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Ad Pricing by Multi-Channel Platforms: How to Make Viewers and Advertisers Prefer the Same Channel?

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Ad-financed TV channels are two-sided platforms where media houses provide communication from advertisers to viewers. Most media houses air several channels, some of which are particularly valuable to advertisers. At first glance, one might expect the ad volumes to be highest for the channels that are the advertisers' favorites. However, a crucial management challenge for media houses is to ensure that viewers go where the potential for raising advertising revenue is greatest. Because viewers dislike ads, we show that this implies that advertising volumes will be relatively low (and advertising prices relatively high) in such channels. Indeed, other things equal, the ad volume in a channel is inversely related to its attractiveness to the advertising market. Only if the costs of using alternative tools to attract viewers to the advertisers' favorite channels are sufficiently small will the advertising volume in channels with high demand for ads be larger than in channels with low demand for ads.

Ad-financed television is a two-sided market where consumers select programs with their eyeballs, and media houses deliver eyeballs to advertisers. Advertisers and viewers thus interact

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through a platform (a media house) that accounts for the externalities between the two groups.[1] Empirical studies indicate that TV viewers dislike ads, whereas advertisers prefer a large audience. In this sense, there is a negative externality from advertisers to viewers and a positive externality from viewers to advertisers. Being interrupted by commercial breaks might thus be considered an implicit price that ad-averse viewers have to pay for watching TV. Consequently, it is not surprising to find that the variable fee for watching TV is typically zero, and that media houses make a large share of their revenue from the advertising side of the market.[2]

In general, advertisers go where TV viewers go. However, for a given number of viewers, some TV channels (program profiles) are valued more than others by the advertisers. One reason for this is that the sales-enhancing effect of an ad may vary between channels. "People cannot be coughing and dying right before a Lucky [Strike] ad" is the way Don Draper and his colleagues at the Sterling Cooper Advertising Agency put it (from the TV drama *Mad Men*, set in 1960s New York). In a similar vein, the value of advertising for a journey to South Africa is greater in a feel-good travel channel than in a news channel that discusses the wide-spread violence in the country.

Our main research question is: If a given media house airs more than one channel, and advertisers value some channels more than others, how should the media house set advertising prices and advertising volumes? Using insight from one-sided markets, one might expect that the more attractive it is to advertise in a channel, the higher the channel's profit maximizing advertising volume will be. Taking the two-sidedness of the market into account, we show that the opposite may be true. A central management challenge for a multi-channel media house is to ensure that viewers go where the advertisers prefer them to go. We show that this implies that it is optimal to choose ad prices such that the ad volumes in the advertisers' favorite channels are reduced compared to channels with lower demand for ads. Other things equal, this tends to make the channels with the highest potential for raising advertising revenue more attractive to ad-averse viewers.

Multi-channel media firms may have alternative tools available, such as programming investments, to make viewers and advertisers prefer the same channels (the advertisers' favorites). However, unless the costs of using such alternative tools are sufficiently low, multi-channel media houses should use pricing strategies which ensure that ad volumes are lowest in the channels with the highest demand for ads. There is one important caveat here; if the viewers have a high willingness to shift from one channel to another (i.e., if the audience perceives the channels as close substitutes in terms of viewer utility), a given media house might find it optimal to close down the channel with the lower potential for raising advertising revenue.

Our qualitative results hold independent of whether the multi-channel media house faces competition from other media firms. Due to the two-sided nature of ad-financed TV, the opportunity cost of having a high advertising level is smaller at a channel with low demand for ads than at a channel with high demand for ads. Consequently, it is optimal for the media

[1]This feature of a two-sided market is also found in other ad-financed media markets, where the platform provider links the audience and the advertisers, such as newspapers, social networks (like Facebook®), and search engines (Google™ links advertisers and searchers). See, for example, Rysman (2009) and Parker and van Alstyne (2005) for more examples.

[2]The most common price structure in the TV market is one where the viewers pay a fixed fee for accessing a channel (or a bundle of channels) independent of actual viewing time. Pay-per-view TV still has a relatively small share of the market.

house, also under competition from other media houses, to charge a high advertising price and accept a low advertising volume at the advertisers' favorite channels. An observation that one channel has more ads than another, thus, does not necessarily imply that the channel is particularly valuable for the advertisers. Actually, it could indicate that the channel faces a relatively low demand for ads.

RELEVANT LITERATURE

Wilbur (2008), testing a discrete choice model using U.S. data, provided important insights into the two-sided nature of ad-financed TV channels and the interplay between advertising and viewing markets. He found that viewers are strongly ad-averse, and that a 10% increase in advertising levels is likely to reduce audience size by about 25% for a highly rated network (all other things equal). Previous studies also showed that TV viewers try to avoid advertising breaks (see, e.g., Danaher, 2002; Moriarty & Everett, 1994).[3] Hence, to obtain viewer demand estimates, it is crucial to control for advertising levels. Wilbur further posed the question of whether it is the viewers or the advertisers that have the larger impact on TV channels' program selection. His study did not contain a theoretical model, but based on his empirical study, he showed that the viewers' two most preferred program genres, action and news, account for only 16% of network program hours, whereas reality and comedy, which are the advertisers' preferred genres, account for 47% of network program hours. More generally, his findings suggest that advertisers' preferences have a stronger impact than viewers' preferences on media houses' programming choices. This resembles the theoretical results in this article.

Our article is also closely related to the literature on two-sided markets. Seminal articles on the pricing in such markets are Rochet and Tirole (2003, 2006), Armstrong (2006), Caillaud and Jullien (2003), Economides and Katsamakes (2006), and Parker and van Alstyne (2005).[4] In general, it is well-known that prices in two-sided markets depend on the set of demand elasticities and marginal costs on both sides of the market (Rochet & Tirole, 2003, 2006; Rysman, 2009). This insight has important implications for the pricing strategy in media markets. A pioneering theoretical contribution to the two-sided nature of ad-financed media markets is provided by Anderson and Coate (2005), who analyzed both advertising-financed TV and pure pay TV. Kind, Nilssen, and Sørgard (2009) studied how competitive forces influence the way media firms are financed. They found that a media firm's ability to fully finance content by ads is constrained by the number of competitors. Godes, Ofek, and Sarvary (2009) analyzed how competition between firms in different media industries, such as TV channels and newspapers, affects pricing strategies (see also Dukes & Gal-Or, 2003).[5] In this article, we assume that the viewers can watch TV free of charge because we focus on how media houses should react to the interplay between advertisers' and viewers' preferences for TV content.

[3] In other media markets, consumers may not dislike ads. Kaiser and Wright (2006), for instance, showed that readers of women's magazines appreciate ads. Rysman (2004) analyzed the market for Yellow Pages directories, and he found that consumers' utility increases with the number of pages with ads.

[4] Eisenmann, Parker, and van Alstyne (2006) provided a guide to business strategies in two-sided markets.

[5] When advertisers' preferences have an impact on the quality, this obviously raises welfare issues. Anderson and Gabzewicz (2006) discussed how advertisers' preferences may distort the newspaper content away from the readers' preferences. We do not address welfare issues in this article.

THE MODEL

We consider a context where a media house operates two channels, $i = H, L$, that differ in their programming profiles. One of the channels might, for instance, be a sports channel and the other a film channel. The time spent watching channel i is denoted by V_i, and we follow Kind et al. (2007, 2009) in assuming that the consumers' gross utility of watching TV is given by

$$U = (1 + Q_H) V_H + (1 + Q_L) V_L - \frac{1}{2}\left[4(1-s)\left(V_H^2 + V_L^2\right) + s(V_H + V_L)^2\right], \quad (1)$$

where $Q_i \geq 0$ is the viewers' perceived quality of the programs offered by channel i. The channels are vertically differentiated if $Q_i > Q_j$, with channel i having the higher quality. The parameter $s \in [0, 1]$ is a measure of the extent of horizontal differentiation: The viewers consider the TV channels' programs as completely unrelated if $s = 0$, and as perfect horizontal substitutes if $s = 1$. More generally, the higher s, the closer substitutes are the channels from the viewers' point of view. Note that the viewers do not have preferences for one channel over the other if $Q_1 = Q_2$. *Ceteris paribus*, the consumers, therefore, prefer to use 50% of their total viewing time on each channel.[6]

In most countries, consumers pay, for example, a cable operator—a fixed monthly fee (F) to obtain access to TV channels, which can subsequently be watched free of charge. The focus of this article is to analyze the implications of the fact that advertisers have a greater willingness to pay for ads in some types of programs than in others. For simplicity, we therefore abstract from the distribution layer of the TV industry and set $F = 0$, but this does not affect the qualitative results at which we arrive.

Consistent with empirical data, we assume that viewers have a disutility of being interrupted by commercials. We let the viewers' subjective cost of watching channel i be given by $C_i = \gamma A_i V_i$, where A_i is the channels's advertising level and $\gamma > 0$ is a parameter that measures the viewers' disutility from advertising. This means that the consumer surplus from watching TV is given by

$$CS = U - \gamma(A_H V_H + A_L V_L). \quad (2)$$

Solving $V_i = \arg\max CS$, we find that the viewing time on each channel equals

$$V_i = \frac{1}{2} + \frac{(2-s)(Q_i - \gamma A_i) - s\left(Q_j - \gamma A_j\right)}{4(1-s)}. \quad (3)$$

[6]Utility function (1) is due to Shubik and Levitan (1980), and is a modification of the standard quadratic utility function. Under the standard quadratic utility function, a change in the parameter s would affect both the substitutability between the goods and the size of the market (see, e.g., McGuire & Staelin, 1983). This is not the case with the Shubik and Levitan utility function, where s is a unique measure of channel substitutability. Our qualitative results would also go through with the standard quadratic utility function, but then an increase in s would both reduce the size of the market and increase the substitutability. This makes it more difficult to perform comparative statics. See Motta (2004) for a general discussion of the advantages of the Shubik and Levitan utility function over the standard quadratic utility function. Specific applications of the Shubik and Levitan utility function are, for instance, Shaffer (1991) and Foros, Hagen, and Kind (2009).

Each TV channel makes profits by selling advertising space. To simplify the exposition, but without affecting the general insights to follow, we assume that variable production costs in a TV channel are zero. In accordance with these assumptions, the profit function for the media house is

$$\Pi = R_H A_H + R_L A_L - \phi Q_H^2 - \phi Q_L^2 \qquad (\phi > 0), \tag{4}$$

where R_i is the price that the advertiser has to pay for an advertising slot on channel i. The term ϕQ_i^2 captures the channel's cost of investing in programming quality. In practice, this could be the costs of buying programs that the audience finds attractive (like popular baseball matches or movies). For simplicity, we treat this as a continuous variable.

Let A_{ki} denote advertiser k's advertising level in channel i. It is reasonable to assume that the advertiser's gross gain from advertising is increasing in its advertising level and in the number of viewers. To make it simple, we let the gross gain be equal to $\eta_i A_{ki} V_i$, where η_i is a positive constant—the larger η_i, the more attractive is channel i for the advertisers. This implies that the net gain for advertiser k from advertising on TV equals

$$\pi_k = \sum_i \left(\eta_i A_{ki} V_i - A_{ki} R_i\right), \; k = 1, .., n, \tag{5}$$

where n is the number of advertisers and R_i is the price that the advertiser has to pay for an advertising slot on channel i.

In the following, we consider a three-stage game. At Stage 1, the media house determines advertising prices (R_i) and quality investments (Q_i). At Stage 2, the advertisers choose how much advertising space to buy. At Stage 3, the consumers decide their viewing time on each channel. We solve the game by backward induction, and the solution to the final stage is given by Equation 3.

At Stage 2, we solve $\partial\pi_k/\partial A_{ki} = 0$, and find that advertiser k's demand for advertising on channel i is

$$\frac{\partial \pi_k}{\partial A_{ki}} = 0 => \qquad R_i = \eta_i V_i + \left[\eta_i A_{ki}\frac{\partial V_i}{\partial A_{ki}} + \eta_j A_{kj}\frac{\partial V_j}{\partial A_{ki}}\right]. \tag{6}$$

Abstracting from the terms in the brackets on the right-hand side of Equation 6, we see that the willingness to pay for an ad on channel i is proportional to the size of the audience ($R_i \sim V_i$). However, a higher advertising level on channel i makes this channel less attractive for the TV viewers and the other channel more attractive. These effects are captured by the terms $\frac{\partial V_i}{\partial A_{ki}} = -\frac{(2-s)}{4(1-s)}\gamma < 0$ and $\frac{\partial V_j}{\partial A_{ki}} = \frac{s}{4(1-s)}\gamma > 0$.[7]

We assume that each advertiser is a price taker in the sense that he rationally disregards the possibility that his advertising volume has any effect on the attractiveness of the TV channels (meaning that the brackets in Equation 6 equal zero). This amounts to assuming that the number of advertisers (n) is infinitely large:

[7]Note that the absolute value of these effects is increasing in s. This captures the fact that the better substitutes the public perceives the channels to be, the more willing they are to shift from a channel with a high advertising level to a channel with a low advertising level.

Assumption 1: Let $n \to \infty$.

Solving Equation 6 and using Equation 3, we find that aggregate demand for advertising at each channel equals

$$A_i = \frac{1}{\gamma}\left[1 + Q_i - (2-s)\,\frac{R_i}{\eta_i} - s\frac{R_j}{\eta_j}\right]. \tag{7}$$

Equation 7 shows that the demand curve for advertising is downward-sloping, $\partial A_i/\partial R_i < 0$, and more interestingly, that the demand for advertising on channel i is decreasing in channel j's advertising prices ($\partial A_i/\partial R_j < 0$). The reason is that viewers dislike ads. Therefore, if the price of an ad slot (R_j) increases, the ad level on channel j falls, making channel j more attractive to viewers. Channel i, on the other hand, ends up with a smaller audience and a lower demand for advertising.

In our model, we have assumed that the viewers do not have preferences for one channel over the other. This assumption is made to bring forward, as clearly as possible, the advertisers' influence on the audience's allocation of viewing time across the two channels. To capture the fact that a certain type of program profile is more valuable to advertisers, we assume that channel H is preferred by advertisers in the sense that advertisers' gross gains from advertising are higher on channel H than on channel L—that is

Assumption 2: $\eta_H > \eta_L$.

Equation 7 makes it clear that advertising demand for channel i is increasing in η_i ($\partial A_i/\partial \eta_i > 0$) and decreasing in η_j ($\partial A_i/\partial \eta_j < 0$). We thus note the following:

Remark 1: Other things equal, there is a larger demand for advertising in the H-channel than in the L-channel.

Without Quality Investments

We start out by assuming that the media house cannot make any programming investments ($Q_H = Q_L = 0$). At Stage 1, the media house thus solves $\{R_H, R_L\} = \arg\max \Pi$. The corresponding first-order condition is

$$\frac{\partial \Pi}{\partial R_i} = \left[A_i + R_i\frac{\partial A_i}{\partial R_i}\right] + R_j\frac{\partial A_j}{\partial R_i} = 0. \tag{8}$$

The term in the brackets on the right-hand side depicts the usual change in marginal revenue following a change in the advertising price R_i. A higher price increases the profit margin at channel i, but it also causes advertising sales for channel i to fall ($\partial A_i/\partial R_i < 0$). Non-standard is the last term on the right-hand side. It exhibits how advertising demand for channel j responds to a rise in the ad price of channel i. From Equation 7, it follows that the demand for ad slots on channel j falls when the price of ad slots on channel i rises—that is $\partial A_j/\partial R_i < 0$. This effect makes it clear that multi-channel media houses tend to set lower advertising prices than media houses that only operate one channel.

Solving Equation 8 simultaneously for the two channels, and inserting for A_i from Equation 7, we obtain the optimal price for ads in channel i as

$$R_i = \frac{(4-3s)\,\eta_i - \eta_j s}{N_1}\eta_i\eta_j, \tag{9}$$

where $N_1 \equiv 16\eta_H\eta_L(1-s) - s^2(\eta_H-\eta_L)^2 > 0$ whenever the second-order conditions and non-negativity constraints hold (see the Appendix).

Combining Equations 3, 7, and 9, assuming that both channels are aired, we have:

$$A_i = \frac{2(1-s)\left[4\eta_i - s\left(\eta_i-\eta_j\right)\right]\eta_j}{\gamma N_1} \text{ and } V_i = \frac{\left[(4-3s)\,\eta_i - \eta_j s\right]\eta_j}{N_1}. \tag{10}$$

Lessons from one-sided markets indicate that the more attractive it is to advertise on a channel, the more ads it will contain. In particular, one might expect that if at the outset $\eta_H = \eta_L = \eta$, then a small increase in the attractiveness of channel H would increase the ad volume of that channel. Rather surprisingly, the opposite is true:

Proposition 1: Assume that the channels are initially equally attractive to advertisers ($\eta_H = \eta_L = \eta$), and that the attractiveness of channel H subsequently increases ($d\eta_H > 0$). Then, the equilibrium advertising level in the channel that has become more attractive for the advertisers falls while the advertising level in the other channel increases:

$$\left.\frac{\partial A_{iH}}{\partial \eta_H}\right|_{\eta_H=\eta_L=\eta} = -\frac{1}{16}\frac{s}{\eta} < 0 \text{ and } \left.\frac{\partial A_{iL}}{\partial \eta_H}\right|_{\eta_H=\eta_L=\eta} = \frac{1}{8}\frac{s}{\eta} > 0.$$

Demand for ads in channel H is, by definition, increasing in η_H (see also Remark 1). We nonetheless see that the media house responds by reducing the supply of ad space in that channel if η_H increases. The intuition for this result is that the channel thereby attracts more viewers, allowing it to charge a higher advertising price. Because it further increases the ad volume of the other channel, it will thus reallocate viewers from the channel where the advertisers have a low willingness to pay for ads to the channel where they have a high willingness to pay. This also explains why we more generally find from Equation 10 that the ad volume is highest in the channel least preferred by the advertisers:

$$A_H - A_L = -\left(\eta_H^2 - \eta_L^2\right)\frac{2s(1-s)}{\gamma N_1} < 0.$$

Wilbur (2008) demonstrated that a 1% reduction in a channel's ad level might increase the size of its audience by 2.5%. His result indicates that adjustment of ad levels may be an effective tool to attract viewers. In our setting, this insight can be obtained by examining the equations that follows from using Equations 9 and 10 to derive

$$\begin{aligned} R_H - R_L &= (\eta_H - \eta_L)\frac{2\eta_H\eta_L(2-s)}{N_1} > 0 \\ V_H - V_L &= \frac{\left(\eta_H^2-\eta_L^2\right)s}{N_1} > 0 \end{aligned} \tag{11}$$

Summing up, we have:

Proposition 2: When the media house does not invest in program quality ($Q_H = Q_L = 0$), and both its channels are aired, the channel with the greater value for advertisers (channel H) has

1. More viewers ($V_H > V_L$).
2. Higher advertising prices ($R_H > R_L$).
3. Lower advertising volume ($A_H < A_L$).

Note that the closer substitutes the channels are from the audience's point of view, the more willing the viewers are to shift from one channel to the other. Because the H-channel is the most profitable one for the media house, it can be shown that it is optimal to close down the L-channel if the consumers perceive the channels to be close substitutes:

Corollary 1: When $Q_H = Q_L = 0$, the low-value channel (L) will not be aired if the two channels are sufficiently close horizontal substitutes—that is, if

$$s > s^{crit} \equiv \frac{4\eta_L}{n_H + 3\eta_L}.$$

With Quality Investments

In this section, the media house determines both the advertising price (R_i) and programming investments (Q_i) at Stage 1. Compared to the previous section, the media house now has an additional tool available to affect the absolute and relative attractiveness of the two channels. The game structure is the same as before, and the outcomes at Stage 3 and Stage 2 of the game are still given by Equations 3 and 7, respectively.

Solving $\{R_i, Q_i\} = \arg\max \Pi$ at Stage 1, we obtain the following first-order conditions for optimal ad prices and investment levels:

$$R_i = 2\eta_i\eta_j\gamma\phi\frac{2\gamma\left[\eta_i(4-3s) - \eta_j s\right]\phi - \eta_i\eta_j}{N_2} \tag{12}$$

and

$$Q_i = \eta_i\eta_j\frac{2\gamma\left[4\eta_i(1-s) - s\left(\eta_j - \eta_i\right)\right]\phi - \eta_i\eta_j}{N_2}, \tag{13}$$

where $N_2 \equiv 4\gamma^2 N_1\phi^2 - 4\gamma\eta_H\eta_L(\eta_H + \eta_L)(2-s)\phi + \eta_H^2\eta_L^2 > 0$ (see the Appendix).

Inserting Equations 12 and 13 in 3 and 7, we derive expressions for the ad levels and the size of the audiences as

$$A_i = 4\phi\eta_j\frac{2\gamma(1-s)\left[4\eta_i - s\left(\eta_i - \eta_j\right)\right]\phi - \eta_i\eta_j}{N_2} \tag{14}$$

and

$$V_i = 2\phi\eta_j\gamma \frac{2\gamma\left[\eta_i(4-3s) - \eta_j s\right]\phi - \eta_i\eta_j}{N_2}. \tag{15}$$

Note that advertisers do not care about the channels' quality levels *per se*. However, other things equal, the higher a channel's quality level, the more viewers it attracts, and the larger is the demand for advertising. Because the media house's incentives to make quality investments are positively related to the advertisers' willingness to pay for an ad, we find from the first-order conditions that the H-channel has a higher quality level than the L-channel:

$$Q_H - Q_L = \frac{4\eta_H\eta_L\phi\gamma\,(\eta_H - \eta_L)\,(2-s)}{N_2} > 0.$$

From Equations 12 and 15, we can show that the advertising price and the number of viewers are higher for the H-channel than for the L-channel:

$$V_H - V_L = \frac{2\phi\gamma[2\phi\gamma s(\eta_H + \eta_L) + \eta_H\eta_L](\eta_H - \eta_L)}{N_2} > 0$$

and

$$R_H - R_L = \frac{8\eta_H\eta_L\phi^2\gamma^2(2-s)(\eta_H - \eta_L)}{N_2} > 0.$$

This result is similar to what we found when the media house could not invest in program quality (confer Proposition 2 for $s > 0$). However, the cost of quality investments determines which channel will have the higher ad volume; from Equation 14, we find

$$A_H - A_L = \frac{4\phi(\eta_H - \eta_L)[\eta_H\eta_L - 2\gamma s(1-s)(\eta_H + \eta_L)\phi]}{N_2},$$

which means that $A_L > A_H$ if, and only if, $\phi > \phi^* = \frac{\eta_H\eta_L}{2s(1-s)\gamma(\eta_H+\eta_L)}$.

Summing up, we have the following:

Proposition 3: When the media house invests in program quality and both its channels are aired, the channel with the greater value for advertisers (channel H) has

1. More viewers ($V_H > V_L$).
2. Higher advertising prices ($R_H > R_L$) and higher quality investments ($Q_H > Q_L$).
3. Lower advertising volume ($A_H < A_L$) if $\phi > \phi^* \equiv \eta_H\eta_L/[2s(1-s)\gamma(\eta_H + \eta_L)]$.

Proposition 3 makes it clear that when the media house can use ad levels as well as quality investments to enhance the attractiveness of a channel, both instruments will be used in favor of the channel that is valued the most by the advertisers. Advertising demand, therefore, not only determines the ad levels; implicitly, it also determines the relative and absolute quality levels of the two channels. At the heart of this strategy is the insight that it is profit maximizing for a media house to make viewers and advertisers prefer the same channel. It should nonetheless be noted that still it is optimal for the media house to have the lower ad volume in the advertisers'

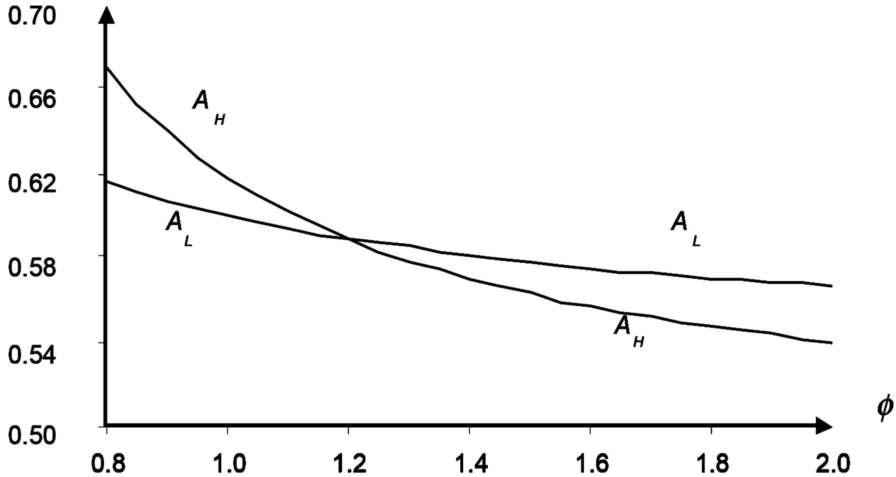

FIGURE 1 Advertising levels with investments.

favorite channel if it is expensive to increase the perceived program quality (ϕ high). Indeed, investment costs are prohibitively high if $\phi \to \infty$, in which case we obtain the same results as in the previous section. However, if the marginal investment costs are sufficiently low, the media house can profitably ensure that the relative quality level of the H-channel is so high that it attracts the larger audience even if it has the higher advertising level. This explains why $(A_H > A_L)$ if $\phi < \phi^*$, as stated in Part 3 of Proposition 3.

The relation between investment costs and advertising levels is illustrated in Figure 1, where we have assumed that $\eta_H = 1.5$, $\eta_L = 1.0$, and $s = 0.5$. The figure shows that the advertising volume at the H-channel is higher than at the L-channel if, and only if, $\phi < \phi^* \approx 1.2$. Otherwise, the channel that is preferred by the advertisers has the lower advertising volume.

Recall that in absence of quality investments, we found that if the audience perceives the TV channels to be sufficiently close horizontal substitutes ($s > s_{inv}^{crit}$), the media house would close down the low-value channel. In this case, we have the following:

Corollary 2: With quality investments, the low-value channel will not be aired if the two channels are sufficiently close horizontal substitutes—that is, if

$$s > s_{inv}^{crit} \equiv s^{crit} - \frac{\eta_L n_H}{2\gamma\phi(n_H + 3\eta_L)}.$$

Other things equal, the number of viewers will be smaller with one than with two channels. However, the more the media house invests in programming quality for the H-channel, the fewer viewers it loses by closing down channel L. Therefore, it is profitable for the media house to close down the low-value channel even if the other channel is a relatively poor substitute. On the expenditure side, it should be noted that this tends to reduce the media-house's total investment costs.

EXTENSION: COMPETITION AMONG MEDIA HOUSES

Earlier we have demonstrated that the manager of a media house that runs at least two channels should sell the lowest volume of advertising space on the channel with the highest advertising demand, other things equal. This is due to the two-sided nature of the TV industry. So far, we have only analyzed the case where the media house faces no competition from other TV channels. However, the qualitative results survive also with competition and independent of whether competing media houses control one or several channels. This is clear because the first-order conditions for optimal advertising prices derived earlier (Equation 8) do not hinge on the media house being in a monopoly situation. In particular, consider an arbitrary media house k that runs one H-channel and one L-channel. Even if the media house does face competition, we still have that $\frac{\partial \Pi_k}{\partial R_{ki}} = 0$ implies

$$A_{ki} + R_{ki}\frac{\partial A_{ki}}{\partial R_{ki}} + R_{kj}\frac{\partial A_{kj}}{\partial R_{ki}} = 0.\ (i, j = H, L;\ i \neq j),$$

where the third term on the left-hand side is negative; $R_{kj}\frac{\partial A_{kj}}{\partial R_{ki}} < 0$.

Recall from Equation 8 that the sign of this term reflects the fact that a higher advertising price at channel i reduces the advertising volume in that channel and, thus, shifts viewers from channel j to channel i. Thereby, advertising demand for the j-channel falls. Important in this respect is the fact that the higher the willingness to pay for an ad on the j-channel is, the greater the subsequent loss will be for the media house. The opportunity cost of setting a high price for advertising is, thus, smaller at the H-channel than at the L-channel. Consequently, it is optimal for the media house, also under competition, to charge a high advertising price and accept a low advertising volume at channel H.

In the Appendix we provide an illustration of this through an example where we have two media houses, where each control one H-channel and one L-channel (this symmetry is chosen only to simplify the algebra). Otherwise, the model is the same as before. We then show the following:

Proposition 4: Assume competition between two media houses, each having one H-channel and one L-channel. The channel that is of greater value to advertisers (H) has the lower advertising volume if

$$\phi > \phi^{**} = \frac{(2-s)\eta_H\eta_L}{4\gamma s(1-s)(\eta_H + \eta_L)}.$$

The intuition for the result in Proposition 4 is the same as for Part 3 of Proposition 3; if ϕ is large, it is too expensive to attract viewers to the H-channel through offering a high program quality. Instead, they must ensure that the viewers go to the channel preferred by the advertisers by setting $A_L > A_H$. Regardless of whether there is competition, we thus cannot infer that channels with high advertising levels are particularly valuable to advertisers. On the contrary, the opposite may be true. What we should expect, though, is that programming investments are higher the more attractive a channel is to the advertisers (although the advertisers do not care about programming quality *per se*). In this sense it is advertiser preferences, rather than viewer preferences, which determine broadcasters' quality levels.

CONCLUSION

Television absorbs one-fourth of all advertising expenditures in the United States. Given the fact that the average American spends over 4 1/2 hr per day watching television, the scope for profit among advertisers and media houses is vast. The business model of media houses must take into account the externalities that arise between advertisers and viewers, and this yields some paradoxical results compared to what one might expect using insight from one-sided markets.

The driving force behind our results is that multi-channel media houses must try to transfer viewers from channels where demand for ads is low to channels where demand for ads is high. As a consequence, media houses will choose, for example, advertising levels and investments in programming quality so as to make the viewers watch the advertisers' preferred channels. Our results, thus, fit well with recent empirical evidence by Wilbur (2008), who, based on U.S. ad-financed television, found that advertisers have a stronger impact than viewers on networks' program selection. A question for future research, then, is how this will influence the TV industry's business models in the future. In particular, technological changes have significantly increased the scope for charging the consumers directly for watching TV. With viewers' preferences being muted in advertising-financed networks, this should give rise to a competitive advantage for channels financed by a pay-per-view business model. Such alternative business models may lead TV channels to respond better to the program selection preferred by the viewers and to their willingness to pay for quality.

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APPENDIX

Without Quality Investments

The second-order condition. Inserting for Equations 3 and 7 into Equation 4, and setting $Q_i = 0$, we find

$$\frac{\partial^2 \Pi}{\partial R_I^2} = -2\frac{2-s}{\gamma \eta_i} < 0 \text{ and } \left(\frac{\partial^2 \Pi}{\partial R_H^2}\right)\left(\frac{\partial^2 \Pi}{\partial R_L^2}\right) - \left(\frac{\partial^2 \Pi}{\partial R_H \partial R_L}\right)^2 = 4\frac{(2-s)^2}{\gamma^2 \eta_H \eta_H} > 0,$$

which shows that the second-order conditions for profit maximization are always satisfied.

Proof that $N_1 > 0$ in the relevant area. Solving $\{R_H, R_L\} = \arg\max \Pi$, we find Equations 9 and 10, where $N_1 \equiv 16\eta_H \eta_L (1-s) - s^2 (\eta_H - \eta_L)^2$. Differentiation of N_1 yields

$$\frac{dN_1}{d\eta_H} = 16\eta_L (1-s) - 2s^2 (\eta_H - \eta_L),$$

which means that the denominator N_1 is decreasing in η_H of $\eta_H > \eta_L$. From Equation 10, we find that $V_L = 0$ for $\eta_H \geq \frac{4-3s}{s}\eta_L$. Because $N_1|_{\eta_H = \frac{4-3s}{s}\eta_L} = 16\eta_L^2 (1-s)(2-s)^2/s > 0$, it follows that N_1 is positive in the relevant area.

With Quality Investments

Proof that $N_2 > 0$ in the relevant area. Solving $\{R_i, Q_i\} = \arg\max \Pi$, we find Equations 12 and 13.

The second-order conditions require that $H_1 \equiv -2\phi < 0$, $H_2 \equiv 4\phi^2 > 0$, $H_{3i} \equiv -2\phi \frac{4\phi\gamma(2-s)-\eta_j}{\gamma^2 \eta_j} < 0$, and $H_4 \equiv \frac{N_2}{\eta_H^2 \eta_L^2 \gamma^4} > 0$. Note that $H_{3i} < 0$ if $\eta_j < 4\phi\gamma(2-s)$; using Equation 15, it can be shown that a higher value of η_j makes $V_i < 0$. H_{3i} is, thus, negative if both channels have non-negative audiences. Moreover, the Hessians H_1, H_2, and H_4 clearly have the required signs whenever $\phi > 0$ and $N_2 > 0$.

Competition Among Media Houses

Proof of Proposition 4. With two media houses each running their H-channel and L-channel, we must modify Equation 1 to

$$U = \sum_{i=1}^{2} \left[(1 + Q_{iH}) V_{iH} + (1 + Q_{iL}) V_{iL} \right]$$

$$- 2 \left((1 - s) \sum_{i=1}^{2} \left(V_{iH}^2 + V_{iL}^2 \right) + \frac{s}{4} \sum_{i=1}^{2} (V_{iH} + V_{iL})^2 \right).$$

This implies that

$$V_{1H} = \frac{1}{4} + \frac{(4 - s)(Q_{1H} - \gamma A_{1H}) - s(Q_{1L} - \gamma A_{1L} + Q_{2H} - \gamma A_{2H} + Q_{2L} - \gamma A_{2L})}{16(1 - s)},$$

with similar expressions for V_{1L}, V_{2H}, and V_{2L}. Thereby, demand for ads equals

$$A_{1H} = \frac{1}{\gamma} \left[1 + Q_{1H} - (4 - 3s) \frac{R_{1H}}{\eta_H} - s \left(\frac{R_{1L}}{\eta_L} + \frac{R_{2H}}{\eta_H} + \frac{R_{2L}}{\eta_L} \right) \right],$$

with similar expressions for A_{1L}, A_{2H}, and A_{2L}.

Maximizing profits for the two media houses with respect to advertising levels and quality investments, we find a symmetric equilibrium. Omitting subscripts for each media house, we have (with $j = H, L$):

$$Q_j = \frac{2\phi\gamma \left[(8 - 7s) \eta_j - s\eta_{-j} \right] - \eta_j \eta_{-j}}{N_3} \eta_j \eta_{-j},$$

and

$$R_j = 2\phi \frac{2\phi\gamma \left[(8 - 7s) \eta_j - s\eta_{-j} \right] - \eta_j \eta_{-j}}{N_3} \eta_j \eta_{-j} \gamma,$$

where

$$N_3 = 8\gamma^2 \left[8\eta_H \eta_L (1 - s)(4 - s) - s^2 (\eta_H - \eta_L)^2 \right] \phi^2 - 2\gamma \eta_H \eta_L (8 - 5s)(\eta_H + \eta_L) \phi + \eta_H^2 \eta_L^2.$$

Advertising levels are then given by

$$A_j = 4\phi\eta_{-j} \frac{4\gamma (1 - s) \left[\eta_j (8 - 5s) + s\eta_{-j} \right] \phi - \eta_j \eta_{-j} (2 - s)}{N_3},$$

which, in turn, implies that

$$A_H - A_L = -4\phi (\eta_H - \eta_L) \frac{4\gamma s\phi (1 - s)(\eta_H + \eta_L) - \eta_H \eta_L (2 - s)}{N_3},$$

such that $A_L > A_H$ if $\phi > \phi^{**} = \frac{(2-s)\eta_H \eta_L}{4\gamma s(1-s)(\eta_H + \eta_L)}$.