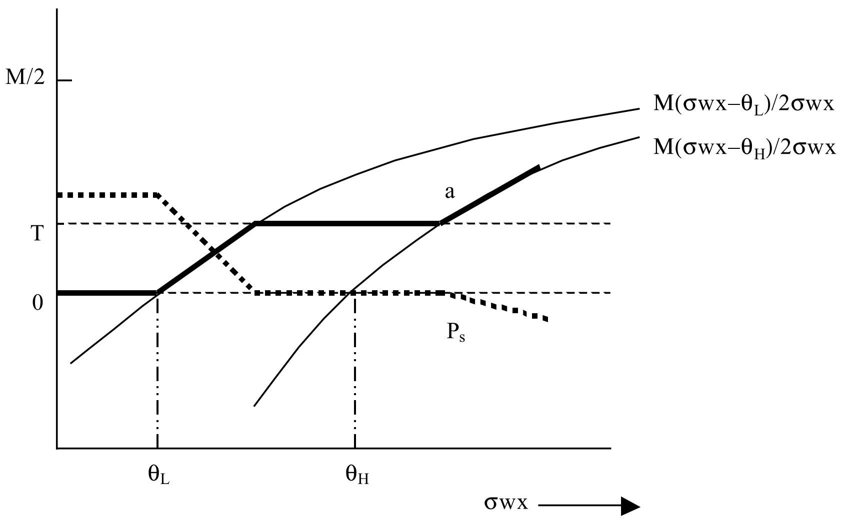

Fig. 4. Subscription price and advertising in a pooling strategy.

participation of the low and high-income segments, respectively. The full solution is given in the following proposition:

Proposition 4: *If* $\frac{N_H(\theta_H-\theta_L)}{N_L}+\sigma w\lambda-\theta_L>0$ *and* $\theta_H>\theta_L/\lambda$ *an optimal separating strategy exists where the media provider offers options* (p_{sH}, a_H) *and* (p_{sL}, a_L)*; the high-income segment selects* (p_{sH}, a_H) *and the low-income segment selects* (p_{sL}, a_L)*. Where,*

(i) *if* $T>\frac{M}{2\sigma w\lambda}\left(\frac{N_H(\theta_H-\theta_L)}{N_L}+\sigma w\lambda-\theta_L\right)$, *then* $p_{sL}=\theta_L(T-a_L)$, $p_{sH}=\theta_H(a_L-a_H)+\theta_L(T-a_L)$, $a_L=\left[\frac{N_H(\theta_H-\theta_L)}{N_L}+\sigma w\lambda-\theta_L\right]\frac{M}{2\sigma w\lambda}$, *and* $a_H=M(\sigma w-\theta_H)/2\sigma w$ *if* $\sigma w>\theta_H$ *else 0.*

(ii) if $\frac{M}{2\sigma w\lambda}\left(\frac{N_H(\theta_H-\theta_L)}{N_L}+\sigma w\lambda-\theta_L\right)\geq T>\frac{M(\sigma w\lambda-\theta_L)}{2\sigma w\lambda}$, *then* $p_{sL}=0$, $p_{sH}=\theta_H(T-a_H)$, $a_L=T$ *and* $a_H=M(\sigma w-\theta_H)/2\sigma w$ *if* $\sigma w>\theta_H$ *else 0.*

(iii) *if* $\frac{M(\sigma w\lambda-\theta_L)}{2\sigma w\lambda}\geq T\geq\frac{M(\sigma w-\theta_H)}{2\sigma w}$, *then* $p_{sL}=\theta_L(T-a_L)$, $p_{sH}=\theta_H(T-a_H)$, *and* $a_H=M(\sigma w-\theta_H)/2\sigma w$ *if* $\sigma w>\theta_H$ *else 0,* $a_L=(\sigma w\lambda-\theta_L)M/2\sigma w\lambda$.

(iv) *if* $\frac{M(\sigma w-\theta_H)}{2\sigma w}>T\geq\frac{M}{2\sigma w}\left(\sigma w-\theta_H-\frac{N_L(\theta_H-\theta_L)}{N_H}\right)$, *then* $p_{sL}=\theta_L(T-a_L)$, $p_{sH}=0$, *and* $a_H=T$, $a_L=(\sigma w\lambda-\theta_L)M/2\sigma w\lambda$.

(v) if $\frac{M}{2\sigma w}\left(\sigma w-\theta_H-\frac{N_L(\theta_H-\theta_L)}{N_H}\right)>T$, *then* $p_{sH}=\theta_H(T-a_H)$, $p_{sL}=\theta_L(a_L-a_H)+\theta_H(T-a_H)$, $a_H=\left[\frac{N_L(\theta_L-\theta_H)}{N_H}+(\sigma w-\theta_H)\right]M/2\sigma w$, $a_L=(\sigma w\lambda-\theta_L)M/2\sigma w\lambda$.

The proposition covers the actions that the media provider should take over the full parameter range. The intrinsic value of the program T appears to be particularly relevant in determining the appropriate strategy. For programs of high intrinsic value, a subscription-based approach is to be preferred and for low intrinsic value programs, an advertisement-based approach. The figure provides a graphical illustration of the proposition (Fig. 5).

Under a separating strategy, the high-income customers always pay a higher subscription price and get to view less advertisements than the low-income customers. It is thus a requirement that the low-income segment must always see some advertisements, else both would see no advertisements and pooling would result. Two conditions are required to ensure this: $\frac{N_H(\theta_H-\theta_L)}{N_L}+\sigma w\lambda-\theta_L>0$ and $\theta_H>\theta_L/\lambda$. When low-income customers are of very little value to advertisers, so that the latter condition is violated, it is better for the media provider not to segment the viewers. Violation of the former condition resulting in pooling is seen in the left part of the figure. Observe that as advertisers value consumers more, the amount of advertising increases while the subscription price, with some exceptions, decreases.

Proposition 4(i) shows that it is best to give the high-income consumers their efficient quality. In other words, the consumers see a program in which the amount of advertising is sufficiently small that they would rather not pay to have it reduced further. The low-income segment gets less than the quality they would have preferred. In other words, low-type customers will probably be dissatisfied with the amount of advertising they view. Although they are willing to pay to avoid some advertising, this option is not made available to them. The reason is that if low-income customers are provided with too high a quality, the high-income customers may also prefer this option instead of the one that was designed for them. This results in cannibalization and suboptimal profits. High-income consumers always prefer the separating strategy to the limited access strategy since they get the same amount of advertising but pay a lower price. This may be seen by noting that the subscription price for the high-income consumers is lower in a separating equilibrium than in limited access. The low-income segment consumers get no surplus and are indifferent between purchasing the product and any outside option that they may have.

Proposition 4(v) shows a reverse situation to 4(i). The high-income segment obtains no surplus and would be willing to pay to see less advertisements. The low-income segment does obtain a surplus. The scenarios 4(ii), 4(iii) and 4(iv) may be grouped together. In each of these, the two segments obtain no surplus since they are barely indifferent between viewing or not viewing the program. It may happen that one, but not both, of the segments obtains the program for free.

4.4. Comparisons of strategies

The following proposition shows that for a range of parameter values, the separating strategy is best.

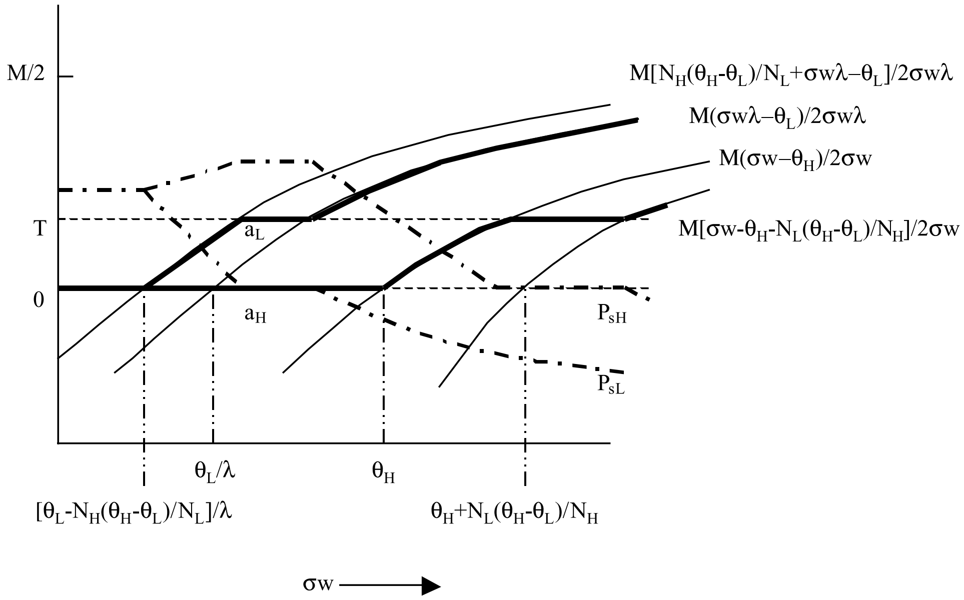

Fig. 5. Subscription price and advertising in a separating strategy.

Proposition 5: *Comparing strategies in terms of profits to the media provider,*

(i) the optimal separating strategy does better than other strategies if $\frac{N_H(\theta_H-\theta_L)}{N_L}+\sigma w\lambda-\theta_L>0$ *and* $\theta_H>\theta_L/\lambda$.

(ii) If $\frac{N_H(\theta_H-\theta_L)}{N_L}+\sigma w\lambda-\theta_L\leq 0$, *there is no advertising revenue and either pooling or limited access is best depending, respectively, on whether* $(N_H+N_L)\theta_L-N_H\theta_H$ *is positive or negative.*

(iii) If $\theta_L/\lambda\geq\theta_H/x>\theta_H$ *then free access is never optimal.*

The conditions on part (i) are the same as those on Proposition 4. Hence, this result states that when a separating strategy exists, it is the best strategy. Note there is no dominance ordering between the profit expressions of pooling and limited access or free access under all circumstances when separating is not the best strategy. Part (ii) of the proposition shows that a larger segment size of high types favors limited access over pooling. Part (iii) shows that if separation is unprofitable due to the very low valuation of advertisers for the low types, then free access may also be inappropriate. Since free access profit is totally based on what advertisers are willing to pay for access to the low types, this is an understandable result.

5. Discussions

To provide normative guidelines for the media provider, we relate the substance of our findings back to the research issues and some of the examples from the introduction.

Revenue issues: The media provider should compute the profits from different strategies for its specific situation and select the strategy that is most profitable. Thereafter, the corresponding subscription price and advertising level should be chosen. From the previous section, several factors are found to impact the media provider's decisions. These include the size of the segments and their value to the advertiser, the degree to which customers dislike advertising in comparison to their dislike for paying subscription, and the program quality. In addition, the decisions will depend upon the degree to which these preferences are homogeneous or heterogeneous in the population.

A pure advertiser-supported or pure pay-per-view strategy is optimal only under certain parameter ranges. Table 2 shows the required conditions, where separating is presented in two rows, 'high' and 'low' for the options selected by the high- and low-income segments, respectively.

Consider first the pure pay-per-view column. The required condition is a low value of σw in comparison to the value of θ. We know that the former is a measure of the value of a consumer to advertisers, whereas the latter is a measure of consumers' disutility for advertising. Essentially therefore, when consumers are willing to pay more to avoid advertising than advertisers are willing to pay to advertise, we obtain a pay-per-view situation.

A pure advertiser-supported strategy, corresponding to a zero or negative subscription price, can also be optimal. The main indications that a pure advertiser-supported strategy is optimal are that the advertiser has a high value for consumers and the programming content T is low quality. In many cases, it is worthwhile for the media provider to pay consumers to view the program and the advertisements. Existing free subscription schemes in the broadcast media will be suboptimal in these cases.

However, a policy where viewers are paid for viewing ads needs careful implementation to ensure that viewers opting for this scheme are not able to accept the money and avoid the ads. For example, use of Internet ads that viewers can easily click into and out of are not appropriate. The interactivity of the Internet is ideal for monitoring behavior to ensure that viewers indeed view the ads, and this may take the form of requiring button clicks (e.g. http://www.adsenger.com, http://www.desktopdollars.com) or having ads concurrently showing on screen so that the viewer cannot avoid them. Payments can be in digital cash, or alternatively, take the form of tickets to a lottery draw (e.g. http://www.adbroadcast.com).

Table 2
Conditions for pure advertiser support and pure pay-per-view

Strategy	Advertising support ($p_s \leq 0$)	Pay-per-view ($a = 0$)
Limited access	Cannot be implemented	$\theta_H \geq \sigma w$
Free access	$T < M(\sigma w\lambda - \theta_L)/2\sigma w\lambda$	Cannot be implemented
Pooling	$T \leq M(\sigma wx - \theta_L)/2\sigma wx$	$\theta_L \geq \sigma wx$
Separating (High)	$T \leq M(\sigma w\lambda - \theta_H)/2\sigma w\lambda$	$\theta_H \geq \sigma w$
Separating (Low)	$T \leq M\left[\frac{N_H}{N_L}(\theta_H - \theta_L) + (\sigma w\lambda - \theta_L)\right]/2\sigma w\lambda$	Cannot be implemented

Subscriber market issues: To answer the question of whether to segment or not segment the market depends on whether the pooling policy provides higher profits than the other policies, since the remaining strategies treat consumer segments differently. Proposition 5 provided some conditions when pooling was optimal, e.g. a relatively large low-type segment and high valuation by the advertisers for the low types.

Based on the analysis, consider what suggestions can be made for the examples for telephone, voicemail, etc., mentioned previously. In the case of telephone and voicemail, there is no unique programming content, therefore, competition from outside options is higher. The presence of alternatives probably means that for a new company like Freefone, the number of low-type users, attracted by the possibility of a lower price, is high, making a limited access strategy least preferable and a pooling strategy most preferable. The lack of unique content implies that advertising revenues will be the major component. For these reasons, a single option with high advertising content seems the best strategy.

Internet, cable and video-on-demand all have high intrinsic programming content. The separating strategy described for slashdot.com and salon.com is generally appropriate given Proposition 5. A limited access strategy is most favored if a program provides high value and if there exists a large high-income segment. On the other hand, if the program provides high value, but the low-income segment is large and all segments have similar preferences, then limited access is not the best option. When the program is intrinsically low value, revenues should be obtained from advertising alone. The best solution may then be free access to pay the viewers to view the programming content through prizes, sweepstakes and pay-as-you-go schemes such as Cybergold.

Advertiser market issues: An advantage of the separating equilibrium is that access to different segments of consumers can be independently sold to advertisers at different rates. The advertiser model developed in Section 2 provided the per-person advertising rates at which access to the segments should be sold. If the segments are separately accessible, the advertising rates are given by Eqs. (4a) and (4b).

Advertisers who are willing to advertise are those whose products have a higher margin, implying a higher benefit from advertising. However, in the case of a separating strategy, there are more advertisers advertising to the low-income segment, who have an overall lower probability of purchasing, than to the high-income segment. Although unintuitive from the viewpoint of the advertiser, this result occurs because the media provider controls access to the audience and enforces a lower level of advertising for the high-income segment.

A media provider may feel that if different advertising rates can be obtained for different consumer segments, it would be best to always segment the market so that access to these different segments can be separately sold to advertisers. As we saw from Proposition 5, this turns out to not always be the case. This means there are situations in which it is not appropriate to try to mass-customize the viewing experience.

5.1. The effect of competition

There are three types of competitive effects that may moderate the results and we proceed to discuss them individually: These are, (1) the competition among media providers for viewers, (2) the competition among media providers for advertisers, and (3) the competition among advertisers for buyers.

If competition for viewers exists, the competing media provider provides an outside option to consumers (Rochet & Stole, 1998). Thus, under competition, the ability to charge higher subscription prices or have more advertising is reduced. In addition, price discrimination is difficult to incorporate in a competition setting since price discrimination itself is a realization of monopoly power. A duopoly result might be specialization by media providers where each focuses on serving one of the two segments. The effect of competition is thus to reduce or prevent price discrimination, i.e. the separating strategy becomes less attractive.

Competition among media providers for advertisers affects the parameter w, the probability that a viewer will be influenced to buy the product by viewing the ad. The argument is that advertisers will only pay for the incremental probability that advertising on a media will provide (Wildman, McCullough, & Kieschnick, 2001). Suppose that, on average, the same advertisement is seen by a viewer on K competing sites. For an advertiser with profit margin s, the incremental value of placing an ad on the $(K+1)$th site is $sw(1-w)^K$, i.e. the probability that the influence was due to this ad and not due to any of the others. We can refer to $w' = w(1-w)^K$ as the effective purchase probability.

Fig. 6 shows how even a small number of competing sites can reduce the effective purchase probability from a program. Consequently, less can be charged from advertisers. However, the figure also shows that the effect is less important when purchase probabilities are low to start with, which is normally the case. For example, if one in a hundred viewers purchased the product, a viewer would have to see the advertisement on 70 programs before the effective probability is reduced by half. This indicates that the effect of competition for advertisements is rather small. Returning to the analysis, the conclusion is that subscriber support becomes more attractive since the value of $\sigma w'$ drops in comparison to the value of θ.

Regarding competition between advertisers for buyers, this affects both advertisers' margins s and the number of potential advertisers M. In general, competition will reduce profit margins and under perfect competition, none of the firms make positive profit. The net result is that the number of potential

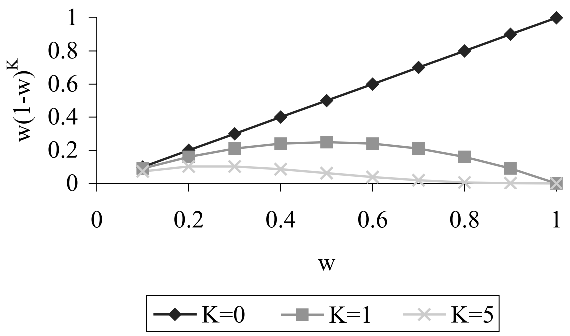

Fig. 6. Effect of K competing providers on effective purchase probability.

advertisers decreases. Examining the analytical results, the amount of advertising in all cases decreases as well.

In summary, the latter two types of competition reduce the amount of advertising revenue, whereas competition for viewers reduces both the subscription and advertising revenue. To the extent that different programming would be quite unique and attract a distinct audience, it is justifiable to consider a monopoly media provider from the point-of-view of the audience. In that case, competition reduces mainly advertising revenue. The implication for managers is that they should examine the possibility of raising revenue from subscriptions more closely.

6. Conclusions and future research

Media providers operate simultaneously in two markets. In the program or entertainment market, they sell their program to consumers for a subscription price. In the advertising market, they charge an advertising rate from advertisers for access to different segments of consumers. The issues we examine are, what is the optimal subscription price, advertising rate and market segmentation strategy for the media provider.

We discuss four strategies for the media provider that are denoted limited access, free access, pooling and separating. They have distinct segmentation, pricing and advertising implications. We derive the optimal implementation of each strategy and suggest when its use is appropriate.

A key aspect of these strategies is the dual role of advertising. Not only is advertising a source of revenue for the media provider but it can, in addition, be used to segment the market. Although advertising is an annoyance to consumers, it can be used to segment the market if different consumer segments are willing to pay different prices for the opportunity to watch the program at different levels of advertising. As an example of deliberately using advertisements to annoy, consider 'nagware', shareware that starts and ends with a screen asking for registration fees (Shapiro & Varian, 1999). Customers that are willing to tolerate the nagging can continue to use the software for free while other consumers must pay for the convenience of not being nagged. Similarly, when downloading a web page, nonsubscribed viewers, in contrast to subscribers, may have to view advertisement banners blink on and off several times before the text appears.

This dual role of advertising is particularly relevant for the separating strategy and its implementation by contemporary media. A feature present in contemporary electronic media such as the internet and video-on-demand services, but absent in traditional media such as newspapers and magazines, is the ability to flexibly and inexpensively provide consumers with a choice of different versions of the program so that they can choose their own comfort level of subscription price and advertising. Whereas some of the strategies we discuss are applicable to traditional media, the latter feature makes the separating strategy feasible in electronic media. Furthermore, we are able to show that the separating strategy is the best strategy for a broad range of parameters.

From a methodological perspective, the study uses a two-segment model and analytical methods to determine conditions under which to use each strategy. The methodology of quality-based price discrimination used in this paper is widely applied. However, the media provider's problem is unusual since it can choose to make the product quality positive or negative depending on the amount of advertising it provides with the program. For a typical product, the quality provided must always be positive or the customer will not buy it. The firm obviously will not both pay the customer and give him the product to take away. Here, the situation is quite different because the media provider has two potential sources of revenue, namely, advertisers and subscriptions. As a result, the strategy space for the media provider is enlarged because negative valuations by viewers are possible. The viewer can be paid to consume the product and yet the firm is the better off for it.

A traditional model of second degree price discrimination for a standard product with two segments (high and low), whose preferences conform to the single crossing property, can only generate the subset of the outcomes where quality is positive. Thus, while the separating strategy may be possible, parts (ii)–(v) of Proposition 4 cannot be implemented. Likewise, only part (i) of the pooling strategy would apply. The free access strategy would not be implementable at all. It is the sign of the quality attribute and the second source of revenue (advertisers) that leads to the other outcomes being possible. This is the critical aspect of the context that makes this model different from existing research.

To conclude, we summarize what this study accomplishes from a managerial perspective:

- It identifies issues related to balancing the advertising and subscription revenues that are critical to both traditional and contemporary media providers, and to the market for advertising, but that have not been subjected to prior theoretical investigation (Section 1).
- It identifies four distinct strategies that the media provider can pursue, denoted limited access, free access, pooling and separating (Section 3). These strategies classify and provide a theoretical basis and evaluative criteria for schemes seen in practice. Examples of each strategy are identified in practice.
- It characterizes the optimal price and advertising level for the media provider under each strategy (Propositions 1–4). The conditions under which pay-per-view or pure advertising supported programming is optimal are found (Table 2).
- It finds the profit expressions from which we can find the strategy that is best for a particular situation (Propositions 1–4). In particular, we find that providing options to consumers using the separating strategy does better than alternative strategies except under a few specified conditions (Proposition 5).

In examining the response of customers to different levels of advertising, the paper deals with the impact of information technology and new media on the future of communications, advertising and promotions. It is not unlikely that the separating pricing strategies that we discuss here will become more pervasive with time since contemporary electronic media make it possible to implement it much more efficiently than was possible in the past. The implications are higher profits for media providers, more choices for customers, and more targeted advertising for advertisers.

As a suggestion for future research, the effects of incorporating competition for subscribers may be examined in more detail by considering two strategic competitors offering differentiated options catering to different types of consumers. In addition to competition from other agents, the effect of competition from pirated access can also be examined. If piracy exists, it results in a larger user base but a lower willingness to pay subscription fees, therefore, it is likely that the best strategy in a piracy-dominated market is to depend mainly on advertising revenues.

Acknowledgements

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Appendix A

Proof of Proposition 1

$$\text{Maximize } \Pi_1 = N_H[\theta_H(T-a) + \sigma w(1-a/M)a]$$
with respect to a and subject to $M \geq a \geq 0$ and $T > a$. (A1)

The first order condition with respect to a is $-\theta_H + \sigma w(1-a/M) - a\sigma w/M = 0$. The second order condition is satisfied. We now have:

(a) If $T > M(\sigma w - \theta_H)/2\sigma w > 0$

$$a = M(\sigma w - \theta_H)/2\sigma w \tag{A2}$$

$$p_{aH} = (\sigma w + \theta_H)/2 \tag{A3}$$

$$\Pi_1 = N_H[\theta_H T + M(\sigma w - \theta_H)^2/4\sigma w] \tag{A4}$$

(b) If $T \leq M(\sigma w - \theta_H)/2\sigma w$

$$a = T - \varepsilon, \varepsilon > 0, \varepsilon \to 0 \tag{A5}$$

$$p_{aH} = \sigma w(1 - T/M) \tag{A6}$$

$$\Pi_1 = N_H \sigma w T(1 - T/M) \tag{A7}$$

(c) If $M(\sigma w - \theta_H)/2\sigma w \leq 0$

$$a = 0 \tag{A8}$$

$$\Pi_1 = N_H \theta_H T \tag{A9}$$

Q.E.D. □

Proof of Proposition 2

$$\text{Maximize } \Pi_2 = N_L[\theta_L(T-a)+\sigma w\lambda(1-a/M)a]$$
$$\text{with respect to } a \text{ and subject to } M\geq a\geq 0 \text{ and } T<a. \quad \text{(A10)}$$

The first order condition with respect to a is $-\theta_L + \sigma w\lambda\ (1-a/M) - a\sigma w\lambda/M = 0$. We get:

(a) If $T < M(\sigma w\lambda - \theta_L)/2\sigma w\lambda$

$$a = M(\sigma w\lambda - \theta_L)/2\sigma w\lambda \quad \text{(A11)}$$
$$p_{aH} = (\sigma w\lambda + \theta_L)/2 \quad \text{(A12)}$$
$$\Pi_2 = N_L[\theta_L T + M(\sigma w\lambda - \theta_L)^2/4\sigma w\lambda] \quad \text{(A13)}$$

(b) If $T \leq M(\sigma w - \theta_H)/2\sigma w$

$$a = T + \varepsilon, \varepsilon > 0, \varepsilon \to 0 \quad \text{(A14)}$$

$$\Pi_2 = N_L\sigma w\lambda T(1 - T/M) \quad \text{(A15)}$$

Q.E.D. □

Proof of Proposition 3

$$\text{Maximize } \Pi_3 = (N_H+N_L)[\theta_i(T-a)+p_a a)]$$
$$\text{w.r.t. } a \text{ and s.t.Eq. (4) and } M\geq a\geq 0. \quad \text{(B1)}$$

The first order condition with respect to a is $-\theta_i + p_a + ap_a' \leq 0$ c.s. $a \geq 0$. Substituting from Eq. (4), i.e. $p_a = \sigma wx[1-a/M]$ where $x = \frac{N_H+\lambda N_L}{N_H+N_L}$, we obtain the following results:

$$a = M(\sigma wx - \theta_i)/2\sigma wx \text{ if } \sigma wx > \theta_i \text{ else } 0 \quad \text{(B2)}$$

$$p_a = (\sigma wx + \theta_i)/2 \quad \text{(B3)}$$

From Eq. (B2), it is clear that $a(\theta_L) > a(\theta_H)$ and there are three possible cases to consider:

(a) If $T > a(\theta_L) > a(\theta_H)$ then $p_s = V_L(T-a)$ and in Eqs. B(1–4) replace θ_i with θ_L.
(b) If $a(\theta_L) > a(\theta_H) > T$ then $p_s = V_H(T-a)$ and in Eqs. B(1–4) replace θ_i with θ_H. Observe that since $a(\theta_H) > T$, it must be the case that $\sigma wx - \theta_H > 0$ since $T > 0$ by definition.

For both these cases, the second order condition for maximum is easily verified. Next, substituting all values into the profit function $\Pi_3 = (N_H+N_L)[\theta_i(T-a) + p_a a)]$, we obtain

$$\Pi_3 = (N_H+N_L) \times \left[\theta_L T + \frac{M(\sigma wx - \theta_i)^2}{4\sigma wx}\right] \text{ if } \sigma wx > \theta_i \text{ else } \Pi_3 = (N_H+N_L)\theta_i T \quad \text{(B4)}$$

Now consider what the remaining case $a(\theta_L) > T > a(\theta_H)$ implies. If we start by assuming $p_s = \theta_L(T-a)$ for $a < T$, we find $a > T$ contradicting our initial assumption. Similarly, if we start with the assumption $p_s = \theta_H(T-a)$ under $a > T$, we obtain the contradiction $a < T$. This leaves the solution $a = T$ in which case $p_s = 0$ and $p_a = \sigma wx(1 - T/M)$. The profit is

$$\Pi_3 = (N_H+N_L)T\sigma wx(1-T/M) \quad \text{(B5)}$$

Q.E.D. □

Proof of Proposition 4

We have:

$$\text{Max} \quad \Pi_4 = N_H\left(p_{sH} + \sigma w\left(1-\tfrac{a_H}{M}\right)a_H\right) + N_L\left(p_{sL} + \sigma w\lambda\left(1-\tfrac{a_L}{M}\right)a_L\right)$$

w.r.t. (p_{sH}, a_H) and (p_{sL}, a_L), subject to constraints:

IC_L: $\theta_L(T-a_H) - p_{sH} \leq \theta_L(T-a_L) - p_{sL}$

IC_H: $\theta_H(T-a_H) - p_{sH} \geq \theta_H(T-a_L) - p_{sL}$

IR_L: $\theta_L(T-a_L) - p_{sL} \geq 0$

IR_H: $\theta_H(T-a_H) - p_{sH} \geq 0$

If an option has higher advertisements, then it must be the case that it has a lower price than the other option, and vice versa, otherwise the option with lower advertising and lower price would dominate for all types. Mathematically, $\text{Sign}(a_L - a_H) = \text{Sign}(p_{sH} - p_{sL})$.

We can show that the low types always see more advertising, otherwise the IC_L and IC_H will contradict each other. Proof: Write IC_H: $\theta_H(a_L - a_H) \geq p_{sH} - p_{sL}$, and IC_L: $\theta_L(a_L - a_H) < p_{sH} - p_{sL}$. Since $\text{Sign}(a_L - a_H) = \text{Sign}(p_{sH} - p_{sL})$, it must be that this sign is positive otherwise $\theta_H \leq \frac{p_{sH} - p_{sL}}{a_L - a_H} < \theta_L$ in contradiction to our assumption that $\theta_H > \theta_L$. It turns out that imposing the constraints $\theta_H > \theta_L/\lambda$ and $\frac{N_H(\theta_H - \theta_L)}{N_L} + \sigma\lambda - \theta_L > 0$ are sufficient in all cases below to ensure $a_L > a_H$ required for separation. If these conditions are not met, separation is not possible.

Now consider the following three cases:

Case A: $T-a_L>0(\Rightarrow T-a_H>0)$. We find IR_L and IC_H bind.
Case B: $T-a_L\leq 0$ and $T-a_H\geq 0$. IR_L and IR_H bind.
Case C: $T-a_H<0\Rightarrow T-a_L<0)$. IR_H and IC_L bind.

We now examine these cases in detail:

Case A: IR_H can be ignored since it is implied by IC_H+IR_L. IC_H binds: If not, increase p_{sH} and profits rise without any violation of constraints. IR_L binds: If not, increase both p_{sH} and p_{sL} by the same amount and profits rise. Thus, we get:

$$p_{sL}=\theta_L(T-a_L) \tag{C1}$$

$$p_{sH}=\theta_H(a_L-a_H)+\theta_L(T-a_L) \tag{C2}$$

Inserting Eqs. (C1) and (C2) into the profit expression to be maximized, and differentiating, we obtain the following first order conditions:

$$a_H=M(\sigma w-\theta_H)/2\sigma w \text{ if } \sigma w>\theta_H \text{ else } 0 \tag{C3}$$

$$a_L=\left[\frac{N_H(\theta_H-\theta_L)}{N_L}+\sigma w\lambda-\theta_L\right]M/2\sigma w\lambda \tag{C4}$$

The required condition for this case to exist is thus, $T>\left[\frac{N_H(\theta_H-\theta_L)}{N_L}+\sigma w\lambda-\theta_L\right]M/2\sigma w\lambda$.

Case B: Under the conditions for this case, the incentive compatibility conditions are always satisfied. Hence, the provider leaves no surplus with either customer type. Thus, IR_L and IR_H bind. We have

$$p_{sL}=\theta_L(T-a_L) \tag{C5}$$

$$p_{sH}=\theta_H(T-a_H) \tag{C6}$$

The profit function is $\Pi_4=N_H[\theta_H(T-a_H)+\sigma w(1-(a_H/M))a_H]+N_L[\theta_L(T-a_L)+\sigma w\lambda(1-(a_L/M))a_L]$. The first order conditions give:

$$a_H=M(\sigma w-\theta_H)/2\sigma w \text{ if } \sigma w>\theta_H \text{ else } 0 \tag{C7}$$

$$a_L=(\sigma w\lambda-\theta_L)M/2\sigma w\lambda \text{ if } \sigma w\lambda>\theta_L \text{ else } 0 \tag{C8}$$

We can distinguish between three subcases and the conditions that lead to them:

Case B (i): $T-a_L<0$ and $T-a_H>0$.
This requires $M(\sigma w\lambda-\theta_L)/2\sigma w\lambda>T>M(\sigma w-\theta_H)/2\sigma w$.
Case B (ii): $T-a_L=0$ and $T-a_H>0$
This requires $a_L=T>M(\sigma w-\theta_H)/2\sigma w$.
Case B (iii): $T-a_L<0$ and $T-a_H=0$
This requires $M(\sigma w\lambda-\theta_L)/2\sigma w\lambda>T=a_H$.

Case C: IR_L can be ignored since it is implied by IC_L+IR_H. IC_L binds, else increase p_{sL} and profits rise without any violation of constraints. IR_H binds: If not, increase both p_{sH} and p_{sL} by the same amount and profits rise. Thus, we get:

$$p_{sH}=\theta_H(T-a_H) \tag{C9}$$

$$p_{sL}=\theta_L(a_L-a_H)+\theta_H(T-a_H) \tag{C10}$$

Inserting Eqs. (C9) and (C10) into the profit expression to be maximized, and differentiating, we obtain the following first order conditions:

$$a_H=\left[\frac{N_L(\theta_L-\theta_H)}{N_H}+(\sigma w-\theta_H)\right]M/2\sigma w, \tag{C11}$$

$$a_L=(\sigma w\lambda-\theta_L)M/2\sigma w\lambda. \tag{C12}$$

The required condition for this case to exist is, $T<\left[\frac{N_L(\theta_L-\theta_H)}{N_H}+(\sigma w-\theta_H)\right]M/2\sigma w$.

Q.E.D. □

Proof of Proposition 5

Note that by setting $p_{sH}=p_{sL}=p_s$ and $a_H=a_L=a$ where (p_s, a) are the optimal pooling solutions, the problem reduces to the pooling problem and no constraints are violated. When $p_{sH}\neq p_{sL}$ or $a_H\neq a_L$, the separating strategy does strictly better. For limited access versus separating, note that we can replicate the limited access results by setting $p_{sL}=0$, $a_L=T$, so that high types IC is the same as their IR. This reduces the problem to the limited access problem. However, the low types continue to contribute advertising revenues in a separating strategy as opposed to a limited access strategy. Hence, when the separating strategy is possible, it does strictly better. A similar argument holds for free access versus separating.

We, thus, have to identify the parameter space where separation cannot be maintained. From Proposition 4, we find $a_H < a_L$ is violated:

(i) When $\frac{N_H(\theta_H-\theta_L)}{N_L} + \sigma w\lambda - \theta_L \leq 0$.

(ii) For $\frac{M}{2\sigma w\lambda}\left(\frac{N_H(\theta_H-\theta_L)}{N_L} + \sigma w\lambda - \theta_L\right) \geq T > \frac{M}{2\sigma w}\left(\sigma w - \theta_H - \frac{N_L(\theta_H-\theta_L)}{N_H}\right)$ when $\theta_H \leq \theta_L/\lambda$.

(iii) For $\frac{M}{2\sigma w}\left(\sigma w - \theta_H - \frac{N_L(\theta_H-\theta_L)}{N_H}\right) > T$ when $\theta_H + \frac{N_L(\theta_H-\theta_L)}{N_H} \leq \theta_L/\lambda$.

Thus, only two constraints $\frac{N_H(\theta_H-\theta_L)}{N_L} + \sigma w\lambda - \theta_L > 0$ and $\theta_H > \theta_L/\lambda$ are required to ensure separation is better.

For part (ii) of Proposition 5, when $\frac{N_H(\theta_H-\theta_L)}{N_L} + \sigma w \lambda - \theta_L \leq 0$, there is no advertising (i.e. $a=0$) in all strategies. Thus, free access cannot be optimal. The profits from limited access and pooling when there is no advertising are $N_H\theta_H T$ and $(N_H+N_L)\theta_L T$, respectively.

For part (iii), we compare the profit expressions for pooling and free access under $\theta_L/\lambda \geq \theta_H/x$. Note that $x = \frac{N_H+\lambda N_L}{N_H+N_L} > \lambda$ (since $\lambda < 1$ is required to ensure $\theta_L/\lambda \geq \theta_H$). We find, from Propositions 2 and 3, that the pooling profit $(N_H+N_L)[\theta_H T + (Mx(\sigma w - \theta_H/x)^2)/(4\sigma w)]$, is term-by-term higher than $N_L[\theta_L T + (M\lambda(\sigma w - \theta_L/\lambda)^2/(4\sigma w)]$, the free access profit.

Q.E.D. □

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