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Online advertising: Pay-per-view versus pay-per-click with market power

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Online advertising: Pay-per-view versus pay-per-click with market power[*]

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Abstract

We analyze the choice of pay-per-view (PPV) and pay-per-click (PPC) under imperfect competition where a web publisher is a price setter in the market for advertising banners, the number of visits to the web site is decreasing in advertising, and the click-through-rate is constant.

We find that the optimal amount of advertising under pure PPV or PPC pricing is decreasing in market power, and lower than for a price taking web publisher. If the web publisher sells both PPV and PPC advertising, the ratio of the prices should equal the click-through-rate if the market power is the same in both markets. However, if the market power for PPV advertising exceeds that for PPC advertising, then the ratio of the prices should be less than the click-through rate. Conversely, if the market power for PPV advertising is less than that for PPC advertising, then the ratio of the prices exceed the click-through rate.

Keywords: internet advertising, pricing models, click-through rate, banners, web publishers.

JEL: M21, M31

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1 Introduction

When selling banner space to advertisers, web publishers typically choose between two price regimes: pay-per-view (PPV) and pay-per-click (PPC).[1] PPV means the advertiser pays a certain amount for each time a consumer opens the web site and is exposed to the advertisement. PPC means that the advertiser pays only if the consumer clicks on the advertisement to read more about the product.[2] Understanding the optimal pricing under these price models is thus of importance to a great deal of web publishers.[3]

Mangani (2004) attempts to answer the question of how a price *taking* web-publishers should allocate advertising space between the two price models and concludes that a combination of the two is optimal. The question is later revisited by Fjell (2009) who, despite using the same assumptions of perfect competition, arrives at the conclusion that a price taking web publisher should choose *either* PPV *or* PPC, and not a combination of the two. The rate of clicks to views, or the click-through-rate, is central to the choice of price model. Specifically, if the click-through rate is less than the ratio of PPV to PPC prices, then PPV should be chosen, and vice versa.

In this paper, we extend this analysis to the more realistic assumption of imperfect competition where web publishers have market power to set PPV and PPC prices that are different from those of other web-publishers. The amount of advertising sold as PPV and PPC is decreasing in the PPV and PPC prices respectively.

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[1] Often the term "cost" is used in place of "pay" as it is a cost from the advertisers' perspective. Furthermore, sometimes a third type of payment regime is described; pay-per-action where advertisers only pay per user who completes a transaction, such as a purchase or sign-up. We consider this in principle to be a form of PPC. See e.g. Hoffman and Novak (2000) for more.

[2] The number of clicks is related to the number of views through the click through rate, i.e. the rate of views that turn into clicks.

[3] For an overview of internet pricing models, see e.g. Hoffman and Novak (2000).

We find that the optimal amount of advertising under pure PPV or PPC pricing is decreasing in market power, and lower than for a price taking web publisher. If the web publisher sells both PPV and PPC advertising, the ratio of the prices should equal the click-through-rate if the market power is the same in both markets. However, if the market power for PPV advertising exceeds that for PPC advertising, then the ratio of the prices should be less than the click-through rate. Conversely, if the market power for PPV advertising is less than that for PPC advertising, then the ratio of the prices exceed the click-through rate.

We present the model in section 2, the analysis in section 3, and the conclusion in section 4.

2 Model

We consider a web publisher with market power facing a downward sloping demand curve for advertising space on its web site. Its prices for advertising space are c_1 per view and c_2 per click. $A \in [0, \bar{A}]$ is the quantity of advertising on a webpage and is considered to be continuous and bounded above by screen space, $\bar{A}$.

$N(A)$ is the number of visits to the web site. It may be interpreted as the demand by consumers for visiting the web site to view its content, and the amount of advertising on the web site is the implicit price they pay.[4] Advertising represents a disutility to visitors, and hence the number of visits to the web site ("views") is decreasing in advertising such that $\frac{\partial N}{\partial A} < 0$. Further, $N(A)$ is continuously differentiable on A and weakly concave. It is bounded above $\left(N(A=0) = \bar{N}\right)$ and below $\left(N\left(A=\bar{A}\right)=0\right)$. There is no explicit subscription fee.

[4] The demand function adheres to the regularity assumptions set forth by Talluri and van Ryzin (2005).

$C(A)$ is the number of clicks which cannot exceed the number of visits, $C(A) \leq N(A)$, since the former always precede the latter, but a visit may not always result in a click. Mangani (2004) considers both a direct and an indirect effect of advertising on the number of clicks. The direct effect is assumed to be positive as more advertising increases choice and also curiosity by the viewer. However, the increase in advertisement reduces the number of visits which in turn reduces the total number of clicks, and this indirect effect is assumed to dominate such that $\frac{\partial C}{\partial A} < 0$.[5] $C(A)$ is continuously differentiable and weakly concave. Furthermore, the click-through-rate is assumed to be constant and given by:[6]

$$w \equiv \frac{C(A)}{N(A)} \qquad \text{where } w \in [0,1] \tag{1}$$

Unlike under perfect competition (Mangani, 2004, and Fjell, 2009), the amount of banner space sold by the web publisher under imperfect competition is a function of the prices it sets. Specifically, $A(c_1, c_2) = A_1(c_1) + A_2(c_2)$ where A_1 is the amount of banners sold as PPV and A_2 is the amount of banners sold as PPC, and $\frac{\partial A}{\partial c_1} = \frac{\partial A_1}{\partial c_1} < 0$ and $\frac{\partial A}{\partial c_2} = \frac{\partial A_2}{\partial c_2} < 0$. Assuming zero costs, the web publisher is faced with the task of maximizing revenues from advertising given by:

$$R(c_1, c_2) = [c_1 A_1(c_1) + c_2 w A_2(c_2)] N(A(c_1, c_2)) \tag{2}$$

Advertisers have no buying power and consider the prices as given.

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[5] Like Mangani (2004), we do not explicitly include this indirect effect in (1), as doing so would reduce tractability without altering our conclusions.

[6] The click-through rate is sometimes also thought to be related to position on the web-site. A position high up (or near the result from a query) is assumed to have a higher click-through rate than a position lower on the screen (e.g. Edelman et al., 2007). We do not consider that dimension.

3 Analysis

In this section, we first derive the general solution from the model. Then we compare the optimal pure PPV and PPC pricing results with those from Fjell (2009) for pricing under perfect competition. Finally, we discuss the optimal pricing for an interior solution when the web publisher sells a mix of PPV and PPC advertising.

3.1 Model solution

From (2) we obtain the following set of first order conditions:

$$\frac{\partial R}{\partial c_1} = \left(\frac{\partial A_1}{\partial c_1} c_1 + A_1 \right) N + \left(A_1 c_1 + A_2 c_2 w \right) \frac{\partial N}{\partial A} \frac{\partial A}{\partial c_1} = 0 \tag{3a}$$

$$\frac{\partial R}{\partial c_2} = \left(\frac{\partial A_2}{\partial c_2} c_2 w + A_2 w \right) N + \left(A_1 c_1 + A_2 c_2 w \right) \frac{\partial N}{\partial A} \frac{\partial A}{\partial c_2} = 0 \tag{3b}$$

Expressing (3) in terms of elasticities, we get the following conditions:

$$\varepsilon_{N,A} = -\left(1 + \frac{1}{\varepsilon_{A_1,c_1}} \right) \left(\frac{A c_1}{A_1 c_1 + A_2 c_2 w} \right) \tag{4a}$$

$$\varepsilon_{N,A} = -\left(1 + \frac{1}{\varepsilon_{A_2,c_2}} \right) \left(\frac{A c_2 w}{A_1 c_1 + A_2 c_2 w} \right) \tag{4b}$$

where $\varepsilon_{N,A} < 0$ is the elasticity of web site views with respect to advertising, and $\varepsilon_{A_i,c_i} < 0$ is the elasticity of advertising sold with respect to c_i where $i \in [1, 2]$.

3.2 Pure PPV or PPC pricing

Fjell (2009) finds that a price taking web publisher should choose either PPV (i.e. $A_2 = 0$) or PPC (i.e. $A_1 = 0$) depending on the click-through-rate, and subsequently set the amount of

advertising such that $\varepsilon_{N,A} = -1$. Let us compare this with the pure pricing results (i.e. either PPV or PPC) under imperfect competition.[7] From (4), these are:

$$\varepsilon_{N,A} = -\left(1 + \frac{1}{\varepsilon_{A_1,c_1}}\right) \quad \text{or} \quad \varepsilon_{A_1,c_1} = -\left(\frac{1}{1+\varepsilon_{N,A}}\right) \tag{5a}$$

$$\varepsilon_{N,A} = -\left(1 + \frac{1}{\varepsilon_{A_2,c_1}}\right) \quad \text{or} \quad \varepsilon_{A_2,c_2} = -\left(\frac{1}{1+\varepsilon_{N,A}}\right) \tag{5b}$$

If the web publisher is facing perfect competition in the market for advertising, then $\varepsilon_{A_1,c_1} = \varepsilon_{A_2,c_2} = -\infty$. From the first terms in (5) we then get the result from Fjell (2009) that the web publisher should set advertising amount such that the elasticity of views with respect to advertising is unit elastic.

Now consider a gradual departure from this extreme to a situation where the web publisher has market power. Thus the elasticity of advertising with respect to price in (5) should be smaller than infinity (in absolute value). This means that (the absolute value of) the corresponding optimal elasticity of views with respect to advertising should also be lower, that is it should be inelastic. Recall that the number of views is declining in advertising as advertising may be considered an implicit price visitors pay for access to the web site's content. It is reasonable to assume that the elasticity of views with respect to advertising becomes lower (in absolute value) as the amount of advertising becomes lower.[8] Thus the more market power the web publisher has with respect to advertisers, the higher the

[7] The second order conditions under pure pricing will hold under linearity if $\varepsilon_{A_i,c_i} < \frac{-\varepsilon_{N,c_i}}{1+\varepsilon_{N,c_i}}$ where ε_{N,c_i} is the elasticity of views expressed in terms of advertising price. It is positive since a higher price reduces advertising which in turn increases views.

[8] This is analogous to the traditional (inverse) demand curve based on an explicit price which typically becomes less elastic as price decreases because the relative change in quantity becomes lower and the relative change in price becomes higher as price decreases.

advertising price, and the lower the resulting advertising amount would be, *ceteris paribus*. Hence, more market power would lead to less advertising and subsequently to more visits. This leads to the following proposition:

Proposition 1: *Under pure PPV or PPC pricing, the optimal amount of advertising is decreasing in market power.*

Conversely, from the second terms in (5) we see that if visits are perfectly inelastic with respect to advertising, i.e. $\varepsilon_{N,A} = 0$, we get the traditional result that advertising price should be set such that the price elasticity of demand for advertisers is unit elastic. However, if visits are falling in advertising, i.e. $-1 < \varepsilon_{N,A} < 0$, the web publisher should price in the elastic range of the demand for advertising, which means it should set a higher price than if $\varepsilon_{N,A} = 0$.

The intuition is that although raising price, and thereby reducing advertising, has a negative direct effect on revenue from advertising, it has a positive indirect effect on revenue through increased visits. On the margin, these two effects should be equal. Furthermore, since the price elasticity of advertising is negative, we see from the second terms in (5) that the elasticity of visits with respect to advertising must be inelastic. We can summarize this in the following corollary:

Corollary 1: *The higher the (absolute value of) elasticity of visits is to advertising, the higher is the optimal advertising price and the lower is the optimal amount of advertising. The elasticity of advertising with respect to price should be elastic, whereas the elasticity of visits to advertising should be inelastic.*

Next we consider the situation where the optimal solution involves selling advertising both as PPV and PPC.

3.3 A combination of PPV and PPC pricing

If the optimal pricing solution is interior so that the web publisher should sell a positive amount of advertising both as PPV and PPC, we have from (4) that:[9]

$$\frac{c_1}{c_2}\left(\frac{1+\frac{1}{\varepsilon_{A_1,c_1}}}{1+\frac{1}{\varepsilon_{A_2,c_2}}}\right)=w \qquad (6)$$

If competition is perfect and the firm is a price taker such that $\varepsilon_{A_1,c_1}=\varepsilon_{A_2,c_2}=-\infty$, (6) reduces to $\frac{c_1}{c_2}=w$ which is the condition found by Fjell (2009). The same is true if the web publisher has market power, but the extent of market power is the same for both PPV and PPC advertising, i.e. $\varepsilon_{A_1,c_1}=\varepsilon_{A_2,c_2}$. In both these cases, the ratio of the optimal PPV to PPC prices should equal the click-through-rate. However, if the web publisher's market power is greater in, for instance, the PPV market, i.e. $\left|\varepsilon_{A_1,c_1}\right|<\left|\varepsilon_{A_2,c_2}\right|$, then price in that market should be relatively higher, i.e. $\frac{c_1}{c_2}>w$, and vice versa. Hence ratio of the optimal PPV to PPC prices would depart from the click-through-rate. We can summarize this in the following proposition:

[9] The second order conditions are assumed to hold.

Proposition 2: *For an interior solution, the ratio of PPV to PPC prices should be* higher *than the click-through-rate if the (absolute value of) price elasticity of demand for PPV advertising is* lower *than that for PPC advertising, and vice versa. If price elasticities are equal, the ratio of the optimal PPV to PPC prices should equal the click-through-rate.*

4 Conclusion

We have expanded on previous literature (Mangani, 2004, and Fjell, 2009) by analyzing the choice of pay-per-view (PPV) and pay-per-click (PPC) under imperfect competition where a web publisher is a price setter in the market for advertising banners, the number of visits to the web site is decreasing in advertising, and the click-through-rate is constant.

We find that the optimal amount of advertising under pure PPV or PPC pricing is decreasing in market power, and lower than for a price taking web publisher (Fjell, 2009). If the web publisher sells both PPV and PPC advertising, then the ratio of the PPV to PPC prices should equal the click-through-rate if the market power is the same in both markets. However, if the market power for PPV advertising exceeds that for PPC advertising, then the ratio of the PPV to PPC prices should also exceed the click-through rate. Conversely, if the market power for PPV advertising is less than that for PPC advertising, then the ratio of the PPV to PPC prices should also be less the click-through-rate.

Future research might consider expanding on our model by exploring several issues. The source of market power in the advertising market has been exogenous in our paper. Related to this is also the possible substitution between PPV and PPC advertising by advertisers when both payment models are offered.

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