



## Inter-firm price coordination in a two-sided market<sup>☆</sup>

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### ABSTRACT

In many two-sided markets we observe that there is a common distributor on one side of the market. One example is the TV industry, where TV channels choose advertising prices to maximize own profit and typically delegate determination of viewer prices to independent distributors. We show that in such a market structure the stronger the competition between the TV channels, the greater will joint profits in the TV industry be. We also show that joint profits may be higher if the wholesale contract between each TV channel and the distributor consists of a simple fixed fee rather than a two-part tariff.

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### 1. Introduction

The most widespread business model in the TV industry is one where different TV channels use a common distributor to reach the viewers. The TV channels set advertising prices on their own, but delegate to the distributor to determine the prices that the viewers have to pay. This delegation has the benefit that there will be no price competition between the TV channels in the viewer market; any business-stealing effects will be internalized by the distributor. In a traditional (“one-sided”) market, such inter-firm price coordination would always be beneficial to the firms. Other things equal, it would generate the same joint profit that would be obtainable in a perfect cartel. However, we show that this logic does not apply in a two-sided market.<sup>1</sup>

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<sup>1</sup> In the media sector we observe the use of a common distributor towards the end-users not only in the TV market, but also in the newspaper market. Another example is the market for game consoles, where the producers contract directly with software developers and sell hard- and software through retailers. For a definition of two-sided markets, see Weyl (2010). Examples, in addition to the TV industry, are other media industries, the payment-card industry, real-estate brokerage, and the computing industry (computer operating systems, software, game consoles etc.). See Wright (2004) for a general discussion of the problems associated with applying a one-sided logic to a two-sided market. Note, however, that he does not discuss the points we make in this paper.

To understand this, note that the distributor does not fully internalize the impact of high viewer prices on revenues from the advertising side of the market. Likewise, the TV stations, in setting their prices to advertisers, do not fully internalize the effect that advertising volume has on viewers' willingness to pay for watching TV. Due to these shortcomings, inter-firm coordination can lead to some seemingly counter-intuitive results. We find, for instance, that if the TV channels become less differentiated, then joint industry profits increase even though the TV channels compete more fiercely. The reason for this surprising result is that the lack of internalization becomes less serious if the competitive pressure increases.

In our analysis, we allow the distributor and each TV channel to bargain over a two-part wholesale contract that consists of a fixed fee and a unit wholesale price. Since the viewer price is increasing in the unit wholesale price, one might expect that the contract could be used to induce firms to set optimal end-user prices. The problem, however, is that the unit wholesale price affects the relative profitability between the two sides of the market and therefore changes both the viewer price and the advertising price. It follows that a two-part tariff does not solve the coordination problems. Indeed, we show that joint profits are higher if the industry can commit to simple fixed fees rather than to a two-part wholesale contract. To see why, note that, if a channel receives a higher unit wholesale price from the distributor, it will optimally reduce the ad volume in order to attract a larger audience. But then the rival channels will reduce their ad levels too, and their profits fall. This profit effect is not internalized in a non-cooperative equilibrium, so unit wholesale prices – and thus viewer prices – are distorted upwards. Two-part tariffs consequently lead to inefficiently high prices. Both the industry and the consumers would be better off if the

wholesale contracts instead consisted of simple fixed fees. Although we apply our model to the TV industry, the coordination problem we highlight is of relevance in all two-sided markets.

The focus on the TV industry is a timely one, since business models in this industry are about to change. The presence of the Internet has made it possible for TV channels to bypass independent distributors and instead sell directly to viewers. One example is Hulu, a US company that offers TV shows, clips, movies, etc., over the Internet.<sup>2</sup> Another example is the TV market in Norway, where it is possible to watch programs from both the public broadcaster and the largest commercial broadcaster directly over the Internet.<sup>3</sup> Bearing this technological development in mind, we analyze the consequences of skipping the distributor. In such a situation TV stations set prices non-cooperatively in both markets. Now, each firm takes into account the interdependence between the two sides of the market, and thus coordinates its prices (intra-firm price coordination). In other words, a TV station uses both viewer prices and advertising prices in order to account for the externalities involved between its two groups of consumers. The downside is that there will be no inter-firm coordination of prices, since the distributor has disappeared. We show that if TV stations' products are sufficiently differentiated in viewers' demand, so that competition for viewers is sufficiently lax, then a regime with intra-firm coordination of prices leads to higher industry profit than one with inter-firm coordination through the distributor. Welfare, on the other hand, is always higher in the former case.

Early studies of media markets, such as Steiner (1952), were mostly concerned with how competition for raising advertising revenue affects media plurality.<sup>4</sup> More recent studies – such as Rochet and Tirole (2003, 2006), Caillaud and Jullien (2003), Anderson and Coate (2005), Armstrong (2006), Kind et al. (2007, 2009), and Peitz and Valletti (2008) – emphasize how important it is to take the view that these industries are two-sided markets, serving both content consumers and advertisers. However, the media-economics literature does not analyze the kind of coordination problems that we focus on in this paper. Most models on competition between TV stations in two-sided markets, for example, either abstract from the role of distributors, or implicitly assume that these distributors are passive firms with no influence on end-user prices. This does not seem to fit well with how the TV industry typically is organized in most countries.

Bel et al. (2007) is the only other paper we are aware of that discusses the presence of distributors in a two-sided TV market.<sup>5</sup> They focus on a situation where a firm is vertically integrated, controlling both the distribution and the program production. They do not compare regimes where either distributors or TV stations set end-user prices, as we do here.

In the next section we present a model of the TV industry. In Section 3 we solve this model for the situation where the distributor sets viewer prices, and in Section 4 we solve it for the situation without the distributor, where each TV station sets both its prices. The outcomes are compared in Sections 5. In Section 6 we study a TV station's incentives to bypass the distributor unilaterally. Some further issues are discussed in Section 7, while Section 8 concludes. Appendixes A and B present a few elaborations of our analysis.

<sup>2</sup> See [hulu.com](http://hulu.com). One option is to pay a monthly fee (currently \$ 7.99), and then receive TV programs including commercial breaks.

<sup>3</sup> NRK is the public broadcaster, where access is free through [nrk.no](http://nrk.no) and there is no advertising. TV2 is the commercial broadcaster, where viewers can purchase access through the Internet portal [sumo.tv2.no](http://sumo.tv2.no). Sumo viewers pay directly as well as indirectly through watching advertising slots. Consistent with the assumptions we apply in our model, both the viewer and advertising prices are set by TV2. In addition to the reasons for bypassing distributors which we focus on in this paper, it should be noted that channels might also go on the Internet in order to enlarge the size of the market (e.g. by allowing people to watch TV on smart phones outside their homes).

<sup>4</sup> Steiner (1952) and Beebe (1977) discuss how competition affects content, while Spence and Owen (1977) discuss how financing of TV stations affects content.

<sup>5</sup> Vertical integration in a two-sided media market is discussed in Barros et al. (2004), though. But there the interest is with respect to integration between platforms and consumers, in particular between Internet portals and advertisers.

## 2. A model of the TV industry

We consider a setting with two TV stations that earn revenues from advertisers and viewers. The advertising level in the programs provided by TV station  $i$  (hereafter  $TV_i$ ) is denoted  $A_i$ , and the level of viewers' consumption of program content is denoted  $C_i$ ,  $i = 1, 2$ . Advertisers pay  $r_i$  per unit of advertising on  $TV_i$ , while consumers pay  $p_i$  per unit of program content.

The preferences of a representative viewer are given by the following quadratic utility function:

$$U = C_1 + C_2 - \left[ (1-s)(C_1^2 + C_2^2) + \frac{s}{2}(C_1 + C_2)^2 \right], \quad (1)$$

where  $s \in [0, 1]$  measures product differentiation: viewers perceive the TV stations' content as independent if  $s = 0$  and as perfect substitutes as  $s \rightarrow 1$ .

This formulation of viewer preferences has two realistic features. First, viewers do not choose just one TV station, but rather consume content from both TV stations; this is called multi-homing and is a feature of consumer behavior common in the TV industry that distinguishes it from many other two-sided markets. Secondly, viewers' total demand across TV stations is not fixed, which allows for viewers to respond to lower prices with an increase in total demand. Neither of these features is present in the Hotelling-line approach to viewer demand, which is widely used in analyses of media markets.<sup>6</sup>

Viewers' consumer surplus from watching  $TV_i$  depends both on the viewer price  $p_i$  and on the advertising level  $A_i$ . To capture this dependency, we follow the standard procedure in the media economics literature in letting the *generalized price* for watching content on  $TV_i$  be given by

$$G_i = p_i + \gamma A_i. \quad (2)$$

In Eq. (2),  $\gamma > 0$  measures viewers' disutility of being interrupted by ads.<sup>7</sup> The total price paid by viewers is thus the sum of the direct payment ( $p_i$ ) and the indirect payment ( $\gamma A_i$ ) due to disutility from watching ads. Consumer surplus can now be written as

$$CS = U - (G_1 C_1 + G_2 C_2).$$

We choose the unit size of advertising such that  $\gamma = 1$ . Viewers' demand for each media product is found by solving  $\frac{\partial CS}{\partial C_i} = 0$ ,  $i = 1, 2$ , to obtain:

$$C_i = \frac{1}{2} - \frac{(2-s)(A_i + p_i)}{4(1-s)} + \frac{s(A_j + p_j)}{4(1-s)}, \quad i, j = 1, 2, i \neq j. \quad (3)$$

There are a total of  $n$  advertisers interested in buying advertising space on the two TV channels. Let  $A_{ik}$  denote advertiser  $k$ 's advertising level on  $TV_i$ , such that  $A_i = \sum_{k=1}^n A_{ik}$ . The advertiser's gross gain from advertising on  $TV_i$  is naturally increasing in its advertising level and in the number of viewers exposed to the ads. We make it simple by assuming that the gross gain equals  $\eta A_{ik} C_i$ , where  $\eta > 0$ . This implies that the net gain for advertiser  $k$  from advertising on TV equals

$$\pi_k = \eta(A_{1k} C_1 + A_{2k} C_2) - (r_{1k} A_{1k} + r_{2k} A_{2k}), \quad (4)$$

where  $r_i$  is the advertising price charged by TV channel  $i$  for one unit of advertising.

<sup>6</sup> The merit of using the particular utility function in Eq. (1), which is due to Shubik and Levitan (1980), is that market size does not vary with; see Motta (2004) for further discussion.

<sup>7</sup> While advertisers obviously benefit from the presence of viewers, empirical studies like that of Wilbur (2008) indicate that the typical viewer has a disutility from the presence of advertising.

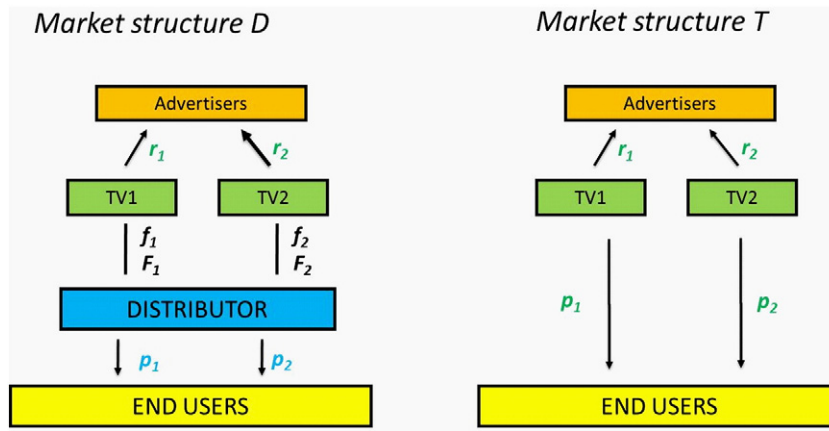


Fig. 1. Market structure with and without distributor.

Simultaneous maximization of Eq. (4) with respect to  $A_{1k}$  and  $A_{2k}$  for each  $k$ , subject to Eq. (3), yields the demand for advertising at TV channel  $i$ :

$$A_i = \frac{n}{n+1} \left[ (1-p_i) - \frac{1}{\eta} [2r_i - s(r_i - r_j)] \right]. \quad (5)$$

Our interest is in the situation where a downstream distributor buys the right to transmit programs to viewers. For this he pays  $TV_i$  a fixed fee  $F_i$  and a variable fee  $f_i$  per unit of program content that viewers watch ( $i = 1, 2$ ). The distributor subsequently sets the viewer price  $p_i$ , while  $TV_i$  sets the advertising price  $r_i$ ; see the left panel of Fig. 1, where we denote this situation  $D$ . We will compare this with another situation, denoted  $T$ , where the TV stations bypass the distributor and offer their content directly to the consumers, i.e.,  $TV_i$  sets both  $p_i$  and  $r_i$ ; see the right panel of Fig. 1.

These two market structures mirror what we can observe in the TV market. Traditionally, TV channels have been distributed through a common retailer. This could be a cable operator, a satellite provider, or a digital terrestrial TV network. Each TV station writes a contract with the distributor, and then the distributor sets prices to end users. On the other side of the market, each TV station contracts directly with advertisers. This corresponds to market structure  $D$ . Alternatively, the TV channels can bypass the distributor and sell directly to end-users, typically through the Internet, as Hulu is doing in the US and TV 2 Sumo is doing in Norway. This corresponds to market structure  $T$ , where a TV station contracts directly with both advertisers and end users.

We abstract from any costs for the TV stations and the distributor, except for access charges. Joint profits for these firms are thus equal to the sum of advertising revenue and consumer payment:

$$\Pi_j = \sum_{i=1}^2 (r_i A_i + p_i C_i). \quad (6)$$

Welfare is the combination of consumer surplus, joint industry profits, and advertisers' net payoffs:

$$Welfare = CS + \Pi_j + \sum_{i=1}^2 (\eta A_i C_i - r_i A_i).$$

After insertions, this becomes:

$$Welfare = U + (\eta - 1)(A_1 C_1 + A_2 C_2). \quad (7)$$

We make the following assumption in order to simplify the analysis and highlight the mechanisms:

**Assumption 1.** (i)  $\eta = 1$ ; (ii)  $n = 1$ .

If the TV stations and the distributor acted as a cartel, they would maximize Eq. (6) with respect to viewer prices and advertising prices. With  $\eta = n = 1$ , this would lead to  $p = p^{opt} = \frac{1}{2}$  and  $A = A^{opt} = 0$ , implying a generalized price  $G^{opt} = \frac{1}{2}$ , for any  $s \in [0, 1)$ . Joint profits are thus maximized when there is no advertising and viewers instead are charged directly through a high  $p$ . We further see that welfare simply equals  $U$ , which is maximized at  $C = \frac{1}{2}$ . This can be implemented by setting the generalized price equal to zero. Denoting welfare optimum with superscript  $W$ , we thus have  $G^W = p^W = A^W = 0$ .

The effect of Assumption 1 is not dramatic for our results. Clearly, a larger  $\eta$  would yield a greater demand for advertising space, since the benefit of advertising would now be higher. Joint profits would then be maximized at  $A^{opt} > 0$  and  $p^{opt} < \frac{1}{2}$ , whereas welfare would be maximized at  $A > 0$  (even though this would mean  $C < \frac{1}{2}$ ). A similar effect would come from an increase in the number of advertisers  $\eta$ ; total demand for advertising space goes up, as Eq. (5) shows, so that a cartel would put more weight on advertising (but not affect social optimum). Apart from that, our qualitative results do not hinge on our simplifications in Assumption 1.

### 3. Market structure with distributor

As already indicated, our main focus is on situation  $D$  in Fig. 1, where a distributor buys the rights to transmit the channels' contents. Specifically, it signs contracts  $(f_i, F_i)$  and  $(f_j, F_j)$  with the two TV stations;  $f_j$  is a variable fee that  $TV_i$  charges the distributor per unit of content a viewer watches, and  $F_i$  is a fixed fee. The size of these fees is determined at stage 1, and at stage 2 the distributor sets viewer prices and the TV stations set advertising prices.<sup>8</sup>

The profits of the distributor and of  $TV_i$  are now respectively given by:

$$\Pi = \sum_{j=1}^2 [(p_j - f_j) C_j - F_j], \text{ and} \quad (8)$$

$$\pi_i = r_i A_i + f_i C_i + F_i, i = 1, 2. \quad (9)$$

We start with stage 2, and first solve  $\frac{d\pi_i}{dp_i} = 0, i = 1, 2$ , to find  $TV_i$ 's best response:

$$r_i = \frac{1 - p_i + f_i - s r_j}{2(2 - s)}, i, j = 1, 2, i \neq j. \quad (10)$$

<sup>8</sup> All results in this section extend to the case of  $m \geq 2$  TV stations. See Appendix A for details.

Eq. (10) shows that  $\frac{dr_i}{dp_i} < 0$ . This is essentially because an increase in  $p_i$  reduces the viewing time at TV $i$  and thus the willingness among advertisers to pay for an ad. We also have  $\frac{dr_i}{dr_j} < 0$ . This is because channel  $j$  will have less ads if it increases its advertising price, and will thus become more attractive to viewers. Thereby channel  $i$  becomes relatively less attractive, making it optimal to charge a lower advertising price. Advertising prices are consequently strategic substitutes, in contrast to what is typically the case with prices in one-sided markets.<sup>9</sup>

Next, let us consider the distributor's maximization problem. Holding advertising prices fixed, and solving  $\{p_1, p_2\} = \arg \max \Pi$ , we find

$$p_i = \frac{1}{2} + \frac{f_i + (2-s)r_i + sr_j}{2}. \tag{11}$$

Viewer prices are naturally increasing in the distributor's marginal costs, so that we have  $\frac{dp_i}{df_i} > 0$ . We further see that viewer prices are increasing in the TV stations' advertising prices:  $\frac{dp_i}{dr_i} > 0$  and  $\frac{dp_i}{dr_j} > 0$ . This is so because the higher the advertising prices, the less ads the TV stations will show, and the more attractive they will be for viewers. Therefore the distributor finds it optimal to charge higher prices.

Equilibrium prices are, from Eqs. (10) and (11), as follows:<sup>10</sup>

$$p_i = \frac{1}{2} + \frac{1 + (6-s)f_i}{2(5-s)} - \frac{s(2-s)}{4(5-4s)(5-s)}(f_i - f_j), \text{ and} \tag{12}$$

$$r_i = \frac{1 + f_i}{2(5-s)} + \frac{3s}{4(5-4s)(5-s)}(f_i - f_j). \tag{13}$$

### 3.1. Symmetric, exogenous wholesale prices

Below, we shall endogenize the wholesale prices, but to see the mechanisms as clearly as possible it is useful first to fix them at some exogenous values, with  $f_1 = f_2 = f$  and  $F_1 = F_2 = F$ . In order to ensure positive prices and quantities, we assume that

$$-1 < f < \frac{2-s}{8-s} \tag{14}$$

Later we shall see that this holds when contract terms are endogenized.

Eqs. (12) and (13) yield

$$p = \frac{1}{2} + \frac{1 + (6-s)f}{2(5-s)}, \text{ and } r = \frac{1 + f}{2(5-s)}, \tag{15}$$

where for simplicity we have skipped subscripts. We further have

$$C = \frac{6-s-(4-s)f}{8(5-s)}, \text{ and } A = \frac{2-s-(8-s)f}{4(5-s)}. \tag{16}$$

The fact that the advertising volume decreases in  $f$  induces the distributor to set a viewer price that increases in  $f$ : the higher is  $f$ , the less advertising there is on TV, and the more are viewers willing to pay for watching TV. Additionally, a higher  $f$  means an increase in the distributor's marginal cost. This magnifies the positive relationship between  $p$  and  $f$  further. We therefore have  $\frac{dp}{df} > 0$ .

<sup>9</sup> This is a mechanism that is present also in other models of media markets, see for example Nilssen and Sørsgard (2001), Gabszewicz et al. (2004), and Kind et al. (2009).

<sup>10</sup> Note that this holds only when the expression for advertising prices is positive, which requires that variable fees  $f_1$  and  $f_2$  are not too different, in particular that  $\frac{3s}{5(2-s)} < \frac{1+f_1}{1+f_2} < \frac{5(2-s)}{3s}$ .

Other things equal, advertising revenue is clearly decreasing in viewer prices (since  $\frac{dC}{dp} < 0$ ). However, the distributor does not take this into consideration when setting viewer prices. The TV stations likewise choose advertising prices without taking into consideration that more advertising reduces viewers' willingness to pay for watching TV. These neglections have the important implication that the generalized viewer price,

$$G = p + A = \frac{1}{2} + \frac{4-s}{4(5-s)}(1 + f),$$

is higher than the one maximizing joint profits:  $G > G^{opt} = p^{opt} = 1/2$ ; recall the restriction  $f > -1$ .

It is now straightforward to verify the following:<sup>11</sup>

**Lemma 1.** *With distributor. Suppose that wholesale prices are fixed and symmetric ( $f_1 = f_2 = f$ ). The generalized viewer price and the advertising level are inefficiently high, but decrease in  $s$  ( $\frac{dG}{ds} < 0$ ,  $\frac{dA}{ds} < 0$ ). The advertising price and the viewer price increase in  $s$  ( $\frac{dp}{ds} > 0$ ,  $\frac{dr}{ds} > 0$ ).*

The closer substitutes the TV stations' contents, the more fiercely the stations will compete by setting a high advertising price in order to induce a low advertising volume.<sup>12</sup> This explains why  $\frac{dA}{ds} < 0$  and  $\frac{dr}{ds} > 0$ . The lower advertising volume in turn allows the distributor to charge higher viewer prices:  $\frac{dp}{ds} > 0$ . However, since the generalized price is excessively high ( $G > G^{opt}$ ), the distributor will increase the monetary price by less than what the reduced advertising volume would allow for. Thus, the generalized price decreases in  $s$ :  $\frac{dG}{ds} < 0$ .

The distributor's profit is found from Eqs. (8), (15), and (16):

$$\Pi = 2[(p-f)C - F] = \frac{1}{8} \left( \frac{6-s-f(4-s)^2}{5-s} \right) - 2F, \tag{17}$$

while each TV station's profit is

$$\pi = rA + fC + F = \frac{(1+f)[(4-s)(10-s)(1-f) - 2fs]}{16(5-s)^2} + F. \tag{18}$$

Joint profits thus equal

$$\Pi^D = \Pi + 2\pi = \frac{(1+f)[(40-12s+s^2)(1-f) - 2s]}{8(5-s)^2}. \tag{19}$$

Notably, we now have:<sup>13</sup>

**Lemma 2.** *With distributor. Suppose that wholesale prices are fixed and symmetric ( $f_1 = f_2 = f$ ). Joint industry profits increase in  $s$ :  $\frac{d\Pi^D}{ds} > 0$ .*

Technically, it is not surprising that joint profits increase in  $s$ , since  $G > G^{opt}$  and  $\frac{dG}{ds} < 0$ . It is nonetheless remarkable that stronger competition between the TV stations benefits both the industry and the consumers (the latter effect following trivially from the fact that consumer surplus is higher the lower the generalized viewer price).

### 3.2. Endogenous wholesale prices

At stage 1 the distributor and the TV stations bargain over the wholesale contracts  $(f_1, F_1)$  and  $(f_2, F_2)$ . This bargaining is done simultaneously and independently between the distributor and each TV station; formally, we solve for a contract equilibrium as introduced by Crémer and Riordan (1987). Since the two parties in each negotiation bargain over two-part tariffs, this bargaining will be efficient, in the

<sup>11</sup> We have  $\frac{dA}{ds} = 3 \frac{dC}{ds} = -\frac{1+f}{4(5-s)^2} < 0$ , and  $\frac{dr}{ds} = \frac{dp}{ds} = \frac{1+f}{2(5-s)^2} > 0$ .

<sup>12</sup> This is a core result on the effect of utility-reducing advertising in two-sided markets, see, e.g., Barros et al. (2004) and Anderson and Coate (2005).

<sup>13</sup> Using Eqs. (17) and (18) yields  $\frac{d\Pi^D}{ds} = \frac{(1+f)[11-3s+2fs-14f]}{4(5-s)^3} > 0$ , as long as Eq. (14) holds.



sense that the distributor and TV station  $i$  will agree on that variable fee  $f_i$  that maximizes their joint profits, taking  $f_j$  as given. The distributor and TV $i$  thus seek to maximize

$$\begin{aligned} \Pi + \pi_i &= [(p_i - f_i)C_i + (p_j - f_j)C_j - F_i - F_j] + [f_i C_i + r_i A_i + F_i] \\ &= p_i C_i + r_i A_i + (p_j - f_j)C_j - F_j \end{aligned} \quad (20)$$

with respect to  $f_i$ .

Simultaneous maximization of Eq. (20) for each  $i$  gives rise to a symmetric equilibrium in which the two variable fees are the same and equal to

$$f_D := \frac{s(1-s^2)}{2[100(1-s)^2 + s(18-s)(1-s^2) + 4s]} > 0 \text{ for } s \in (0, 1). \quad (21)$$

The fixed fee,  $F_i$ , is then determined by the parties' bargaining power. As usual in such negotiations, the fixed fee's sole role is to split surplus between the bargaining parties; it does not affect pricing decisions.

From Eq. (21) we see that  $f_D \rightarrow 0$  as  $s \rightarrow 0$  or  $s \rightarrow 1$ . More generally,  $f_D$  is a hump-shaped function of  $s$  ( $\frac{df_D}{ds} > 0$  for  $s < \tilde{s}$  and  $\frac{df_D}{ds} < 0$  for  $s > \tilde{s}$ , where  $\tilde{s} \approx 0.84$ ), as shown in Fig. 2. And  $f_D$  satisfies our assumption in Eq. (14).

From Lemma 1 we know that  $A$  decreases in  $s$  and  $p$  increases in  $s$  if the wholesale price is constant. This relationship is even stronger when  $\frac{df_D}{ds} > 0$ , but it does not necessarily hold when  $\frac{df_D}{ds} < 0$ . The reason is that a lower wholesale price tends to make it more profitable for a TV station to sell ads and for the distributor to reduce the viewer price. However, by inserting for Eq. (21) into Eqs. (15) and (16), we can nonetheless state:

**Proposition 1.** *With distributor. Suppose that  $f$  is endogenous.*

- a) *The generalized viewer price monotonically decreases in  $s$ , with  $G^D > G^{opt}$  for all  $s$ .*
- b) *The advertising level is lower in the neighborhood of  $s = 1$  than at  $s = 0$ :  $A_{s \rightarrow 1} < A_s = 0$ .*
- c) *Both the viewer price and the advertising price are higher in the neighborhood of  $s = 1$  than at  $s = 0$ :  $p_{s \rightarrow 1} > p_s = 0$ , and  $r_{s \rightarrow 1} > r_s = 0$ .*

By inserting for Eq. (21) into Eq. (19) we find joint profits. Since the generalized price is inefficiently high, but decreasing in the substitutability between the channels, we find, analogously to Lemma 2, that aggregate industry profits are higher the less differentiated are the TV stations' contents:

**Proposition 2.** *With distributor. Suppose that  $f$  is endogenous. Joint industry profits increase in  $s$ :  $\frac{d\Pi^D}{ds} > 0$ .*

The fact that  $G > G^{opt}$  indicates that the wholesale price should optimally be negative in order to press down the generalized price. It can be verified that this is actually true: if the two TV stations and the distributor maximize joint profits, then they would set  $f^{opt} < 0$ . The finding that  $f_D > 0$  is thus somewhat surprising. The intuition for the result is the inefficiency that arises in the negotiations because the parties, when bargaining over  $f_i$ , do not take into account how a change in  $f_i$  affects profits for TV $j$ . More specifically, a higher  $f_i$  increases the relative profitability of the viewer market compared to the advertising market for TV $i$ , making it optimal to increase its advertising price so that its volume of advertising gets lower. This is negative for TV station  $j$ , which consequently responds by increasing its own advertising price. Therefore also TV $j$  loses advertising revenue when  $f_i$  increases.

So  $f = f^{opt} < 0$  is not a Nash equilibrium. If the distributor and TV1, say, agreed on setting  $f_1 = f^{opt}$ , then the distributor and TV2 would increase their joint profit by setting  $f_2 > f^{opt}$ . But even if  $f = f^{opt}$  is not implementable, we might imagine that the industry is able to commit

to using only a fixed fee and not a two-part tariff in the wholesale contracts. Setting  $f = 0$  in Eq. (19), we find that aggregate industry profit now is equal to

$$\Pi_{f=0}^D = \frac{(10-s)(4-s)}{8(5-s)^2}$$

As under a two-part tariff, the fixed fees ( $F_1$  and  $F_2$ ) will be used to distribute profits in accordance with the parties' bargaining power. Comparing joint profits in this case with what the industry achieves with an equilibrium wholesale price, we find:<sup>14</sup>

**Proposition 3.** *With distributor. Joint profits are higher in an equilibrium with simple fixed-fee wholesale contracts ( $f_i = 0$ ) than in an equilibrium with two-part wholesale tariffs ( $f_i = f_D$ ).*

The joint profit for the TV channels and the distributor is thus higher with a simple fixed fee than with a two-part tariff. The reason is that such a commitment to a fixed fee eliminates the competition between the TV channels on the price per unit in the contract with the distributor. Each TV channel would like to have a high price per unit (positive  $f_i$ ) to lower own advertising and thus attract viewers from the other TV channel. This distortion in prices is reduced if they commit to using only a simple fixed fee.

#### 4. Market structure without distributor

Now, let us look at the alternative situation, where the TV channels sell directly to viewers. As argued in the Introduction, this is a scenario that is of increasing relevance as technological developments allow TV stations to use the Internet and bypass distributors. This means that the TV stations decide both advertising and viewer prices, and that they do not have to pay any distribution fees to downstream firms ( $f_i = 0$ ,  $F_i = 0$ ). The profit level of TV $i$  is then simply equal to

$$\pi_i = p_i C_i + r_i A_i.$$

Solving  $\frac{\partial \pi_i}{\partial r_i} = 0$  and  $\frac{\partial \pi_i}{\partial p_i} = 0$ , we find TV $i$ 's best responses to TV $j$ 's prices:

$$r_i = \frac{1 - sr_j}{2(2-s)}, \text{ and} \quad (22)$$

$$p_i = \frac{2(1-s) + sp_j}{2(2-s)}. \quad (23)$$

Note that advertising prices are strategic substitutes also in this case; best-response function (22) is qualitatively similar to the one in the previous case, Eq. (18). Eq. (23) reveals a new aspect, though: the channels compete in viewer prices when they bypass the distributor, and these prices are strategic complements:  $\frac{dp_i}{dp_j} > 0$ .

Solving the system of equations in Eqs. (22) and (23), we obtain equilibrium prices:

$$r = \frac{1}{4-s}, \text{ and} \quad (24)$$

$$p = \frac{2(1-s)}{4-3s}, \quad (25)$$

where subscripts are disregarded for simplicity.

Eqs. (3), (5), (24), and (25) further imply:

$$A = \frac{s^2}{2(4-3s)(4-s)}, \text{ and} \quad (26)$$

<sup>14</sup> We have  $\Pi_{f=0}^D - \Pi^D = \frac{[(40-12s+s^2)f+2s]}{8(5-s)^2} > 0$ , for  $f > 0$ . Since  $f_D > 0$  for  $s \in (0, 1)$ , the result follows.

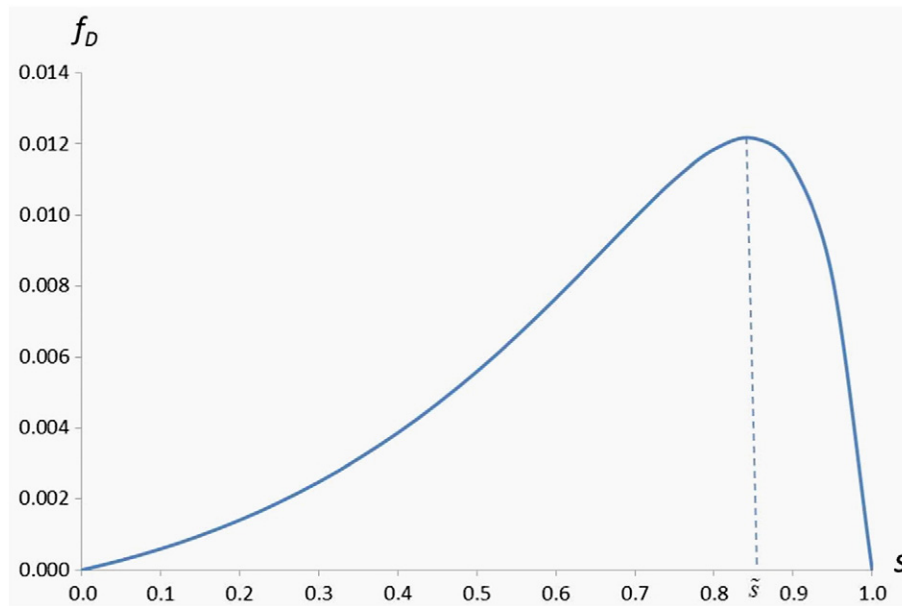


Fig. 2. Variable fees from the distributor to the TV channels.

$$C = \frac{4(4-3s) + s^2}{4(4-3s)(4-s)}. \tag{27}$$

From Eqs. (24) through (27) we can derive:

**Proposition 4.** *No distributor. The monetary and generalized viewer prices decrease in  $s$  ( $\frac{dp}{ds} < 0, \frac{dG}{ds} < 0$ ), while the advertising volume and the advertising price increase in  $s$  ( $\frac{dA}{ds} > 0, \frac{dr}{ds} > 0$ ). The generalized viewer price is below the one that maximizes joint industry profits;  $G^T = \frac{1}{2} - \frac{(2-s)s}{(4-3s)(4-s)} < G^{opt}$ .*

Proposition 4 implies that advertising becomes a more important source of revenue the closer substitutes the TV stations are, while the opposite is true for viewer payments. Note in particular that  $p \rightarrow 0$  in the limit as  $s \rightarrow 1$ , in which case the industry is unable to raise revenue from the viewer market. This reflects the fact that viewer prices are strategic complements, resulting in marginal-cost pricing in the limit when the consumers perceive the stations' contents as being perfect substitutes. The explanation for why the advertising market is still profitable even as  $s \rightarrow 1$ , is (as noted above) that advertising prices are strategic substitutes. This is a relatively mild form of competition; see Kind, et al. (2009) for a thorough discussion.

Joint industry profits, called  $\Pi^T$ , are simply equal to aggregate profits for the TV stations:

$$\Pi^T = 2\pi = \frac{[16(1-s) + s^2](2-s)^2}{(4-3s)^2(4-s)^2}.$$

### 5. A comparison

Let us now compare the performance of the two market structures. The downward-sloping curves in the left and the right panel of Fig. 3 show the equilibrium generalized price under market structure  $D$  and  $T$ , respectively. The straight lines show the optimal price from the industry's point of view (which from Section 2 we know is  $G^{opt} = \frac{1}{2}$ ). The industry faces an overpricing problem in market structure  $D$  and an underpricing problem in market structure  $T$ .

Let us first compare welfare under the two market structures. To this end, recall from Section 2 that the socially optimal consumption level is

$C = C^W = \frac{1}{2}$ , with  $G = G^W = 0$ . From the analysis above, and as illustrated in Fig. 3, we have  $G^T < G^D$ . The generalized prices are consequently too high in market equilibrium, but less so under market structure  $T$  compared to market structure  $D$ . We should therefore expect that market structure  $T$  yields both the highest welfare level (due to a smaller dead-weight loss) and the greatest consumer surplus. This is straightforwardly proved by inserting for Eqs. (16), (21) and (26) into the welfare expression, Eq. (7).

Let us now compare profits and the financing in the two regimes; see Fig. 4.

The left panel of Fig. 4 measures industry profit, and we see that bypassing the distributor yields higher joint profit if and only if  $s$  is sufficiently low ( $s < s_{IT}^{crit} \approx 0.81$ ). To see why, suppose first that  $s = 0$ . Then each TV channel behaves like a monopolist, and it perfectly balances the externalities across the two sides of the market when the distributor is absent. Thus, individual profit maximization coincides with industry optimum. This is not the case when the distributor is present: now the generalized price – as noted above – will be too high, since different firms set prices on the two sides of the market.

The problem with the situation without a distributor is the lack of inter-firm price coordination. Competition between the TV channels will press down viewer prices, and more so the better substitutes the viewers perceive the channels' contents to be. Indeed, as  $s$  approaches 1, any attempt to charge the viewers for watching TV would induce the rival to undercut in a Bertrand manner. The same is not true under market structure  $D$ : here the distributor internalizes price effects, taking into account that a lower  $p_i$  will reduce the revenue it can raise from  $TV_2$ , and vice versa. The advantage for the industry of internalizing these competitive externalities is greater than the disadvantage of not being able to internalize the two-sidedness of the market (the externalities between advertisers and viewers) if  $s > s_{IT}^{crit}$ . In other words, when competition for viewers is sufficiently strong, the need for intra-firm price coordination is dominated by the need for inter-firm price coordination.

From these reflections it also follows that the relative importance of viewer payments,

$$\Omega = \frac{pC}{pC + rA},$$

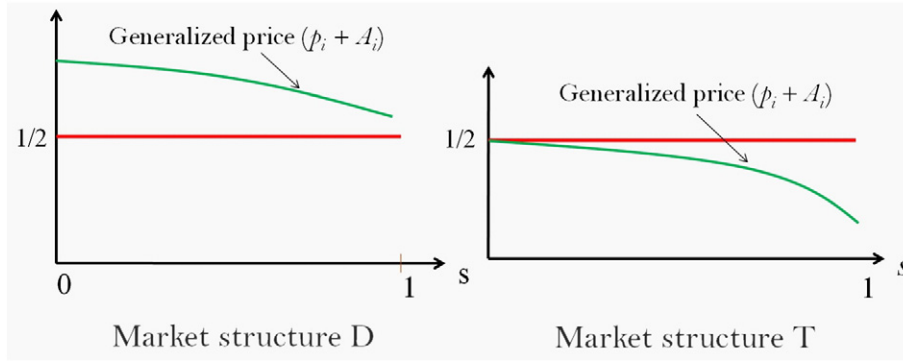


Fig. 3. Generalized price versus the optimal price for the industry.

necessarily must be lower without a distributor than with one, if  $s$  is above some critical value. In the right panel of Fig. 4, we consequently have  $\Omega^T < \Omega^D$  for  $s > s_{\Omega}^{crit} \approx 0.66$ .

**6. Incentives to bypass the distributor**

The analysis above reveals that joint industry profit is higher under market structure  $D$  than under market structure  $T$  if  $s > s_{\Pi}^{crit}$ . However, this does not necessarily mean that market structure  $D$  is an equilibrium outcome in this case. The reason is that we cannot disregard the possibility that each of the TV channels has an individual incentive to deviate and bypass the distributor.

In order to explore individual bypassing incentives, we set up a game where the TV stations and the distributor first bargain over the contract terms for distribution in market structure  $D$ , as discussed above. But we now introduce a new stage 2 where, given the prevailing contract terms, each TV station decides whether to deviate and bypass the distributor. Then, in the final stage, prices are set.

To see the price game in this case, suppose that  $TV2$  deviates unilaterally. Then  $TV2$  sets  $r_2$  and  $p_2$ , while the distributor sets  $p_1$  and  $TV1$  sets  $r_1$ . Formally,  $TV2$  solves  $\{p_2, r_2\} = \arg \max \pi_2$ , while the distributor and  $TV1$  solve  $p_1 = \arg \max[(p_1 - f_D)C_1]$  and  $r_1 = \arg \max \pi_1$ , respectively. The solutions to these three simultaneous maximization problems are

$$p_1 = \frac{2(1-s)(4-3s)(24-12s+s^2)}{z_1z_2} + 6f_D \frac{(2-s)^2}{z_2},$$

$$r_1 = \frac{(4-s)(8-12s+5s^2)}{z_1z_2} - 2f_D \frac{s-2}{z_2},$$

$$p_2 = \frac{2(1-s)(80-96s+30s^2-3s^3)}{z_1z_2} + \frac{3s(2-s)}{z_2} f_D,$$

$$r_2 = \frac{(2-s)(40-44s+7s^2)}{z_1z_2} - s \frac{f_D}{z_2},$$

where  $z_1 = 8(1-s) + s^2$  and  $z_2 = 40(1-s) + 9s^2$ . Using these expressions, we find  $TV2$ 's profit in case it deviates:

$$\pi_2^{dev} = \frac{2-s}{8z_1z_2} \left[ 4(40-52s+14s^2-s^3) + sf_D \frac{sz_1f_D + 4(1-s)(2-s)(4-s)}{1-s} \right].$$

Under market structure  $D$ , joint industry profits,  $\Pi_{f_D}^D$ , are found from Eq. (19) by inserting  $f = f_D$  from Eq. (21). Suppose that the TV stations' bargaining power is such that each receives a share  $\frac{\sigma}{2}$  of  $\Pi_{f_D}^D$  if both channels delegate pricing to the distributor (so the share that goes to the distributor is  $1 - \sigma$ ). It is then not profitable for  $TV2$  to deviate from market structure  $D$  if

$$\frac{\sigma}{2} \Pi_{f_D}^D \geq \pi_2^{dev}. \tag{28}$$

The profit expressions  $\Pi_{f_D}^D$  and  $\pi_2^{dev}$  depend solely on  $s$ . We can thus define a function  $\sigma^{dev}(s)$  which is such that Eq. (28) holds with equality for  $\sigma = \sigma^{dev}(s)$ . Unless  $\sigma \geq \sigma^{dev}(s)$ , each TV channels will have an incentive to deviate from market structure  $D$ .

It can easily be verified that  $\frac{d\sigma^{dev}(s)}{ds} < 0$ , with  $\sigma^{dev}(s \approx 0.93) = 1$  and  $\sigma^{dev}(s \approx 1) \approx 0.52$ . To see why  $\sigma^{dev}(s)$  is downward-sloping, suppose first that  $s \approx 1$ . Then the audience perceives the TV channels as almost perfect substitutes, and even small price differences imply that the cheaper channel captures almost the whole market. As a result, there will be tough price competition if one of the TV channels deviates from market structure  $D$ . In other words, there is much to gain from having a distributor which coordinates viewer prices. Therefore the TV channels have no incentives to deviate from market structure  $D$  even if they "only" receive 26% of joint profits each ( $\sigma^{dev}(s \approx 1) \approx 0.52$ ). If  $s < 1$ , deviation from market structure  $D$  will result in a less severe

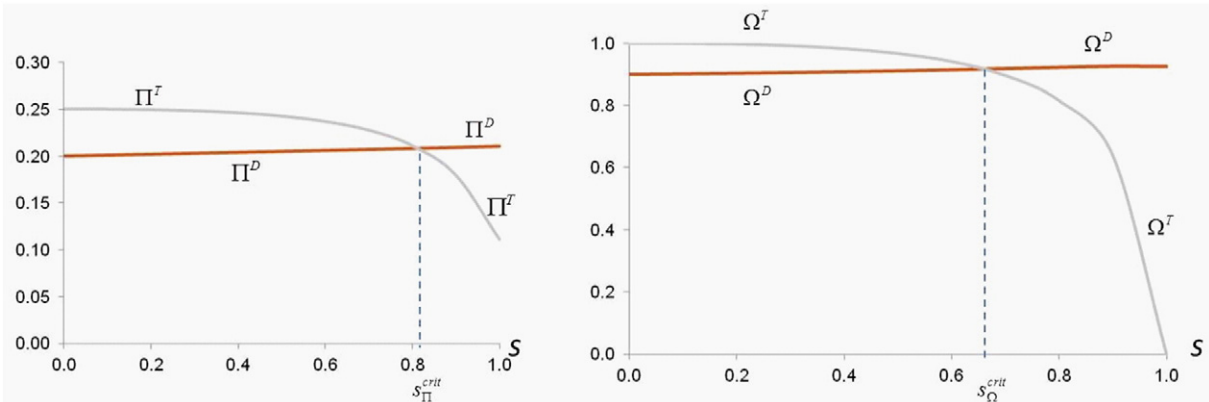


Fig. 4. Comparison of market structures.

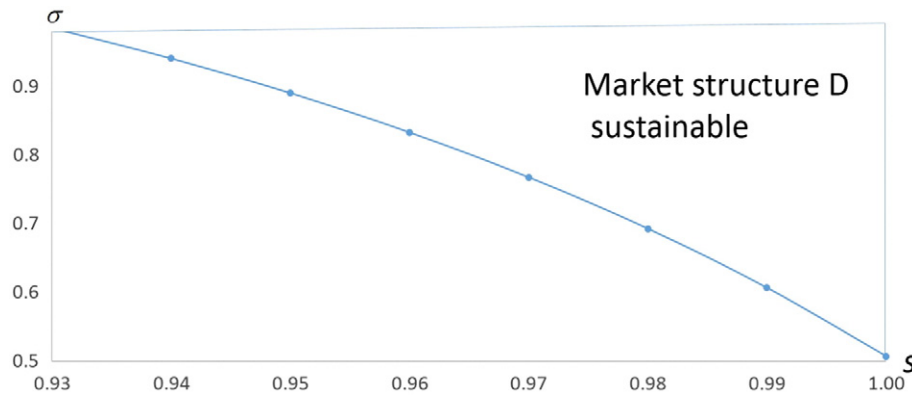


Fig. 5. Sustainability of market structure D.

price competition (smaller punishment) than if  $s \approx 1$ . This explains why it is necessary to allocate a larger share of joint profits to the TV channels in order to make it individually unprofitable to bypass the distributor. Consequently, the smaller is  $s$ , the greater is  $\sigma^{dev}(s)$ . This is illustrated in Fig. 5. Note that since the TV channels cannot capture more than 100% of joint industry profit, market structure  $D$  is not sustainable for  $s < 0.93$ .<sup>15</sup>

We can state:

**Proposition 5.** *In the case where a TV station can deviate unilaterally, market structure  $D$  constitutes an equilibrium only if  $s \geq s^{dev}$ , where  $s^{dev} > s_{TI}^{crit}$ .*

## 7. Discussion

In the previous sections we have elaborated on a specific model for the TV market. In this section we discuss the generality of our results and how our results may change if we relax some of our assumptions.

First, we have assumed that there is no limit on how much advertising a TV station can carry. In reality, there are many ways in which governments put limits on advertising on TV; see, e.g., Anderson (2007). Our analysis can be extended to the case where there is a cap  $\bar{A}$  on the advertising at each TV station. When the cap binds, the equilibrium variable fee has some features that differ from those of the case of no cap (see Appendix B for details): first, it is negative, while it is positive without the ad cap; secondly, it is decreasing in the ad cap  $\bar{A}$  while it is of course independent of it when the cap is not there; and it is monotonically increasing in  $s$ , while it is hump-shaped in the case without an ad cap.

Secondly, we have assumed that consumers dislike advertising. This is a natural assumption for the TV market. But in other markets, for example the newspaper market, it might be that consumers like advertising. However, we expect that our main results will hold also in this case. The reason is that we point at mechanisms that are quite general. A common distributor on one side of the market can coordinate the prices there – the problem is that it will not fully take the two-sidedness of the market into account. This is true independently of the signs of inter-market externalities.

Thirdly, we assume that the consumers pay a price for each TV channel. Alternatively, we could have assumed that consumers pay for a bundle of TV channels if they buy through a joint distributor. Such a modification would not change our main results if there is a downward sloping demand for the bundle: the coordination problem associated with delegating the pricing decision to the distributor is still present. That being said, it is not natural to apply our model to analyzing bundling, since we abstract from many factors that are commonly used to explain why distributors have been reluctant to sell channels individually. In

<sup>15</sup> We see that the critical value of  $s$  is quite high. However, one should be careful when interpreting the absolute level of this critical value. There are many other factors that we do not model, for example technology, that can make firms opt for market structure  $D$ . Our main point is qualitative: market structure  $D$  is an equilibrium if  $s$  is sufficiently high.

particular, the model has nothing to say about how bundling can be used to extract surplus in a manner similar to second-degree price discrimination when consumer preferences are heterogeneous.<sup>16</sup>

Fourthly, we assume that there is only one distributor. This is to mirror the substantial market power observed in distribution in many markets. Clearly, we could have allowed for imperfect competition between distributors. This would make the model considerably more complex (see, e.g., Bergh et al., 2014), but would presumably not qualitatively affect the tension between intra-firm and inter-firm price coordination that has been the focus of this paper.

Finally, we assume that the distributor, when it is present, sets the prices to viewers. This is in line with common observations. In principle, though, we could let each TV station set the price to its own viewers even in this case, thus allowing for Resale Price Maintenance (RPM). Since the generalized viewer prices tend to be too high when the distributor sets viewer prices, one might imagine that the coordination problem could be overcome if the TV stations set a maximum RPM. But if RPM is enforced and viewer prices are reduced, the rivalry between the TV channels in the advertising market would change. In this respect, the consequences of RPM are more complex in a two-sided than in a corresponding one-sided market.<sup>17</sup> We leave this issue for future research.

## 8. Concluding remarks

Our analysis illustrates the challenge firms face when trying to coordinate prices in a two-sided market. It might seem appropriate to let an independent distributor set viewer prices in order to reduce competition between TV channels in the viewer market. This could lead to a cartel-like outcome in a one-sided market, but not exactly so in a two-sided market. The problem is that inter-firm price coordination on just one side of the market prevents intra-firm price coordination across the markets. In this paper we show that this might lead to inefficiently high generalized prices for both the end-users and the industry, and more so if the wholesale contract between a distributor and a TV channel consists of a two-part tariff rather than a simple fixed fee.

For the TV channels, the managerial implications are clear. Given the coordination problems described above, they should bypass the distributor unless the end-users perceive their products as sufficiently close substitutes. Alternatively, they could use an independent distributor to coordinate viewer prices, combined with other ways of taking the two-sidedness of the market into account. For example, the distributors' payment to the TV channels could depend on the TV channels' advertising

<sup>16</sup> See Adams and Yellen (1976). See also Crawford and Cullen (2007) and Crawford and Yurukoglu (2012) who provide empirical estimates of the gain for TV viewers of unbundling.

<sup>17</sup> This is discussed briefly in an earlier version of the paper. An industry-wide RPM is possibly an equilibrium. But at the same time there might not exist unilateral incentives to introduce RPM. If so, RPM can be difficult to implement unless the TV channels can coordinate and commit to imposing industry-wide RPM. See also the analysis of some aspects of RPM in two-sided markets in Gabrielsen et al. (2015).



revenues. In the US we have recently observed contracts that include such elements. In particular, there are examples of contracts between distributors and TV channels where they agree on the amount of advertising.<sup>18</sup> However, this is not a common business model, and we have not seen it used in Europe.<sup>19</sup> Although such complex contracts are feasible in theory, they are for various reasons not implemented.<sup>20</sup>

For the regulator, the picture is very different. The end-users are always better off if end-user prices are not coordinated. According to our model, antitrust authorities should therefore be skeptical to price coordination in two-sided markets. In this respect the one-sided logic – where horizontal price fixing is treated as a serious problem – is still valid.

### Appendix A. An extension to $m$ channels

#### A.1. Market structure $D$ with $m$ channels

As in the main text, we put  $\gamma = \eta = n = 1$ . With  $m \geq 2$  channels, the utility function in Eq. (1) reads

$$U = \sum_{j=1}^m C_j - \frac{1}{2} \left[ m(1-s) \sum_{j=1}^m (C_j)^2 + s \left( \sum_{j=1}^m C_j \right)^2 \right].$$

Choosing consumption so as to maximize consumer surplus,  $CS = U - \sum_{j=1}^m {}_1G_j C_j$ , we find

$$C_i = \frac{1}{m} \left[ 1 - \frac{G_i - s\bar{G}}{1-s} \right], \tag{A1}$$

where  $\bar{G} = \frac{1}{m} \sum_{j=1}^m G_j = \frac{1}{m} \sum_{j=1}^m (p_j + A_j)$ .

Extending Eq. (4) to allow for  $m$  TV stations, we find advertisers' demand for ads at TV channel  $i$  to be

$$A_i = \frac{1}{2} [(1-p_i) - m(1-s)r_i - ms\bar{r}], \tag{A2}$$

where  $\bar{r} = \frac{1}{m} \sum_{j=1}^m r_j$ .

As in Eq. (9), the profit for TV station  $i$  equals

$$\pi_i = r_i A_i + f_i C_i, \quad i = 1, \dots, m.$$

The TV stations simultaneously maximize profits with respect to advertising prices. The first-order condition for channel  $i$  is

$$\frac{\partial \Pi_i}{\partial r_i} = 1 - p_i - 2[m(1-s) + s]r_i - s \sum_{j \neq i} r_j + f_i = 0. \tag{A3}$$

With  $m$  channels, the profit for the distributor, the equivalent of Eq. (8), is

$$\Pi = \sum_{j=1}^m (p_j - f_j) C_j.$$

The distributor's first-order condition with respect to  $p_i$  is

$$\frac{\partial \Pi}{\partial p_i} = C_i + (p_i - f_i) \frac{\partial C_i}{\partial p_i} + \sum_{j \neq i} \left[ (p_j - f_j) \frac{\partial C_j}{\partial p_i} \right] = 0; \quad i = 1, \dots, m. \tag{A4}$$

From Eq. (A1) we have

$$\frac{\partial C_i}{\partial p_i} = -\frac{1}{m} \frac{\frac{\partial G_j}{\partial p_i} - s \frac{\partial \bar{G}}{\partial p_i}}{1-s}.$$

Using that  $\frac{\partial G_i}{\partial p_i} = 1 + \frac{dA_i}{dp_i} = \frac{1}{2}$  and  $\frac{\partial \bar{G}}{\partial p_i} = \frac{1}{2m}$ , we find

$$\frac{\partial C_i}{\partial p_i} = -\frac{m-s}{2m^2(1-s)}. \tag{A5}$$

We likewise have

$$\frac{\partial C_j}{\partial p_i} = \frac{s}{2m^2(1-s)}. \tag{A6}$$

Inserting for Eqs. (A5) and (A6) in Eq. (A4) yields

$$\frac{\partial \Pi}{\partial p_i} = C_i - \frac{1}{2m^2(1-s)} \left[ (m-s)(p_i - f_i) + s \sum_{j \neq i} (p_j - f_j) \right] = 0. \tag{A7}$$

#### A.2. Symmetric, exogenous wholesale prices

As in the main text, let us first assume that  $f_i = f, \forall i$ . Then, Eqs. (A3) and (A7) give rise to a symmetric equilibrium. Letting

$$d_1 \equiv [5-2s]m + 2s > 0,$$

and skipping subscripts, we have

$$p = \frac{1}{2} + \frac{2f(m(2-s) + s) + m(2f + 1)}{2d_1} > \frac{1}{2} \text{ and } r = \frac{f + 1}{d_1}. \tag{A8}$$

Inserting for these equilibrium values into Eqs. (A1) and (A2) allows us to write equilibrium quantities as

$$A = \frac{m(1-s) + s(1-f) - fm(4-s)}{2d_1} \text{ and } C = \frac{(2m + s - ms)(1-f) + m}{2md_1}. \tag{A9}$$

It can be shown that joint channel profits are maximized if  $p = 1/2$  and  $A = 0$ , independently of the number of channels. We further find

$$\frac{dG}{ds} = -\frac{m(m-1)(f+1)}{2d_1^2} < 0; \quad \frac{dA}{ds} = -\frac{3m(f+1)(m-1)}{2d_1^2} < 0$$

and

$$\frac{dr}{ds} = \frac{2(m-1)(f+1)}{d_1^2} > 0; \quad \frac{dp}{ds} = \frac{(m-1)m(f+1)}{d_1^2} > 0.$$

This proves that Lemma 1 holds for an arbitrary number of TV stations.

Joint profits for the distributor and the TV stations equal  $\Pi^D = \Pi + m\pi = m(pC + rA)$ . Using Eqs. (A8) and (A9) we have

$$\frac{d\Pi^D}{ds} = \frac{(f+1)(m-1)}{2d_1^2} T, \tag{A10}$$

<sup>18</sup> See, for example, <http://www.fiercicable.com/special-reports/operators-teaming-programmers-and-pay-tv-rivals-drive-local-ad-revenue>.

<sup>19</sup> See, e.g., the discussion in Ofcom (2010, paragraph 10.36, p. 521).

<sup>20</sup> There may be many reasons why it is not feasible to write very complex contracts, but these are not encompassed in our model. An example is contractual problems that arise when each distributor bargains with a large number of TV channels.

where

$$T \equiv -2(4m + s + m(1-s))f + (4m(1-s) + 4s + m). \tag{A11}$$

Note that  $T$  is decreasing in  $f$ , and that  $\frac{dT}{df} = -\frac{3m+s+m(1-s)}{2d_1} < 0$ . Non-negative ad volumes require  $f < f^{crit} \equiv \frac{m(1-s)+s}{3m+s+m(1-s)}$ . By setting  $f = f^{crit}$  into Eq. (A11) we find that the lowest possible value of  $T$  is given by  $T(f^{crit}) = d_1 \frac{m+s+m(1-s)}{3m+s+m(1-s)} > 0$ . It thus follows from Eq. (A10) that  $\frac{d\Pi^D}{ds} > 0$ . This proves that Lemma 2 holds for any  $m \geq 2$ .

### A.3. Endogenous wholesale prices

We shall now endogenize the wholesale price,  $f$ . Simultaneously solving the  $m$  TV channels' FOCs in Eq. (A3), we find each advertising price as a function of the  $m$  viewer and wholesale prices:

$$r_i = \frac{2m(1-s) + s}{d_2} - \frac{m(2-s)(p_i - f_i)}{d_2} - s \frac{\sum_{j \neq i} f_j - \sum_{j \neq i} p_j}{d_2}, \tag{A12}$$

where

$$d_2 \equiv [(2-s)m + s][2m(1-s) + s].$$

From the distributor's  $m$  first-order conditions in Eq. (A7), we can further express each viewer price as a function of  $m$  wholesale prices and advertising prices:

$$p_i = \frac{1}{2} \left[ 1 + f_i + mn r_i (1-s) + ns \sum_{j=1}^m r_j \right]. \tag{A13}$$

In the pairwise bargaining, the distributor and  $TV_i$  maximize

$$\Pi + \pi_i = p_i C_i + r_i A_i + \sum_{j \neq i} [(p_j - f_j) C_j].$$

with respect to  $f_i$ . This gives rise to the following first-order condition:

$$\begin{aligned} \frac{d\Pi}{df_i} &= C_i \frac{dp_i}{df_i} + p_i \frac{dC_i}{df_i} + r_i \frac{dA_i}{df_i} + A_i \frac{dr_i}{df_i} \\ &+ \sum_{j \neq i} \left[ C_j \frac{dp_j}{df_i} + (p_j - f_j) \frac{dC_j}{df_i} \right] \\ &= 0. \end{aligned} \tag{A14}$$

Total differentiation of Eq. (A12) when  $f_i$  increases yields

$$dr_i = -\frac{m(2-s)(dp_i - df_i)}{d_2} + s \frac{(m-1) \sum_{j \neq i} dp_j}{d_2} \tag{A15}$$

$$dr_j = -\frac{m(2-s)(dp_j)}{d_2} - s \frac{df_i - \sum_{k \neq j} dp_k}{d_2}. \tag{A16}$$

From Eq. (A13) we likewise have

$$dp_i = \frac{1}{2} \left[ df_i + m(1-s)dr_i + s \sum_{j=1}^m dr_j \right] \tag{A17}$$

$$dp_j = \frac{1}{2} \left[ m(1-s)dr_j + s \sum_{j=1}^m dr_j \right]. \tag{A18}$$

Solving Eqs. (A15)–(A18) simultaneously, we find that the following holds in a symmetric equilibrium:

$$\frac{dr_i}{df_i} = \frac{m(5-2s) - s}{[m(5-2s) + 2s][5m(1-s) + 2s]} \tag{A19}$$

$$\frac{dr_j}{df_i} = -\frac{3s}{[m(5-2s) + 2s][5m(1-s) + 2s]} \tag{A20}$$

$$\frac{dp_i}{df_i} = 3 \frac{(1-s)(5-2s)m^2 + (4-3s)sm + s^2}{[m(5-2s) + 2s][5m(1-s) + 2s]} \tag{A21}$$

$$\frac{dp_j}{df_i} = \frac{s[m(1-s) + s]}{[m(5-2s) + 2s][5m(1-s) + 2s]}. \tag{A22}$$

This further implies that

$$\frac{dA_i}{df_i} = -\frac{4(1-s)(5-2s)m^2 + (16-13s)sm + 5s^2}{2[m(5-2s) + 2s][5m(1-s) + 2s]}, \tag{A23}$$

$$\frac{dC_i}{df_i} = -\frac{2(1-s)(5-2s)m^3 + (10s^2 - 5s^3 - 2s)m^2 - (8-7s)s^2m - 2s^3}{2m^2(1-s)[m(5-2s) + 2s][5m(1-s) + 2s]}, \tag{A24}$$

$$\frac{dC_j}{df_i} = \frac{s[(1-s)(11-5s)m^2 + (10-7s)sm + 2s^2]}{2m^2(1-s)[m(5-2s) + 2s][5m(1-s) + 2s]}. \tag{A25}$$

Inserting for Eqs. (A19)–(A25) in Eq. (A14), we find that the equilibrium wholesale price equals

$$f(m) = \frac{m^2 s (1-s) [m(1-s) + 4s]}{(m-1)d_3},$$

where

$$\begin{aligned} d_3 &= (50-23s)(1-s)(2-s)m^4 + 2(5m-2)(m-1)^2s^4 \\ &- (16m^2 - 65m + 26)ms^3 - (21m + 38)m^2s^2 + 36m^3s. \end{aligned}$$

Note that  $f = 0$  if  $s = 0$  or  $s = 1$ .

In the main text we have  $m = 2$ . Looking at the polar case where  $m \rightarrow \infty$ , we find

$$f(m \rightarrow \infty) = \frac{s(1-s)}{(50-23s)(2-s)}. \tag{A26}$$

The wholesale price  $f(m \rightarrow \infty)$  is hump-shaped, similarly to when  $m = 2$ . Inserting for Eq. (A26) into the price and quantity expressions, it can further be shown that the generalized price is decreasing in  $s$  ( $dG/ds < 0$ ) but above  $G^{opt}$ , and that joint profits are increasing in  $s$  ( $d\Pi^D/ds > 0$ ). Thus, Proposition 1, part a, and Proposition 2 hold also in this case. The same can be shown to be true for Proposition 3: joint industry profits are higher at  $f = 0$  than at  $f = f(m)$ .

Interestingly, it can be verified that joint industry profits are higher and the generalized consumer price is lower when  $m \rightarrow \infty$  than when  $m = 2$ . The expression for  $f(m)$  is too complex to prove that  $\Pi^D$  is monotonically increasing and  $G$  monotonically decreasing in  $m$ , but this seems to be the case. In the limit when  $s \rightarrow 1$ , for instance, we find  $G = \frac{4m+3}{2(3m+2)^2}$  with  $\frac{dG}{dm} = -\frac{1}{2(3m+2)^2} < 0$  and  $\Pi_1 = \frac{(m+1)(4m+1)}{2(3m+2)^2}$ , with  $\frac{d\Pi_1}{dm} = \frac{m+4}{2(3m+2)^3} > 0$ . The intuition is that tougher competition between TV channels, whether it is due to greater content similarity (higher  $s$ ) or a larger number of channels (higher  $m$ ), reduces the importance of the negative pecuniary externalities between the TV stations and the distributor. Fig. A1 illustrates this with the cases  $m = 2, m = 10$  and  $m \rightarrow \infty$  for  $G$  (left panel) and  $\Pi^D$  (right panel). The greater is the number of TV channels, the better off are the consumers and the greater are joint industry profits.

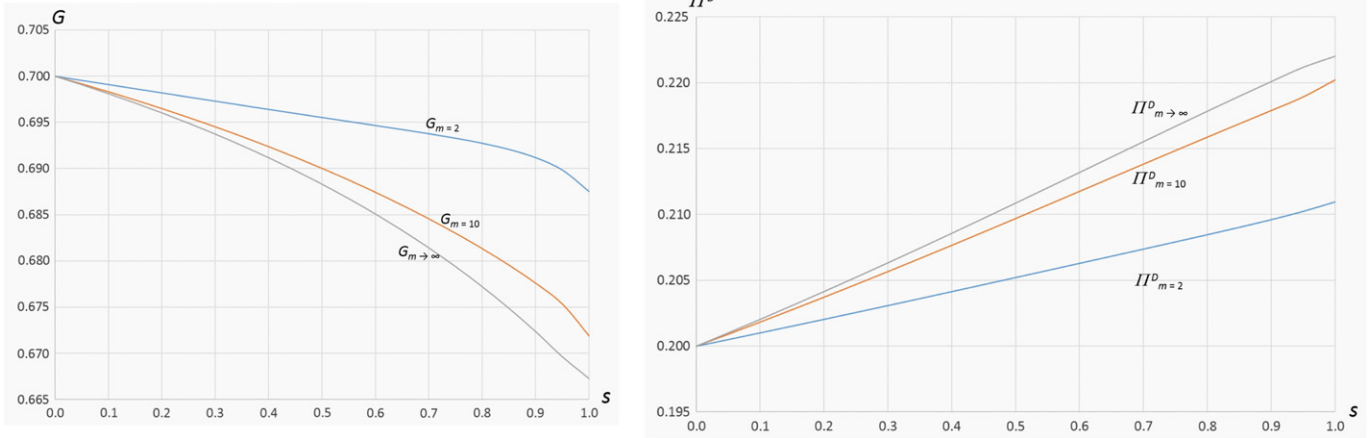


Fig. A1. The generalized consumer price (left) and joint industry profits (right).

Finally, note that  $A|_{s=0} - A|_{s=1} = \frac{3}{10} \frac{m-1}{m+2} > 0$ ,  $p|_{s=0} - p|_{s=1} = -\frac{m-1}{5(3m+2)} < 0$  and  $r|_{s=0} - r|_{s=1} = -\frac{2}{5} \frac{m-1}{3m+2} < 0$ . This proves that Proposition 1, parts b and c, hold for any values of  $m$ .

**Appendix B. A constraint on advertising volume**

Below, we discuss the effect of an ad cap on the equilibrium of our model. Specifically, we assume that an upper limit,  $\bar{A}$  is imposed on how much advertising each TV station can carry. Again, we let  $\gamma = \eta = n = 1$ .

From Eq. (5) in the text, we have advertising at TV station  $i$  as a function of prices:

$$A_i = 1 - p_i - [(2-s)r_i + sr_j]. \tag{B1}$$

Inserting for  $r_i$  from the TV station's best response in (10) in the text, we obtain

$$A_i = \frac{1}{2} (1 - f_i - p_i - sr_j).$$

Clearly, with an ad cap, the best response in Eq. (10) in the text only holds as long as the level of advertising is below the cap  $\bar{A}$ , which amounts to

$$r_j > \frac{1}{s} (1 - f_i - p_i - 2\bar{A}). \tag{B2}$$

Otherwise, that is, if  $r_j \leq \frac{1}{s} (1 - f_i - p_i - 2\bar{A})$ , then we find TV station  $i$ 's best response from Eq. (B1) with  $\bar{A}$  inserted for  $A_i$ . In summary, therefore, TV station  $i$ 's best response in Eq. (10) now becomes

$$r_i = \begin{cases} \frac{1 - p_i + f_i - sr_j}{2(2-s)}, & \text{if } r_j > \frac{1}{s} (1 - f_i - p_i - 2\bar{A}); \\ \frac{1 - p_i - \bar{A} - sr_j}{2-s}, & \text{if } r_j \leq \frac{1}{s} (1 - f_i - p_i - 2\bar{A}). \end{cases}$$

The best response of the distributor is not changed, so Eq. (11) in the text is not affected.

The equilibrium for the case of no ad cap, given by Eqs. (12) and (13) in the text, still holds in the present case of an ad cap as long as the advertising prices satisfy condition (B2). Inserting from Eq. (13) in Eq. (B2) and imposing symmetry, we obtain the condition

$$\bar{A} > \frac{2-s}{2(5-s)} - \frac{8-s}{2(5-s)} f. \tag{B3}$$

With  $f = f_d$ , this condition becomes

$$\bar{A} > \frac{2-s}{2(5-s)} - \frac{8-s}{2(5-s)} \frac{s(1-s^2)}{2[100(1-s)^2 + s(18-s)(1-s^2) + 4s]}. \tag{B4}$$

Suppose, alternatively, that the ad cap is binding for both TV stations. In this case, the equilibrium is found as the solution to

$$\begin{aligned} r_i &= \frac{1 - p_i - \bar{A} - sr_j}{2-s}; \\ p_i &= \frac{1}{2} + \frac{f_i + (2-s)r_i + sr_j}{2}. \end{aligned}$$

For given wholesale prices, we obtain the following equilibrium prices:

$$r_i = \frac{1}{6} (1 - f_i - 2\bar{A}); \tag{B5}$$

$$p_i = \frac{1}{3} (2 + f_i - \bar{A}). \tag{B6}$$

In order to find the equilibrium variable fee  $f$ , we note that the TV viewers' consumption is found by inserting from Eqs. (B5) and (B6) in Eq. (3) and setting  $A_i = \bar{A}$ , from which we obtain

$$C_i = \frac{1}{6} - \frac{1}{3} \bar{A} - \frac{(2-s)f_i - sf_j}{12(1-s)}.$$

The bargaining is done as in the text. The distributor and TV station  $i$  maximize

$$p_i C_i + r_i \bar{A} + (p_j - f_j) C_j - F_j.$$

From the first-order condition to this maximization problem, we get

$$f_i = -\frac{2(1-s) + 8\bar{A}(1-s) + sf_j}{2(2-s)}.$$

Imposing symmetry, we have the equilibrium variable fee in the case of a binding ad cap  $\bar{A}$  for each TV station:

$$f = f_A = -\frac{2(1-s)(1 + 4\bar{A})}{4-s} < 0. \tag{B7}$$

Inserting this in Eqs. (B5) and (B6), we find

$$r = \frac{2-s-2s\bar{A}}{2(4-s)};$$

$$p = \frac{2-(4-3s)\bar{A}}{4-s};$$

thus, the stricter the ad cap (*i.e.*, the smaller is  $\bar{A}$ ), the higher are prices.

We need to check that the resulting equilibrium is consistent with the supposition that the ad cap is binding for the TV stations. In other words, we need to check that, with the resulting variable fee in Eq. (B7), the opposite of condition (B3) holds:

$$\bar{A} \leq \frac{2-s}{2(5-s)} - \frac{8-s}{2(5-s)}f.$$

Inserting for  $f = f_A$ , and rewriting, this becomes

$$\bar{A} \leq \frac{8-8s+s^2}{2(9s-4-s^2)}. \quad (\text{B8})$$

Comparing condition (B8) with Eq. (B4), we find that Eq. (B8) is satisfied whenever Eq. (B4) does not hold. Thus, we can summarize our analysis as follows:

1. If the ad cap  $\bar{A}$  is large, in particular, if  $\bar{A}$  satisfies Eq. (B4), then it does not bind and equilibrium is as before.
2. Otherwise, if Eq. (B4) is not satisfied, then both TV stations have advertising at the ad cap  $\bar{A}$  and the variable fee is given in Eq. (B7).

Fig. B1 contains a picture of the critical value of the ad cap, as a function of  $s$ . For combinations of  $s$  and  $\bar{A}$  above the curve, the ad cap does not bind in equilibrium, while it binds for both TV stations below the curve.

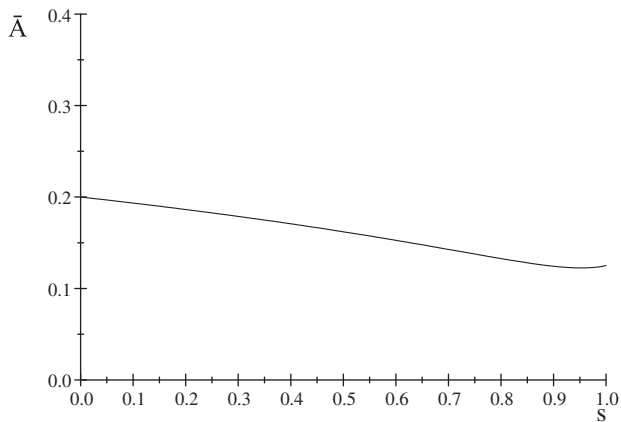


Fig. B1. A binding ad cap.

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