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Abstract

We analyze strategic interactions between two competing distributors of an independent TV channel. Consistent with most of the relevant markets, we assume that the distributors set end-user prices while the TV channel sets advertising prices. Within this framework we show that the distributors have incentives to internalize the fact that viewers dislike ads on TV, but no incentives to internalize how the TV-channel's profits from the advertising market are affected by end-user prices. This leads to some surprising results. First, we show that even undifferentiated distributors might make positive profits. Second, a TV channel might find it optimal to commit to not raising advertising revenue. Third, regulation of the advertising volume might be welfare improving even if the unregulated advertising level is too low from a social point of view.

JEL-Code: L100.

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1 Introduction

TV channels are two-sided platforms serving both advertisers and viewers. However, in most countries TV content is sold and transmitted to the viewers by independently owned distributors. The distributors' role has nonetheless been neglected in most of the literature. The purpose of this paper is to analyze the implications of incorporating distributors with market power in media economics analyzes. Our findings suggest that central predictions in the literature might be reversed.

To investigate the role of the distributors, we set up a model with one content provider ("TV channel") and two distributors. The distributors earn revenue solely from the end-user market, while the TV channel makes revenue from the advertiser market and from charging the distributors. The distributors are horizontally differentiated a-la Hotelling. Each viewer connects to one and only one distributor, and has to pay a connection fee as well as a price for accessing TV content (viewer price). Consistent with observed price setting roles in most countries, we assume that connection and viewer prices are set by the distributors, while advertising prices are set by the TV channel. In our basic model we consider a pay-per-view price. Other things equal, this means that the distributors make higher profits the longer the viewers watch TV. However, our main results are robust to a relaxation of this assumption.[1]

In line with empirical investigations, we assume that the viewers dislike ads on TV. Thus, the higher the advertising volume, the lower will be the willingness to pay for watching TV. According to the existing theoretical literature, we should therefore expect that a TV channel which does not air ads (for instance due to regulatory interventions) will have higher viewer prices than a channel with ads.

[1] In the Appendix we solve the model under the assumption that consumers pay a fixed fee for accessing a TV channel (independent of actual viewing time). More specifically, we analyze whether viewers will want to buy a premium channel in addition to a basic bundle of TV channels offered by a distributor. The viewers are heterogeneous, so that the number of viewers buying the premium channel depends on the price. We show that our main results are valid also in this case. In fact, they hold as long as the price elasticity with respect to total consumption of TV-programs is different from zero. See Appendix A1.

Somewhat surprisingly, our model predicts the reverse result.

To understand this seemingly counterintuitive result, note that since the distributors do not receive advertising revenue, they will not internalize the positive effect that a low viewer price has on the industry's ability to raise advertising revenue through increasing the viewing time. However, they will internalize the negative effect that ads have on the viewers' demand for TV programs. For this reason, a distributor will take into account that when it triggers its costumers to watch more TV programs, it also triggers the TV channel to sell more advertisements. Since the latter is negative for the distributors, they will thus have incentives to set higher program prices than what would maximize profits if the TV channel for some reason were restricted in its ad volume. Hence, there is a counter-productive struggle between the TV channel and the distributors which leads to inefficiently high prices.

We show that a distributor's ability and incentives to use high program prices as a vehicle to reduce the advertising level are increasing in its market share. A distributor with a large market share will thus have higher viewer prices than a smaller rival, and the prices will be higher than what would otherwise maximize profits. An interesting implication of this is that profits per viewer are decreasing in a distributor's market share. This softens the competition between the distributors when they set the connection fees, because each of them knows that capturing more viewers than the rival leads to lower profits per viewer. Indeed, this mechanism softens competition to such an extent that the distributors make positive profits even if they are undifferentiated. This is in sharp contrast to standard results, where undifferentiated firms make zero profits in competitive equilibria.

Our model can easily be applied to analyze the consequences of regulating the amount of advertising on TV. It follows from our discussion that setting a binding advertising cap influences the market outcome even if the regulated amount of advertising is set equal to the one we would observe in an unregulated economy. The reason is that a cap eliminates the distributors' incentives to use high program prices as a vehicle to reduce the advertising volume. The TV channel can exploit this by setting a higher wholesale price. A cap on the amount of advertising will therefore lead to higher profits for the TV channel and lower profits for the distributors. Perhaps most interestingly, an advertising cap will also increase welfare, independent of whether the market otherwise underprovides or overprovides ads.

There are numerous articles analyzing the TV industry as a two-sided market. Gabszewicz et al. (2004), Anderson and Coate (2005), and Kind et al. (2007, 2009), for instance, analyze the nature of competition between media firms, but they abstract from the distribution segment of the market. Armstrong (1999), Stennek (2007), Weeds (2009) and Bergh (2011) explicitly analyze the role of distributors' incentives, and focus on the incentives for a TV channel to be exclusively distributed. Hagiu and Lee (2011) have a similar focus, and show that the incentives for exclusive distribution depend on whether it is the content provider or content distributors who control prices in the end-user market. Bel et al. (2007) and Kind et al. (2010) are concerned with the market imperfections that arise in the relationships between such firms, but do not analyze vertical strategic interaction between a content provider and competing distributors.

The rest of this paper is organized as follows. In the next section we present our model, and in Section 3 we analyze the market equilibrium. In Section 4 we provide some concluding remarks.

2 Some preliminaries

We model a TV industry where a variety of differentiated TV programs are supplied by a TV channel and sold to consumers on a pay-per-view basis by two competing distributors.[2] We assume that each consumer connects to one and only one distributor. To simplify the algebra, we normalize the number of available programs to unity, and treat the number of programs that a consumer watches as a continuos variable. Let $u = c(1-c)$ be the gross utility that a representative consumer derives if he consumes the c programs he likes the most.

The consumers pay a monetary price equal to p_i per program they watch at distributor $i = 0, 1$. Additionally, the net utility of watching TV depends on the advertising level, A_i; the more ads there are in the programs, the lower the consumer

[2] The assumption of pay-per-view is relaxed in Appendix A1

surplus, all else equal. This reflects the fact that most viewers seem to dislike ads on TV.[3] To capture this, we let the subjective consumer cost for watching a program be $(p_i + \gamma A_i)$, where $\gamma > 0$ is a parameter scaling the disutility of being exposed to advertisements.

Consumer surplus from watching TV at distributor i is thus given by

$$s_i(\circ) = u_i - (p_i + \gamma A_i)\, c_i. \tag{1}$$

Solving $\partial s_i / \partial c_i = 0$ gives the following per-consumer demand for TV-programs:

$$c_i(A_i, p_i) = (1 - \gamma A_i - p_i)\, /2. \tag{2}$$

We open up for the possibility that the consumers consider the distributors as being horizontally differentiated. There are several reasons why this might be the case, for instance that the distributors use different transmission technologies or that they offer other channels in addition to the channel included in the model. The exact source and magnitude of the differentiation are of no importance for our results.[4] Like Armstrong (1999) and Stennek (2007) we therefore assume that the degree of differentiation is exogenous, and that the consumers' preferences are uniformly distributed over a Hotelling line of unit length. Distributor 0 is located to the far left on this line, and distributor 1 to the far right. The degree of differentiation between the distributors is measured by the "transportation costs" parameter $t \geq 0$.

The distance between a consumer located at x and distributor 0 is given by $x \in [0, 1]$. The net utility from connecting to distributor 1 for this consumer equals

$$U_0 = v - tx + s_0 - F_0,$$

where v is a positive constant and F_0 is the subscription fee charged by the distributor.[5] The net utility from connecting to distributor 1 is likewise given by

[3] It is well documented that viewers consider advertising breaks on TV as a bad; see Moriarty and Everett (1994), Danaher (1995), and Wilbur (2008).

[4] In fact, our results also hold in the special case where the distributors are perceived as perfect substitutes.

[5] For a distributor offering triple-play, $v > 0$ may for instance represent the utility of telephone and internet access.

$U_1 = v - t(1-x) + s_1 - F_1$. We assume that v is sufficiently large to ensure market coverage, and that each distributor has a positive market share. Setting $U_0 = U_1$ we then find that the number of viewers connected to distributor i equals

$$N_i = \frac{1}{2} + \frac{(s_i - F_i) - (s_j - F_j)}{2t}, \tag{3}$$

for $i, j = 0, 1$, $i \neq j$, and $N_i = 1 - N_j$.

Let f be the wholesale price that the TV channel charges each distributor per program a viewer watches. Setting other costs equal to zero, distributor i's profits can be expressed as

$$\pi_i = N_i \left[c_i (p_i - f) + F_i\right]. \tag{4}$$

Note that f is distributor i's marginal cost and the TV channel's marginal revenue per program consumed.

In addition to the revenue that the TV channel makes from the distributors, it also earns revenue from the advertising market. Letting r denote the price per ad per viewer, advertising revenue equals $rA_0N_0 + rA_1N_1$.[6] We assume that the content provider cannot discriminate between the distributors in terms of advertising levels per program, so we may set $A_0 = A_1 = A$. Since $N_0 + N_1 = 1$, the TV channel's profit can be expressed as

$$\Pi = rA + f(N_0c_0 + N_1c_1), \tag{5}$$

where the first and second terms are the revenue that the TV channel makes from the advertising market and from the distributors, respectively.

By advertising, a producer is able to inform consumers about the products it sells, and the more programs a consumer watches, the greater is the likelihood that he becomes aware of a given ad. The expected value of an ad is thus increasing both in the number of viewers and in each consumer's viewing time. We consequently follow Reisinger (2010) in assuming that the gross benefit for a representative producer of inserting an ad is $(N_ic_i + N_jc_j)$. If producer k buys A_k advertising slots, its profit

[6] Alternatively, we could have assumed that the advertiser pays per slot. It can easily be shown that this would not change our results.

function is consequently equal to

$$\pi_k = (Ac_0 - Ar)\,N_0 + (Ac_1 - Ar)\,N_1, \tag{6}$$

where $k = 1, .., n$.

The first-order condition for advertiser k's demand for ads is found by using equations (2), (3) and (6) to solve $\partial\pi_k/\partial A_k = 0$. Setting $A = \sum^n A_k$ and using that $N_0 + N_1 = 1$, we have

$$A = \frac{n}{n+1}\frac{N_0\,(1-p_0) + N_1(1-p_1) - 2r}{\gamma}. \tag{7}$$

Equation (7) shows that advertising demand is decreasing in the program prices charged by the two distributors. This simply reflects the fact that higher program prices reduce the time consumers spend watching TV. We further see that the number of advertisers merely serves to scale total advertising demand. As a simplification, we therefore set $n = 1$. The Appendix shows that our qualitative results hold for any finite number of advertisers.

Inserting for equations (2) and (7) into equation (5) we can now express the content provider's profits as a function of prices and market shares:

$$\Pi = \frac{1 - 2r - (N_0p_0 + N_1p_1)}{2\gamma}r + \frac{1 + 2r - (N_0p_0 + N_1p_1)}{4}f. \tag{8}$$

The first term on the right-hand side of (8) is advertising revenue and the second term is revenue earned from the distributors.

Using equations (2), (4) and (7) we find the profit level of distributor i :

$$\pi_i = N_i\left[\frac{1 + 2r - p_i + N_j\,(p_j - p_i)}{4}\,(p_i - f) + F_i\right]. \tag{9}$$

Before solving for market equilibrium, the following may be noted (see Appendix A2 for proof):

Lemma 1: *Aggregate profits for the content provider and the distributors are maximized by setting;*

(a) $p_i = 0$ *and* $A > 0$ *for* $\gamma \leq 1/3$,

(b) $p_i > 0$ *and* $A > 0$ *for* $\gamma \in (1/3, 1)$ *and;*

(c) $p_i > 0$ *and* $A = 0$ *for* $\gamma \geq 1$.

The intuition for Lemma 1 is straight forward; if the audience has a strong aversion towards ads ($\gamma \geq 1$), aggregate profits are maximized by letting the programs be advertising-free. Otherwise, the audience's willingness to pay for watching TV will be excessively low. If the aversion to advertising is weak, on the other hand, it is optimal to set a low end-user price to increase consumption of TV programs and sell more ad space. Indeed, for $\gamma \leq 1/3$ it would be optimal with negative viewer prices, if feasible. Finally, for $\gamma \in (1/3, 1)$ aggregate profits are maximized through setting a positive end-user price and a positive advertising level.

3 Market equilibrium

Below, we analyze a three-stage game. At stage 1 we let the content provider determine the wholesale price f. At stage 2, after observing the wholesale price, the distributors compete for viewers by setting connection fees. The content prices and the advertising price are set simultaneously at stage 3. Since a consumer can only buy content from the distributor he is connected to at stage 3, a rational and forward looking consumer will anticipate and take into account the stage 3 content prices when choosing distributor at stage 2.

Summing up the game:

1 . The content provider sets the wholesale price f.

2 . The distributors set connection fees, F_0 and F_1, and each consumer decides which distributor to connect to.

3 . The distributors set program prices (p_0 and p_1) and the content provider sets the advertising price, r.

The structure of the game reflects what we consider to be the degree of flexibility in the prices.

Before we solve the game, it is useful to find the equilibrium program prices if the advertising level is fixed at $A = \bar{A}$. From equations (2) and (4) we then have

$\pi_i = N_i \left[c_i \left(p_i - f\right) + F_i\right]$, with $c_i = \left(1 - \gamma \bar{A} - p_i\right)/2$. Distributor i's profit is thus independent of p_j, and solving $d\pi_i/dp_i = 0$ yields

$$p_i = \left(1 - \gamma \bar{A} + f\right)/2. \tag{10}$$

For the sake of later use, we state the following result:

Lemma 2: *Suppose that the advertising level is fixed at* $\bar{A} \geq 0$ *Then each distributor's profit-maximizing price is*

(a) independent of the price charged by its rival $(dp_i/dp_j = 0)$*, and*

(b) decreasing in the viewers' disutility of ads if $\bar{A} > 0$ $(dp_i/d\gamma < 0)$.

The statements in Lemma 2 are intuitive. Part *(a)* is a direct implication of the fact that the consumers choose distributor at stage 2. There is thus no competition between the distributors when they set their program prices at the final stage of the game. Part (b) is also rather obvious; for any given advertising level, the willingness to pay for watching TV is decreasing in the viewers' disutility of ads. We therefore find that the greater the disutility, the lower will be the optimal program prices.

We are now ready to solve the three-stage game to find the market equilibrium, and we use backward induction. When solving for the last two stages, we implicitly assume that advertising levels and program prices are non-negative. The conditions which ensure that this holds are derived when we analyze the first stage.

3.1 Stage three

At this stage the distributors set their program prices and the content provider its advertising price, all taking the wholesale price f and the distributors' market shares (N_0 and N_1) as given. It is instructive to solve the optimization problems for the two types of agents separately. Starting with the TV channel, we find that $\partial \Pi / \partial r = 0$ yields

$$r = \frac{1 + f\gamma - \left(N_0 p_0 + N_1 p_1\right)}{4}. \tag{11}$$

The higher the wholesale price f, the more does the TV channel gain from a large consumption of TV programs, c.f. equation (5). The incentives to enhance the viewing time at the cost of having a low advertising volume is consequently increasing in f ($dA/df < 0$). Since the demand curve for ads is downward-sloping we thereby find $dr/df > 0$. Higher program prices, on the other hand, reduce the viewing time and thus also demand for ads. This explains why $dr/dp_i < 0$. Finally, if the viewers' disutility of ads increases, it is optimal to reduce the advertising volume and instead charge a higher advertising price, such that $dr/d\gamma > 0$.

Let us now turn to the distributors' maximization problem. Solving $\partial\pi_i/\partial p_i = 0$, we find

$$\frac{\partial \pi_i}{\partial p_i} = \left[c_i + (p_i - f)\frac{\partial c_i}{\partial p_i} \right] + (p_i - f)\underbrace{\frac{\partial c_i}{\partial A}\frac{\partial A}{\partial p_i}}_{+} = 0. \tag{12}$$

The terms in the square bracket in equation (12) show that setting a higher program price has the standard direct effect of increasing the profit margin and reducing sales. However, there is also a positive indirect effect of increasing the program price, namely that it reduces the advertising level ($\partial A/p_i < 0$). In isolation, this increases consumption of TV-programs ($\partial c_i/\partial A < 0$). Since the distributor's profit margin is equal to $(p_i - f)$, the value of this increased consumption is given by the term outside the bracket in (12). Each distributor will consequently have an incentive to set a relatively high program price in order to reduce the content provider's sales of advertising space. In Appendix A3 we show that this has the following striking implication:

Proposition 1: *Assume that the distributors are symmetric and that $f > 0$. Program prices are then higher if the advertising level is endogenously positive than if it is exogenously set to zero.*

The result that the price for watching a program with ads is higher than for watching a program where the advertising level is fixed to zero is at the outset rather surprising, since the viewers' marginal willingness to pay is decreasing in the ad level. Hence, it is seemingly in contradiction to Lemma 2 *(b)*. However, the paradoxical result in Proposition 1 is a direct consequence of the fact that when the advertising level is endogenous, the distributors choose a high program price in order to limit the TV channel's sales of advertisements.

Solving distributor i's maximization problem at stage 3, given by first-order condition (12), we find

$$p_i = \frac{1 + 2r + f + N_j (p_j + f)}{2(2 - N_i)}. \tag{13}$$

From equation (13) we observe, as we would expect, that distributor i responds by charging a higher program price if the wholesale price (f) increases $(dp_i/df > 0)$. We also see that program prices are increasing in the advertising price $(dp_i/dr > 0)$. This is simply because a higher advertising price decreases the advertising level, which in turn increases the viewers' willingness to pay for the programs.

The most surprising observation from equation (13) is the fact that p_i is a function of p_j. This is in stark contrast to the result in Lemma 2 (a), which states that program prices are strategically independent if the advertising level is exogenously determined. Since it is still true that the viewers are locked in when the distributors set the program prices, it must be through the endogenous advertising level that the prices are strategic complements;

Remark 1: *Program prices are strategic complements through the effects they have on the advertising level.*

To see the intuition for Remark 1, suppose that distributor j charges a higher program price. The result will be that the consumers connected to distributor j watch less TV $(dc_j/dp_j < 0)$. This reduces the willingness to pay for ads, and the TV channel responds by selling fewer advertising slots. Since less advertising is to the benefit of all viewers, they end up with a higher willingness to pay for watching TV, independent of which distributor they are connected to. Thus, it will be optimal for distributor i to charge a higher program price too.

Solving equations (11) and (13) simultaneously, and setting $N_1 = 1 - N_0$, gives the following equilibrium prices

$$
\begin{aligned}
r &= \frac{3(1-f)+5f\gamma}{24} - \frac{(N_0-1/2)^2}{D} && (14)\\
p_0 &= \frac{3\,(1+f)+f\gamma}{6} + \frac{N_0-1/2}{D\,(1+N_0)^{-1}} && (15)\\
p_1 &= \frac{3\,(1+f)+f\gamma}{6} - \frac{N_0-1/2}{D\,(2-N_0)^{-1}}, && (16)
\end{aligned}
$$

where $D = 6\,[5 + N_0\,(1-N_0)]\,/\,[3(1-f)+f\gamma] > 0$.[7]

Consistent with the TV channels reaction function, equation (11), we see that the advertising price is increasing in f and γ. The same qualitative relationship holds for program prices; $dp_i/df > 0$ and $dp_i/d\gamma > 0$. The fact that end-user prices are increasing in f is a standard result; higher marginal costs lead to higher selling price. The intuition for why program prices are increasing in the advertisement disutility (γ), is that an increase in disutility leads to lower advertising demand and sales. This has a positive effect on the willingness to pay for watching TV, which in turn makes it optimal for the distributors to increase program prices. Note that this result ($dp_i/d\gamma > 0$) is the opposite of what we found with an exogenous advertising level, c.f. Lemma 2 *(b)*:

Proposition 2: *The prices of programs;*
(a) increase with the disutility of ads if the advertising level is endogenous, and;
(b) decrease with the disutility of ads if the advertising level is exogenous.

From first-order condition (12) it can be shown that independent of any size differences between the distributors, we always have $c_0 = c_1$ and $p_0 = p_1$ if the advertising level is fixed. Interestingly, this changes if the advertising volume is endogenous. This can be seen from equations (15) and (16), which show that $p_i > p_j$ if $N_i > 1/2$. The explanation hinges on the fact that program prices, through their effect on total consumption level, determine the optimal advertising volume. Recall that demand for advertising depends on the total viewing time at the two

[7] Remark 1 and equations (14) - (16) are proved for an arbitrary number of advertisers in Appendix A4 and A5, respectively.

distributors, and the audience shares (N_0 and N_1) serve as weights that settle each distributor's effect on total consumption. This implies that a distributor with a large market share to a greater extent than its rival is able to affect advertising demand. This can be verified by differentiating (7) with respect to p_i :

$$\frac{\partial A}{\partial p_i} = \frac{-N_i}{2\gamma}. \tag{17}$$

To see how the size of the market share affects the consumers' price sensitivity through the advertising market, we totally differentiate (2) with respect to p_i

$$\frac{dc_i}{dp_i} = \frac{1}{2}\left(-\gamma\frac{\partial A}{\partial p_i} - 1\right). \tag{18}$$

Inserting for (17) into (18) we have

$$\frac{dc_i}{dp_i} = -\frac{2 - N_i}{4}. \tag{19}$$

Program demand at distributor i is thus less sensitive to the price it charges the larger its market share. For a distributor with a large market share, this translates into a higher optimal program price:

Lemma 3: *When the advertising level is endogenous, a distributor charges a higher program price the larger its market share.*

An implication of Lemma 3 is that the larger the market share of distributor j, the higher demand distributor i will face from each of its connected consumers. Formally this is seen from

$$\frac{dc_i}{dp_j} = \frac{1 - N_i}{4} > 0\ .$$

The larger distributor thus imposes a positive externality on its rival. Put differently, the smaller distributor "free rides" on the high program price charged by the larger distributor. This has the interesting implication that profits per viewer for a distributor decrease with its market share. To see this, let $I_i \equiv c_i\left(p_i - f\right)$ define profits per viewer for distributor i. We then have

$$\frac{dI_i}{dN_i} = c_i^* \frac{dp_i}{dN_i} + \left(p_i^* - f\right)\frac{dc_i}{dN_i}, \tag{20}$$

where

$$\frac{dp_i}{dN_i} = \frac{9\left(2+6N_i+N_i^2\right)}{\left[3(1-f)+f\gamma\right]D^2} > 0 \text{ and } \frac{dc_i}{dN_i} = -\frac{9\left[11-2N_i\left(1-N_i\right)\right]}{4\left[3(1-f)+f\gamma\right]D^2} < 0. \quad (21)$$

Inserting for (21) into (20) yields

$$\triangle \equiv \frac{dI_1}{dN_1} = -\frac{27\left(3+N_1\right)\left[1+6\left(1-N_1\right)^2+N_1^3\right]}{8\left[3(1-f)+f\gamma\right]D^3} < 0.$$

We further have $\frac{d\triangle/\triangle}{d\gamma/\gamma} = \frac{2f\gamma}{3(1-f)+f\gamma} > 0$.

We can state:

Proposition 3: *A distributor's profit per viewer is decreasing in its market share, and more so the greater the viewers' disutility of ads.*

An interesting implication of the results above is that joint profits would increase if the distributors had reduced the end-user prices while the content provider had maintained the advertising level. In this sense end-user prices are inefficiently high. As stated by Lemma 3, the larger the market share for a distributor, the higher its price. Hence, the larger distributor charges the most inefficient price, and will consequently also make the lowest per-viewer profit. Size therefore comes with a cost in terms of lower profit per captured consumer (though a distributor's total profits are increasing in its market share; $d\pi_i/dN_i > 0$).

We have now derived the outcome at stage 3, which determines end-user and advertising prices as functions of the distributors' market shares.

3.2 Stage two

At stage 2 the distributors compete for the consumers by setting connection fees, F_0 and F_1. The connection fees determine the market shares N_0 and N_1, which we have seen to be crucial for the third stage outcome.

When choosing the optimal connection fee, distributor i maximizes

$$\pi_i = N_i\left[c_i\left(p_i-f\right)+F_i\right] \quad (22)$$

with respect to F_i, taking into account that the consumers are forward looking. In Appendix A8 we show that this gives rise to a unique, symmetric equilibrium. Omitting subscripts, we have

$$F = t - \left[\frac{3(1-f) + f\gamma}{12}\right]^2. \tag{23}$$

Note that we might interpret F as the connection fee net of any marginal costs for the distributors.[8] It then follows from equation (23) that the connection fees can be set below the distributors' marginal costs (but above zero). This can occur if the transportation cost, the wholesale price or the disutility of ads are sufficiently low. Such pricing is in line with observations, as we sometimes see that distributors for instance offer connection equipment at a subsidized price.

For any fixed wholesale price $f = \bar{f}$, equation (23) implies that:

Proposition 4: *Assume $\bar{f} > 0$. Then each distributor charges a connection fee which;*

(a) is increasing in transportation costs t and the marginal wholesale price ($dF/dt > 0$, $dF/d\bar{f} > 0$), and;

(b) is decreasing in the viewers' disutility of ads ($dF/d\gamma < 0$).

Since high transportation costs dampen competition between the distributors, it is a standard result that the connection fee is increasing in the transportation cost. A higher advertising disutility reduces the advertising volume. Other things equal, this increases the distributors' per-viewer revenue at stage 3. Thereby each distributor will have a stronger incentive to set a low connection fee, in order to capture viewers from its rival; this business-stealing effect explains why $dF/d\gamma < 0$. A higher marginal wholesale price, on the other hand, reduces the distributors' profit margins, and thus also their business-stealing motive. Therefore the connection fee is increasing in f; $dF/df > 0$.

Inserting for (23) into the distributors' profit function we find

[8] If we solved the model with a positive marginal cost K, we would find that the connection fee equals $P = F + K$

$$\pi = \frac{t}{2} + \left[\frac{3(1-f)+f\gamma}{24}\right]^2. \tag{24}$$

From equation (24) we derive the standard results that the distributors are harmed by higher marginal costs ($df > 0$), but benefit from being perceived as more differentiated ($dt > 0$). More interestingly, equation (24) shows that the distributors' profit increases with the consumers' disutility of ads for any given wholesale price f, even though the connection fee is decreasing in γ. The intuition follows from Proposition 3; the higher is γ, the more profits per viewer will fall for a distributor when it expands its market share. Thus, it is more costly to capture a large share of the market when γ is high, and this effect softens competition.[9] The result is that the distributors' profit is higher than the standard Hotelling profit $t/2$, and even more remarkable, positive also for $t = 0$:

Proposition 5: *The distributors make positive profits even if they are undifferentiated ($t = 0$).*

3.3 Stage one

We now turn to stage 1, where the wholesale price f is determined. This could clearly be done in several different ways, for instance through a bargaining process between the content provider and the distributors. Somewhat surprisingly, it turns out that the TV channel - the firm that receives the advertising revenue - may have incentives to set f such that it is credible that there will be no ads in the programs. In order to demonstrate this, we shall assume that the TV channel unilaterally sets the wholesale price. We thus solve

$$f = \arg\max \left\{\Pi = rA + f\left(N_0 c_0 + N_1 c_1\right)\right\}. \tag{25}$$

The first-order condition implies that

[9] There is also a second reason why $d\pi/d\gamma > 0$, namely that since $\frac{dp_i}{dN_i} > 0$ and $\frac{dp_j}{dN_i} < 0$, it must also be true that $\frac{d}{dN_i}\left(u(p_i) - u(p_j)\right) < 0$. Thus, the larger market share a distributor is expected to gain, the more it must reduce the connection fee in order to persuade the marginal viewers to connect.

$$f^* = 3\frac{17\gamma - 3}{102\gamma - (\gamma^2 + 9)}, \tag{26}$$

with $df^*/d\gamma > 0$. The wholesale price is increasing in γ, because the higher the disutility of advertising, the less advertisements it is optimal for the TV channel to sell, all else equal. An increase in γ thus makes it optimal for the TV channel to set a higher wholesale price in order to increase revenue from the consumer side of the market.

Given f^*, the profit of the TV channel and the distributors are respectively

$$\Pi^* = \frac{9\gamma}{2\left[102\gamma - (\gamma^2 + 9)\right]}, \tag{27}$$

$$\pi^* = \frac{t}{2} + \left[\frac{2\gamma(3+\gamma)}{102\gamma - (\gamma^2 + 9)}\right]^2. \tag{28}$$

From the analysis above, we know that the TV channel is adversely affected by the fact that the distributors strategically increase program prices in order to repress the advertising level. Since high program prices in turn reduce the TV channel's sales of programs, the question arises whether it could actually be profitable for the content provider to commit to being advertising-free. For such a commitment to be credible, the TV channel's profit margin from the consumer side must be so high that selling ads becomes unprofitable. The following can now be verified:[10]

Lemma 4: If the *TV channel commits to being advertising-free, it maximizes its profit by setting* $f = f^{**}$, *where*

(a) $f^{**} = \frac{1}{2\gamma+1} > \frac{1}{2}$ *for* $\gamma < 1/2$, *and*

(b) $f^{**} = 1/2$ *for* $\gamma \geq 1/2$

Other things equal, the incentive to sell advertising space is decreasing in γ. This means that the higher is γ, the lower is the critical value of the wholesale price which ensures that it is optimal for the content provider to set $A = 0$. This explains why $df^{**}/d\gamma < 0$ for $\gamma < 1/2$. If the consumers' disutility of ads is sufficiently high, though, the content provider prefers not to sell ads even if the wholesale price is

[10] See Appendix A10.

equal to the one that would have been optimal in a one-sided market ($f = 1/2$). Thereby we have $f^{**} = 1/2$ *for* $\gamma \geq 1/2$.

Inserting for f^{**} into the profit function of the content provider yields $\Pi^{**} = \frac{\gamma}{2(2\gamma+1)^2}$ for $\gamma < 1/2$ and $\Pi^{**} = 1/16$ otherwise. Since the content provider prefers to have no ads if $\Pi^{**} > \Pi^{*}$, we can use equation (27) to find:

Proposition 6: *Suppose that* $\gamma > \gamma^* \equiv 3\left(11 - \sqrt{47}\right)/37 = 0.34$. *Then the TV channel chooses a wholesale price* ($f = f^{**}$) *which makes it credible that the programs will carry no ads.The profit level of each distributor equals* $\pi^{**} = t/2 < \pi^{*}$.

Somewhat paradoxically we thus find that even though the inclusion of ads in the programs is a form of product damaging from the distributors' point of view, their profits fall if the TV channel commits to not selling ads. The reason is that profits per viewer will then be independent of market size, such that the competition softening mechanism discussed in 3.2 disappears. In this case the distributors will thus only make the standard Hotelling profit.[11]

Finally, note that since $f = 1/2$ would have been optimal from the content provider's point of view in a one-sided market, and the end-user price is increasing in f for any given advertising level (and in particular for $A = 0$), a direct implication of Lemma 4 is that:

Corollary 1: *The existence of an advertising market implies that end-user prices are higher than they would be in a one-sided market if* $\gamma^* < \gamma < 1/2$.

3.4 A regulatory cap on advertising

Many countries have restrictions on the amount of advertising allowed on TV, and there is a large strand of literature that discusses pros and cons of such regulation (see for instance Anderson and Coate, 2005, Peitz and Valletti, 2008, and Kind et al, 2007). The typical result is that advertising caps harm TV channels, but that the net effect for society is ambiguous. The ambiguity is partly due to the fact

[11] The advertising level is thus positive only if $\gamma < 0.34$, and it can further be shown that positive viewer prices require $\gamma > 0.12$. Assumption 1 above consequently holds for $0.12 < \gamma < 0.34$.

that equilibrium ad levels may be too high or too low from a social point of view, depending on, *inter alia*, the consumers' disutility of ads. Not surprisingly, the literature argues that if there is too little advertising in a free market economy, then a binding cap on advertising reduces welfare. However, the existing models neglect the role of distributors. The aim of this section is to show that once we include distributors in the analysis, we find that a cap on ads may benefit TV channels and actually improve welfare even if the market undersupplies ads.

Let p^* and r^* denote viewer and advertising prices in the symmetric equilibrium derived above, and let $\hat{p}$ and $\hat{r}$ denote the corresponding prices in a regulated economy, where $\hat{A}$ is the advertising cap. Assume further that the advertising cap is set at the unregulated equilibrium level, $\hat{A} = A^*$.

The first thing to note is that the distributors' incentives to set (inefficiently) high program prices in order to repress the advertising level is no longer present. It can therefore be shown that the advertising cap reduces program prices ($\hat{p} < p^*$), such that the consumption level increases: $\hat{c} \equiv c(\hat{p}, \hat{A}) > c^* \equiv c(p^*, A^*)$ for $\hat{A} = A^*$. The higher consumption level in turn leads to a higher advertising price. Since the advertising volume is unchanged, it follows directly that the TV channel's advertising revenue is higher under regulation. The advertisers, on the other hand, are indifferent to the cap, since by assumption we have $\hat{A} = A^*$.

When it comes to the TV channel's revenue from the consumer side of the market, there are two effects that both contribute to increasing profit: First, consumption will be higher under regulation, which for a given wholesale price (f) clearly increases profit. Second, since the distributors no longer strategically overprice the programs, it is optimal for the TV channel to charge a higher wholesale price, i.e. $\hat{f} > f^*$ (see Appendix A11).

For the distributors however, a binding advertising cap is bad news. The explanation is that the cap eliminates the competition softening mechanism provided by an endogenously determined advertising level. Regulation consequently leads to tougher competition between the distributors. Indeed, with regulation the distributors will only make the standard Hotelling profit; $\pi_i = t/2$.

Since the cap leaves the advertising volume unchanged but increases consumption of TV programs, it follows that the regulation is welfare improving (smaller deadweight loss on the consumer side of the market). A stricter cap will harm the advertising side of the market, though, and if the cap becomes sufficiently strict we should expect welfare to fall. Clearly, also the TV channel is harmed if $\hat{A} << A^*$. However, because the cap $\hat{A} = A^*$ leads to a positive jump in welfare and in profits for the TV channel, we can nonetheless use a continuity argument to state:[12]

Proposition 7: *An advertising cap is welfare improving and increases the TV channel's profit unless the cap is too strict. The distributors are harmed by the cap.*

4 Some Concluding Remarks

The purpose of this paper is to investigate how the TV industry, with its two-sided nature, is affected by the fact that end-user prices typically are set by distributors and not by TV channels. Most theoretical studies have neglected the distributors' role, and in this paper we have shown that central predictions from the existing literature may be reversed by incorporating such firms. For instance, end-user prices may be higher in a TV channel with ads than without ads, distributors may make a positive profit even when they are perceived as being perfect substitutes, and an advertising cap may be welfare improving even when the non-regulated advertising level is too low from a social point of view.

The key to understanding these results is to note that imperfect vertical coordination leads to an equilibrium where the advertising level is inefficiently low and program prices are inefficiently high. The underlying mechanism which has hitherto been neglected in the literature is that distributors internalize the negative effect advertising has on demand for TV programs, but do not internalize the positive effect a high consumption of TV programs has on advertising revenue.

[12] A curiosity is that an advertising cap $\hat{A} > A^*$ might actually be employed to increase the advertising level. The intuition for this is most easily seen by noting that if the cap is set just above market equilibrium, then a distributor will be better off by setting program prices which are optimal given the regulated advertising level, rather than by setting a higher price with the aim of reducing the advertising level to the non-regulated level.

In order to illustrate as simply as possible the consequences of the fact that different firms set prices on the two sides of the market, we assume that the TV channel sets a linear wholesale price to the distributors. Standard intuition would tell us that the TV channel has incentives to boost consumption and advertising revenues by selling its programs at a low price to the distributors. However, we find that we may have exactly the opposite result - the TV channel could be better off by setting a very high wholesale price in order to credibly commit not to sell advertisements. More generally, we find that in such a market structure the amount of advertising is lower than what is optimal for the TV industry as a whole.

In theory the firms could use sophisticated wholesale contracts to internalize the externalities across the two sides of the market. In particular, they could let the distributors' payment to the TV channels depend on the TV channels' advertising revenues. However, well informed regulators and TV distributors claim that the current industry norm is a wholesale price that depends on the number of subscribers and not on the TV channels' advertising revenues.[13] If the wholesale contract specifies a linear price, or even a two-part tariff, it means that the industry does not fully internalize the fact that different firms set prices on the two sides of the market. It is consequently necessary to understand the strategic behavior of distributors to understand the functioning of the TV industry, and the present paper is a step in that direction.

[13] See Ofcom (2010), where they write the following concerning regulation of the pay TV industry: '.. *we proposed to put in place linear, per subscriber prices such that a retailer's payments for the wholesale channels would increase linearly with the number of subscribers. Our proposed approach is the current industry norm.* (paragraph 10.36, p. 521)' ... *The Three Parties (BT, Top UP TV and Virgin Media) agreed with our proposed approach to set linear, per subscriber charges in recognition of the fact that this is the current industry norm.'* (paragraph 10.37, p. 521) Although linear prices are the industry norm, both the Three Parties and Sky argue that they should be able to negotiate two-part tariffs However, this would not solve the problems related to the two-sidedness of the market that we focus on.

5 Appendix

Appendix A1: Proof that the Stage 3 results hold with time-independent viewer prices

This section shows that the main results from stage 3 are not restricted to a "pay-per-view" setup. As in the main section, let there be two distributors and a unit mass of consumers. To make comparisons with the results in Section 3.3. meaningful, we assume that the distributors' market shares are determined at an earlier stage.

Both distributors sell a basic bundle of channels and unlimited access to some premium content, for instance a premium channel. We assume that the distributors employ tying strategies, i.e. conditional on having bought the basic bundle, the consumer can buy access to the premium content. This is the most common business model both in Europe and the USA.[14] We will now analyze the pricing game when the distributors set access prices to their base of costumers.

The net utility for a type $\theta \sim u[0,1]$ consumer is:

$$s(\circ) = \theta - p_i - \gamma A, \tag{A1}$$

where p_i is the price of access, γ is the disutility of advertisements, and A is the advertising level. The consumer buys access if $s(\circ) \geq 0$, thus, for the indifferent consumer $\bar{\theta}_i = p_i + \gamma A$. The share of the population that buys access is then:

$$1 - \bar{\theta}_i = 1 - [p_i + A_i \gamma]\,. \tag{A2}$$

Having a market share N_i the distributor then faces demand $N_i(1-\bar{\theta}_i)_i$. If the content provider charges a linear wholesale price f per viewer, distributor i and the content provider make the following profit, respectively:

$$\begin{aligned} \pi_i &= N_i \left[(p_i - f) \left(1 - \bar{\theta}_i\right) + F_i \right], && \text{(A4)} \\ \Pi &= rA + f \left[N_0 \left(1 - \bar{\theta}_0\right) + N_1 \left(1 - \bar{\theta}_1\right) \right]. && \text{(A5)} \end{aligned}$$

[14] See, for instance, Crawford (2008) and Crawford and Yurukoglu (2011).

As in the "pay-per-view" section, the price of an advertisement is r.[15]

For simplicity, assume that if a consumer buys access to the content provider, he will consume all the available content. The number of viewers that is exposed to an advertisement is then $N_0\left(1-\bar{\theta}_0\right)+N_1\left(1-\bar{\theta}_1\right)$. We can then write the profit function for advertiser k, given by equation (6) in the main section, as:

$$\pi_k = A_k N_0\left(1-\bar{\theta}_0\right)+N_1\left(1-\bar{\theta}_1\right)-A_k r.$$

By first solving $\partial\pi_k/\partial A_k = 0$ for A_k and then setting $n=1$ we obtain the advertising demand as:

$$A = \frac{1-r-N_1p_1-N_0p_0}{2\gamma}. \tag{A7}$$

The optimal access price charged by distributor $i=1,2$ is characterized by:

$$\frac{\partial\pi_i}{\partial p_i} = N_i\left(1-\bar{\theta}_i\right)-N_i\left(\frac{\partial\bar{\theta}}{\partial p_i}+\frac{\partial\bar{\theta}}{\partial A}\frac{dA}{dp_i}\right)(p_i-f)=0, \tag{A8}$$

where $\partial\bar{\theta}/\partial p_i = 1$, $\partial\bar{\theta}/\partial A = \gamma$ and $dA/dp_i = -N_i/2\gamma$. Using equation (A7) we obtain the best response function:

$$p_i = \frac{1+(2-N_i)\,f+r+(1-N_i)\,p_j}{2\,(2-N_i)}. \tag{A9}$$

From equation (A9) we observe that here, as in the main section, $\partial p_i/\partial p_j > 0$. Thus, end-user prices are strategic complements. *This result corresponds to Remark 1 in the main section*, and the intuition is analogue.

The best response function for the TV channel when it sets the advertising price is:

$$r = \frac{1+f\gamma-N_ip_i-(1-N_i)p_j}{2}. \tag{A10}$$

The three first order conditions constitute a system of there equations and three unknowns. By solving the system we obtain:

[15] We can use equations (A4) and (A5) to show that Lemma 1 from the "pay-per-view" section holds also for this set-up. That is, aggregate industry profits are maximized with $A^* > 0$ if $\gamma < 1$ and $A^* = 0$ if $\gamma > 1$

$$p_0 = D^{-1}\left\{9 + f(11 + 3\gamma) + N_0\left[3 + f(1 - 4N_0 + \gamma)\right]\right\}, \tag{A11}$$

$$p_1 = D^{-1}\left\{12 + f(8 + 4\gamma) - N_0\left[3 - f(7 - 4N_0 + \gamma)\right]\right\}, \tag{A12}$$

$$r = D^{-1}\left\{4\left[1 - f(1 - 2\gamma)\right] + N_0\left[5(1 - N_0)(1 - f) + 3f\gamma(1 - N_0)\right]\right\} \tag{A13}$$

where $D = 4\left[5 + N_1(1 - N_1)\right]$. From equations (A11) and (A12) it follows that $\partial p_i/\partial\gamma$. It can easily be shown that if the advertising level is exogenous, we have $p_i = (1 + f_i - \gamma A)/2$. *This result corresponds to Proposition 2 in the main section.*

The expected net revenue per consumer for distributor i is $\frac{\pi_i(f,\gamma)}{N_i} = (1 - \bar{\theta}_i)p_i$. It can now be shown that:

$$\frac{\partial\left(\frac{\pi_i(f,\gamma)}{N_i}\right)}{\partial N_i} < 0 \text{ and } \frac{\partial^2\left(\frac{\pi_i(f,\gamma)}{N_i}\right)}{\partial N_i \partial\gamma} < 0.$$

Thus, when a distributor increases its market share, the expected net revenue per viewer decreases. *This result corresponds to Proposition 3 in the main section.*

Setting $N_i = 1/2$ in equation (A11) and (A12) we obtain:

$$p_0 = p_1 = \frac{1 + f}{2} + \frac{1}{6}f\gamma \tag{A12}$$

It is straight forward to show that the optimal end-user price is $p_i = (1 + f)/2$ if the advertising level is fixed to zero. Thus, from equation (A12), it follows that the price is higher than when the advertising level is fixed to zero. *This result corresponds to proposition* 1 *in the main section.*

Appendix A2: Proof of Lemma 1

Maximizing $(\Pi + \pi_0 + \pi_1)$ from equations (8) and (9) with respect to p_0, p_1 and r, we find that the FOCs describe a unique, symmetric equilibrium where all second-order conditions and non-negativity constraints are satisfied if $1/3 < \gamma < 1$. The prices and the advertising level are then equal to

$$p_0 = p_1 = 3\frac{\gamma - 1/3}{6\gamma - \gamma^2 - 1},\ r = \gamma\frac{\gamma + 1}{2(6\gamma - \gamma^2 - 1)} \text{ and} \tag{29}$$

$$A = \frac{1 - \gamma}{6\gamma - \gamma^2 - 1}. \tag{30}$$

From (29) and (30) we immediately see that $p_i > 0$ iff $\gamma > 1/3$ and $A > 0$ iff $\gamma < 1$. *Q.E.D.*

Appendix A3: Proof of Proposition 1

The program price with exogenous advertising levels is given by equation (10). By evaluating this equation for $A = 0$ we obtain $p_i^{A=0} = \frac{1+f}{2}$. From equation (15) we further find that $p_i^* \mid_{N_0=N_1} = \frac{1+f}{2} + \frac{f\gamma}{6}$ with endogenous advertising levels. The difference between the prices is $p_i^* \mid_{N_0=N_1} - p_i^{A=0} = \frac{f\gamma}{6} > 0$ *Q.E.D.*

Appendix A4: Proof of Remark 1 with n advertiser

The FOC for distributor i is:

$$\frac{\partial \pi_i}{\partial p_i} = c_i + \left[\underbrace{\frac{\partial c_i}{\partial p_i}}_{-} + \underbrace{\frac{\partial c_i}{\partial A}}_{-} \underbrace{\frac{\partial A}{\partial p_i}}_{-} \right] (p_i - f) = 0$$

where

$$c_i(A_i, p_i) = (1 - \gamma A_i - p_i)/2$$

and

$$A = \frac{n}{n+1} \frac{N_i(1-p_i) + N_j(1-p_j) - 2r}{\gamma},$$

so $\partial c_i/\partial p_i = -1/2$, $\partial c_i/\partial A = -\gamma/2$ and $\partial A/\partial p_i = -nN_i/(1+n)\gamma$. Substituting this into the FOC we obtain:

$$\frac{\partial \pi_i}{\partial p_i} = \frac{1}{2} \left[\frac{n}{n+1} \left(2r + (N_i - 1)(p_i - p_j) + \frac{1-p_i}{n} \right) + \left(\frac{n}{1+n} N_i - 1 \right) (p_i - f) \right] = 0 \tag{31}$$

Now, set $n = 1$ and solve (31) for p_i to obtain equation (13). It follows directly from equation (13) that $\partial p_i / \partial p_j > 0$. *Q.E.D.*

Appendix A5: Derivation of equilibrium prices at stage 3 with n advertisers

With an arbitrary number of n advertisers, equations (8) and (9) become

$$\Pi = \frac{n}{1+n}\frac{1-2r-(N_0p_0+N_1p_1)}{\gamma}r + \frac{1+2nr-(N_0p_0+N_1p_1)}{2(1+n)}f \text{ and}$$

$$\pi_0 = N_0\left\{\frac{1-p_0+n[2r-N_1(p_0-p_1)]}{2(1+n)}(p_0-f)+F_1\right\}.$$

Solving $\partial\pi_0/\partial p_0 = \partial\pi_1/\partial p_1 = \partial\Pi/\partial r = 0$ yields

$$r = \frac{(n+2)(1-f)+f\gamma(n+4)}{8(n+2)} - \left(N_0-\frac{1}{2}\right)^2\frac{(n+1)\phi}{2} \quad (32)$$

$$p_0 = \frac{(n+2)(1+f)+fn\gamma}{2(n+2)} + \left(N_0-\frac{1}{2}\right)(nN_0+1)\phi \quad (33)$$

$$p_1 = \frac{(n+2)(1+f)+fn\gamma}{2(n+2)} - \left(N_0-\frac{1}{2}\right)[n(1-N_0)+1]\phi, \quad (34)$$

where $\phi \equiv \frac{n[(n+2)(1-f)+fn\gamma]}{(n+2)[(n+4)(n+1)+2n^2N_1(1-N_1)]}$. Equations (32) - (34) show that the qualitative relationship between prices at stage 3 and distributor 1's market share is the same as in equations (14) - (16). *Q.E.D.*

Appendix A6: Proof of Propostion2 with n advertisers

Consider the stage 3 prices given by equation (33) and note that:

$$\frac{\partial p_0}{\partial\gamma} = f\frac{n[n(1+N_0)+2]}{2[4+5n+n^2+2n^2N_0(1-N_0)]} > 0.$$

Appendix A7: Proof of Lemma 3 with n advertisers

Under endogenous advertising levels, the derivative of end-user price with respect to the market share is:

$$\frac{\partial p_i}{\partial N_i} = \left[\left(\frac{3}{2}-2N_i\right)n+1\right]\phi + \frac{d\phi}{dN_i}\left(N_i-\frac{1}{2}\right)[n(1-N_i)+1]$$

where

$$\frac{d\phi}{dN_i} = -2n^3\frac{1-2N_i}{n+2}\frac{n-2f-fn+fn\gamma+2}{(4+5n+n^2+2n^2N_i(1-N_i))^2}.\ Q.E.D.$$

Appendix A8: Derivation of the stage 2 equilibrium connection fees

Inserting for (32) - (34) into the viewers' utility function we find

$$\left.\frac{d(u_0-u_1)}{dN_0}\right|_{N_1=\frac{1}{2}} = -n\frac{[(n+2)(1-f)+fn\gamma]^2}{4(n+1)(n+2)(3n+4)}.$$

Differentiating $N_0 = \frac{1}{2} + \frac{u_0 - u_1}{2t} - \frac{(F_0 - F_1)}{2t}$ with respect to N_0 around the symmetric equilibrium ($N_0 = N_1 = 1/2$) we have

$$\left.\frac{dN_0}{dF_0}\right|_{N_0=\frac{1}{2}} = \frac{1}{2t}\left\{-n\frac{\left[(n+2)(1-f)+fn\gamma\right]^2}{4(n+1)(n+2)(3n+4)}\right\}\left.\frac{dN_0}{dF_0}\right|_{N_0=\frac{1}{2}} - \frac{1}{2t},$$

which yields

$$\left.\frac{dN_0}{dF_0}\right|_{N_1=\frac{1}{2}} = -\frac{8t(3n+4)(n+1)(n+2)}{2t\left\{n\left[(n+2)(1-f)+fn\gamma\right]^2 + 8t(3n+4)(n+1)(n+2)\right\}} \tag{35}$$

Further differentiating $\pi_0 = N_0(c_0(p_0 - f) + F_1)$ with respect to N_0 we have the FOC

$$\frac{d\pi_0}{dF_0} = \left[c_0(p_0 - f) + F_0\right]\frac{dN_0}{dF_0} + N_0\frac{d\left[c_0(p_1 - f)\right]}{dN_0}\frac{dN_0}{dF_0} + N_0 = 0. \tag{36}$$

where $\frac{d[c_0(p_0-f)]}{dN_0} = \frac{dI_I}{dN_i}$ Inserting for (35) into (36) with $N_0 = N_1 = 1/2$ we find

$$F_0 = t - \frac{\left[(n+2)(1-f)+fn\gamma\right]^2}{8(n+1)(n+2)^2} \tag{37}$$

Q.E.D.

Appendix A9: Proof of proposition 4 with n advertisers

The derivative of equation (37) with respect to γ is:

$$\frac{dF}{d\gamma} = -fn\frac{2+n-f(2+n(1-\gamma))}{4(n+1)(n+2)^2} < 0$$

and the derivative with respect to f is:

$$\frac{dF}{df} = \frac{(2+n(1-\gamma))\left[2+n-f(2+n(1-\gamma))\right]}{4(n+1)(n+2)^2} > 0.$$

Q.E.D.

Appendix A10: Proof of Lemma 4

There exists a non-advertising equilibrium if the content provider at stage 3 sets r such that $A = 0$. If distributor i expects that $A = 0$, it will set $p_i^{A=0} = (1+f)/2$. A pure strategy non-advertising equilibrium therefore exists if and only if the distributors set $p_i^{A=0}$ and the content provider sets f such that $A = 0$.

The optimal advertising price as a function of the end-user prices is given by equation (11), and inserting for $p_0^{A=0}$ and $p_1^{A=0}$ we obtain the advertising price that is optimal for the content provider, given that the distributors set the zero-advertising prices. This advertising price is

$$r(p_0^{A=0}, p_1^{A=0}) = \frac{1 - f + 2f\gamma}{8}. \tag{38}$$

If we now substitute for $p_0^{A=0}$, $p_1^{A=0}$ and $r(p_0^{A=0}, p_1^{A=0})$ into equation (7) we obtain:

$$A(p_0^{A=0}, p_1^{A=0}, r^*) = \frac{1 - f - 2f\gamma}{8\gamma} \tag{39}$$

In equilibrium the beliefs must be correct. Hence, there exists a non-advertising equilibrium if and only if equation (39) is non-positive. In particular, this means that the content provider maximizes profits by being advertising free if f is equal to, or higher than,

$$f^{A=0} = \frac{1}{2\gamma + 1} \tag{40}$$

In a one-sided market, i.e. if there did not exist any demand for advertising, the content provider would solve $\partial\Pi^{A=0}/\partial f = 0$, which gives $f = 1/2$. *Q.E.D.*

Appendix A11: Consequences of an advertising cap

Free-market advertising level and viewer price

Inserting for f^* from (26) into equations (15) and (7) with $N_0 = N_1 = 1/2$ we find

$$A^* = 3\frac{3 - 5\gamma}{102\gamma - (\gamma^2 + 9)}$$

and

$$p^* = \frac{75\gamma + 8\gamma^2 - 9}{102\gamma - (\gamma^2 + 9)}$$

Derivation of prices when advertising is regulated

From (10) we know that the program price with an exogenous advertising level equals $p = \frac{1-\gamma A+f}{2}$. Inserting for this into (7) yields $r = \frac{1-3A\gamma-f}{4}$. From equation (2) we further have $c = \frac{1-\gamma A-p}{2}$. The TV channel now maximizes (c.f. equation (5))

$$\Pi = rA + f\left(N_0 c + N_1 c\right)$$

with respect to f. Setting $A = A^*$ this implies that

$$\hat{f} = \frac{54\gamma + 7\gamma^2 - 9}{102\gamma - (\gamma^2 + 9)} \text{ and } \hat{p} = \frac{3}{2}\frac{49\gamma + 7\gamma^2 - 6}{102\gamma - (\gamma^2 + 9)}.$$

We now find that

$$\hat{f} - f^* = \frac{\gamma(7\gamma + 3)}{102\gamma - (\gamma^2 + 9)} > 0 \text{ and } \hat{p} - p^* = -\frac{(3 - 5\gamma)\gamma}{2[102\gamma - (\gamma^2 + 9)]} < 0.$$

Since $\hat{p} < p^*$ it follows that $\hat{c} > c^*$. *Q.E.D.*

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