<u>**Working Paper No 27/07**</u>

**Pricing of on-line advertising:
Pay-per-view or pay-per-click?**

by
Kenneth Fjell

SNF project no 1303

"Konvergens mellom IT, medier og telekommunikasjon:
Konkurranse- og mediepolitiske utfordringer"

Funded by The Research Council of Norway

CASE - Centre for Advanced Studies in Economics

CASE – CENTRE FOR ADVANCED STUDIES IN ECONOMICS

CASE – Centre for Advanced Studies in Economics – is a joint centre for The Norwegian School of Economics and Business Administration (NHH), The Institute for Research in Economics and Business Administration (SNF) and The University of Bergen (UiB). Research at CASE includes all types of issues based on economic theory and method, and researchers at the Centre have particular expertise within the areas of international trade, industrial economics, labour market economics, factor mobility, economic integration, industrial policy, international macro economics, tax policy, international transport and maritime research.

International Trade and Tax Policy

Research within this area focuses mainly on issues related to international trade and tax policy, and has generally been dominated by projects aiming to provide increased insight into global structural issues and the effect of regional economic integration. The staff have particular expertise within the fields of international real economics (trade, factor mobility, economic integration and industrial policy), international macro economics and international tax policy, but are also actively involved in projects relating to public economics and industrial policy.

Industrial Economics

Industrial economics is another central research area at the Centre, within which SNF has long-standing traditions. A series of individual studies have been carried out through large framework programmes funded by the Research Council of Norway and major Norwegian companies. The focal point of these studies is strategic company behaviour in industries with few players, where competition effects are modelled and analysed. The studies have provided important structural and empirical insights into deregulation effects within industries such as airlines, telecommunications and energy and have provided significant input to Norwegian competition policies. The research group includes a number of researchers at both UiB and NHH and has an extensive international network.

Labour Market Economics

The labour market group focuses on mainly two research areas. One central topic is education and family economics. An important aspect is to analyse the production process for human capital; the importance of family, neighbourhood, preschools and schools for adult education and labour market experience. The other main topic is to analyse firm performance and firm restructuring. These analyses include firm performance, adjustment costs, costs of displacement including health costs, the effect of technological change and international trade, and analysis of organisational change.

Human Resources

CASE is a network-based organisation whose staff consists mainly of professors at Department of Economics at NHH and UiB as well as leading international economists who are affiliated to the centre through long-term relations. Members of the academic staff are among the leading in their fields both nationally and internationally and many have served on important public committees. During the last few years the centre has produced several PhDs and the current staff also includes PhD scholars.

Networks

CASE participates in a Scandinavian Network of Excellence on labour market economics and is involved in a major EU project on international trade. The Centre collaborates with central research and educational institutions all over Europe and has particularly close contact with London School of Economics, University of Glasgow, University of Munich, University of Uppsala, Aarhus Business School, Stockholm School of Economics, The Frisch Centre at University of Oslo and Statistics Norway. The staff members participate in international research networks, including CESifo, CEPR, CEP, IZA and IAME.

Pricing of on-line advertising: Pay-per-view or pay-per-click?[*]

Kenneth Fjell[a]

Norwegian School of Economics and Business Administration

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

[a] Address: Helleveien 30, 5045 Bergen, Norway. Tel.: +4755959687, fax: +4755959320, email: Kenneth.fjell@nhh.no .

1. Introduction

When selling banner space to advertisers, web publishers typically choose among two pricing models: pay-per-view (PPV) and pay-per-click (PPC). Mangani (2004) examines the pricing strategy when web publishers are price takers in the market for banner advertisement.[1] His main conclusion is that the distribution of editorial revenues between PPV and PPC "depends on the elasticity of access and actions with respect to the quantity of advertising" (p. 295). In particular, his result suggests that web publishers should choose a combination of the two pricing models, and that the share of advertising sold through each model then should depend on the relation between elasticity of "views" and "clicks" to advertising.

We revisit this pricing issue, but arrive at different conclusions. First, our main result is that a price taking web publisher should choose *either* PPV *or* PPC, and not a combination of the two. Second, only under the strict condition that the click through rate equals the ratio of PPV to PPC market prices, may the web publisher choose a combination. However, in this case, the share of advertising sold through each model is irrelevant. Finally, we find that when the click-through rate is increasing in amount of advertising, the web publisher will choose a higher level of advertising than under PPV, and vice versa.

2. Model

Following Mangani (2004), the market prices for web publishers selling advertising space on their web sites are given by the market and equal to c_1 per view and c_2 per click. The assumption that web publishers are price takers implies a great number of homogenous web sites catering to a certain segment of consumers. A large number of advertisers are interested

---

[1] For a more extensive discussion of the web publisher market, see Mangani (2004).

in exposure, but value a "view" less than a "click"; $c_1 < c_2$. The latter means the consumer takes action by clicking on the banner advertisement to read more about the advertisers' product.

Assuming zero costs, the web publisher is faced with the task of maximizing revenues from advertising given by:

$$R(A) = \alpha c_1 N(A)A + (1-\alpha)c_2 C(A)A \tag{1}$$

where $0 \leq \alpha \leq 1$ is the share of banners paid with the PPV model. A is the quantity of advertising on a webpage and is considered to be continuous. $N(A)$ is the number of visits to the web site ("views") which is assumed to be decreasing in A. $C(A)$ is the number of clicks which is always less than number of visits, $C(A) < N(A)$, 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 $\left(\dfrac{\partial N}{\partial A} < 0\right)$ which in turn reduces the total number of clicks, and this indirect effect is assumed to dominate such that $\dfrac{\partial C}{\partial A} < 0$.[2] Mangani (2004) does not explicitly include this indirect effect in (1). Neither do we, as doing so would reduce tractability without altering our conclusions.

---

[2] Like Mangani (2004) we assume that the objective function in (1) is concave which seems like a reasonable assumption.

As prices are given by the market, the web publisher only has two choice variables; the choice of advertising amount, A, and of pricing model, α. Following the steps of Mangani (2004), we get the following first order conditions:

$$\frac{\partial R}{\partial \alpha} = c_1 N(A)A - c_2 C(A)A = 0 \tag{2a}$$

$$\frac{\partial R}{\partial A} = \alpha c_1 \left[\frac{\partial N(A)}{\partial A} A + N(A) \right] + (1-\alpha)c_2 \left[\frac{\partial C}{\partial A} A + C(A) \right] = 0 \tag{2b}$$

Rewriting (2a), we get:

$$\frac{C(A)}{N(A)} = \frac{c_1}{c_2} \tag{3}$$

Expressing (2b) in terms of elasticities, we get:

$$\alpha c_1 \left[\eta_{N,A} + 1 \right] + (1-\alpha)c_2 \left[\eta_{C,A} + 1 \right] = 0 \tag{4}$$

where $\eta_{N,A}$ is the elasticity of visits with respect to amount of advertising, and $\eta_{C,A}$ is the elasticity of clicks with respect to amount of advertising. By combining (3) and (4), Mangani (2004) derives the following expression for the optimal share of banners paid by PPV:

$$\alpha\left(\eta_{C,A}, \eta_{N,A}\right) = \frac{1 - \left|\eta_{C,A}\right|}{\left|\eta_{N,A}\right| - \left|\eta_{C,A}\right|} \tag{5}$$

Mangani (2004) states that this equation "clarifies the factors on which, in the optimum, the ratio between PPV and PPC depend." (p. 299). Although we agree that the optimal quantity of advertising will depend on the elasticities, we do not agree that the same can be said for the choice of pricing model. Note that the total revenue function (1) is linear in the share of banners sold through PPV, α. Looking at (2a) from which (3) stems, this condition simply shows that for an *interior* solution to exist, $\alpha^* \in (0,1)$, total revenue must be the same whether the web publisher uses strictly PPV or strictly PPC for a given level of advertising,

A . Only if this is the case, will it also be optimal to choose a combination of the two pricing models. Indeed, when (2a) holds, the web publisher is, by implicit assumption, indifferent between the two pricing models as well as *any* linear combination of the two. This means that there is no unique optimal α , contrary to what might be inferred by (5).

We think that a more appropriate interpretation of the optimization problem is as follows. Neither number of visits to the web-site nor number of clicks is dependent on pricing model. Rather, the optimization must be done in two stages. First, maximize revenue under each pricing model separately. Second, choose the pricing model which yields the highest revenue. From (4) we have that the optimal quantity of advertising under pure PPV $(\alpha = 1)$ and under pure PPC $(\alpha = 0)$ are given by the following conditions:

$$\eta_{N,A}\left(A_{PPV}^{*}\right) = -1 \tag{6a}$$

$$\eta_{C,A}\left(A_{PPC}^{*}\right) = -1 \tag{6b}$$

Hence, the amount of advertising should be such that in optimum, the demand for views and clicks should be unit elastic with respect to advertising. This implies that the marginal revenue to the web publisher from an additional ad is zero, and is analogous to the familiar condition for revenue maximization for a single product.

Substituting the optimal advertising amounts (A_{PPV}^{*} and A_{PPC}^{*}, respectively) back into the revenue expressions and comparing the maximized revenue for each model will reveal which pricing model should be adopted. Specifically, PPV should be adopted if $R\left(A_{PPV}^{*}\right) > R\left(A_{PPC}^{*}\right)$ and vice versa.

Mangani (2004) states that "The publisher will advertise until condition (3) has been satisfied." (p. 299). The left side in (3) is the so-called click-through rate which may be defined as:[3]

$$w(A) = \frac{C(A)}{N(A)} \qquad \text{where } w(A) \in [0, 1] \qquad (7)$$

Mangani's statement suggests that the click-through rate is endogenous in advertising. In a manner of speaking, this still places the burden of optimization on advertising. First, by (2a) the level of advertising must be set such that the click-through rate equals the ratio of the given PPV to PPC market prices. However, the optimal level of advertising is also solved for in condition (2b). Thus, the same level of advertising must simultaneously solve (2a) and (2b). Indeed, the following three conditions must be present. First, the click through rate equals the rate of PPV to PPC. Second, this occurs for a level of advertising which maximizes revenues both under PPV and under PPC. And third, the revenue under pure PPV and pure PPC are equal.[4] It seems unlikely that all these conditions would be met by chance. However, should this still be the case, the web publisher will be indifferent between the pricing models. The intuition behind this is that internet users who visit the web site are only influenced by the amount of advertising on the site (A). They are not influenced by the web publisher's choice of pricing model (α) which is invisible to them. Hence, a shift from one pricing model to another will only affect revenue through changing the weighted average of the revenue totals from pure PPV and pure PPC.

---

[3] The click-through rate is 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.

[4] If not, total revenues could be improved by shifting advertisers to the pricing model with the higher total revenue.

Before discussing an endogenous click-through rate, we consider the implications of an exogenous click-through rate. If the click-through rate is exogenous, $w(A) = \overline{w}$ such that $\frac{\partial w}{\partial A} = 0$, then (1) and (3) give us the following results.

Proposition 1: If a price taking web publisher has a click-through rate which is constant and less than the ratio of PPV to PPC prices, it should always choose PPV, and vice versa.

The intuition is that for any given amount of advertising, if $\overline{w} = \frac{C(A)}{N(A)} < \frac{c_1}{c_2}$, then it must also be that $c_2 C(A) < c_1 N(A)$. Hence, the click-through rate is too low relative to the price ratio to compensate the revenue loss from converting an advertiser from PPC to PPV. Note that the pricing method influences neither the number of views nor the number of clicks.

Corollary 1: If a price taking web publisher faces a click-through rate which is constant and equal to the ratio of PPV to PPC prices, the choice of pricing method is irrelevant.

The intuition for corollary 1 is that for any level of advertising, converting advertisers from PPV to PPC will reduce the number of payments by the click-through rate, but this is exactly offset by the higher percentage payment per click.

We now turn to the implications of an endogenous click-through rate. In this case, the level of advertising will influence the rate at which views are turned into clicks. An endogenous click-through rate will not influence the optimal level of advertising under pure PPV as the number

of clicks will not have any revenue impact. However, it will influence the optimal level of advertising under a pure PPC pricing. Rewriting the revenue function, we get:

$$R^{PPC}(A) = c_2 C(A)A = c_2 w(A)N(A)A \qquad (8)$$

Maximizing (8) with respect to A yields the following first order condition:[5]

$$\eta_{N,A} = -(1 + \eta_{w,A}) \qquad (9)$$

Note that if the click-through rate is exogenous (i.e. $\dfrac{\partial w}{\partial A} = \eta_{w,A} = 0$), (9) reduces to (6a). This gives us the following result:

Proposition 2: The optimal amount of advertising for a price taking web publisher who faces a constant click-through rate is the same for both PPV and PPC. The optimal amount of advertising should be set such that $\eta_{N,A} = -1$.

The intuition is that since the click-through rate is unaffected by the amount of advertising, and subsequently independent of the number of visits, the same amount of advertising will maximize revenue under either pricing method. Still, the best choice of pricing method is given by proposition 1. An illustration of this is given in Figure 1.

Insert Figure 1 about here

---

[5] The second order condition expressed in terms of $C(A)$ requires that $\eta_{C,A} < -\dfrac{A^2}{2C}\left(\dfrac{\partial^2 C}{\partial A^2}\right)$.

The upper half of Figure 1 shows linear "demands" for visits and clicks with respect to level of advertising. For linear demand, the elasticity of number of visits with respect to advertising is minus one at the midpoint. This corresponds to condition (6a), and condition (9) when click-through rate is constant. At this point, the amount of advertising is maximizing revenue under both PPV and PPC as illustrated in the lower half of the figure. The total revenue for the optimal level of advertising in the illustration is higher for PPV because $w < \frac{c_1}{c_2}$. As illustrated by the vertical line segment between the maxima under either pricing method, there is no linear combination of pricing methods which can increase total revenue beyond that of pure PPV.

On the other hand, if the click-through rate is endogenous, (9) yields the following result:

Proposition 3: If the click-through rate is increasing (decreasing) in the amount of advertising for a price taking web publisher, the web publisher should set a higher (lower) level of advertising under PPC than under PPV.

The intuition is as follows. From (9) we see that when advertising has a positive effect on the click-through rate $\left(\eta_{w,A} > 0\right)$, the optimal level of advertisement occurs when the number of visits is more elastic to advertising. In this case, the greater the amount of advertising, the more sensitive the number of visits is to a change in advertising. Thus, (9) implies a higher

9

level of advertising under PPC than under PPV, and vice versa.[6] An illustration of such a case is given in Figure 2 where the click-through rate is assumed to be decreasing in the amount of advertising.

Insert Figure 2 about here.

As suggested in Figure 2, when the click-through rate is decreasing in advertising, this leads to a lower optimal level of advertising under pure PPC than under pure PPV. Further, the figure illustrates the point that a comparison of maximized revenues under each pricing method is required to determine which is optimal as stated in Proposition 1. In this case, as in Figure 1, PPV is preferred. Again this is by assumption on click-through rates relative to the PPV to PPC price ratio. As illustrated by the vertical line segment between the revenue curves in the lower part of the figure, there is no linear combination of the pricing methods which can yield higher total revenue.

3. Conclusion

We have analyzed the choice of pay-per-view (PPV) and price-per-click (PPC) when a web publisher is a price taker in the market for advertising banners, and the number of visits is decreasing in advertising. The main result is that the web publisher should always choose either PPV or PPC. If the click-through rate is constant and less than the ratio of the PPV to PPC prices, the web publisher should choose PPV and vice versa. Only if the click-through rate is equal to the price ratio, is the choice of pricing model irrelevant. Regardless, the web publisher should set the amount of advertising such that the elasticity of visits with respect to advertising is unit elastic.

[6] We assume that the right-hand side of (9) is always negative.

If the click-through rate is endogenous, and increasing (decreasing) in advertising, the amount of advertising should be higher (lower) under PPC than under PPV. The choice of pricing method should be based on a straightforward comparison of maximized revenues under each pricing method.

In closing, the pricing issue we have analyzed begs the question: why should web publishers have to choose between the two pricing models? An alternative could be to charge a price per view and then an additional fee per click. We leave this for future research.
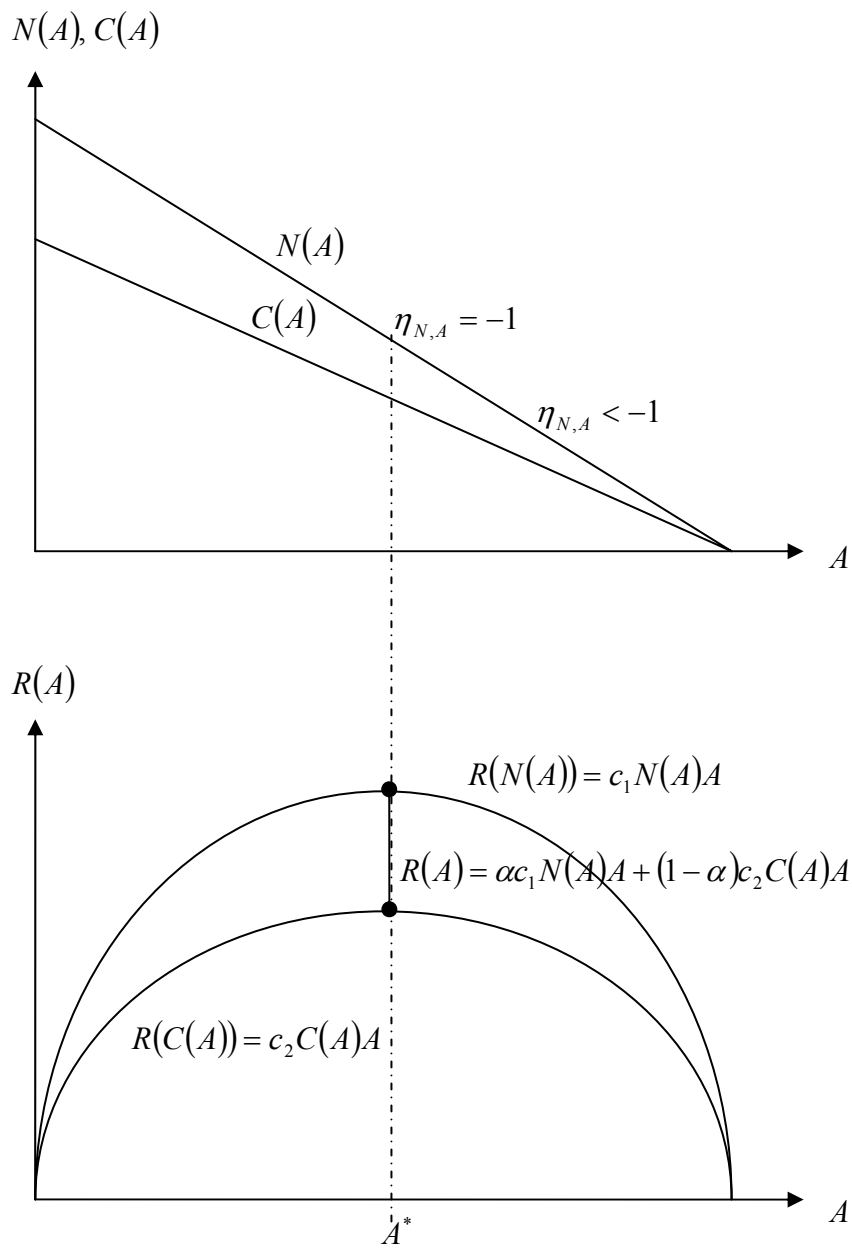
Figure 1 Visits and clicks are linear in advertising and click-through is constant and less than the ratio of PPV to PPC prices, i.e. $w < \dfrac{c_1}{c_2}$.
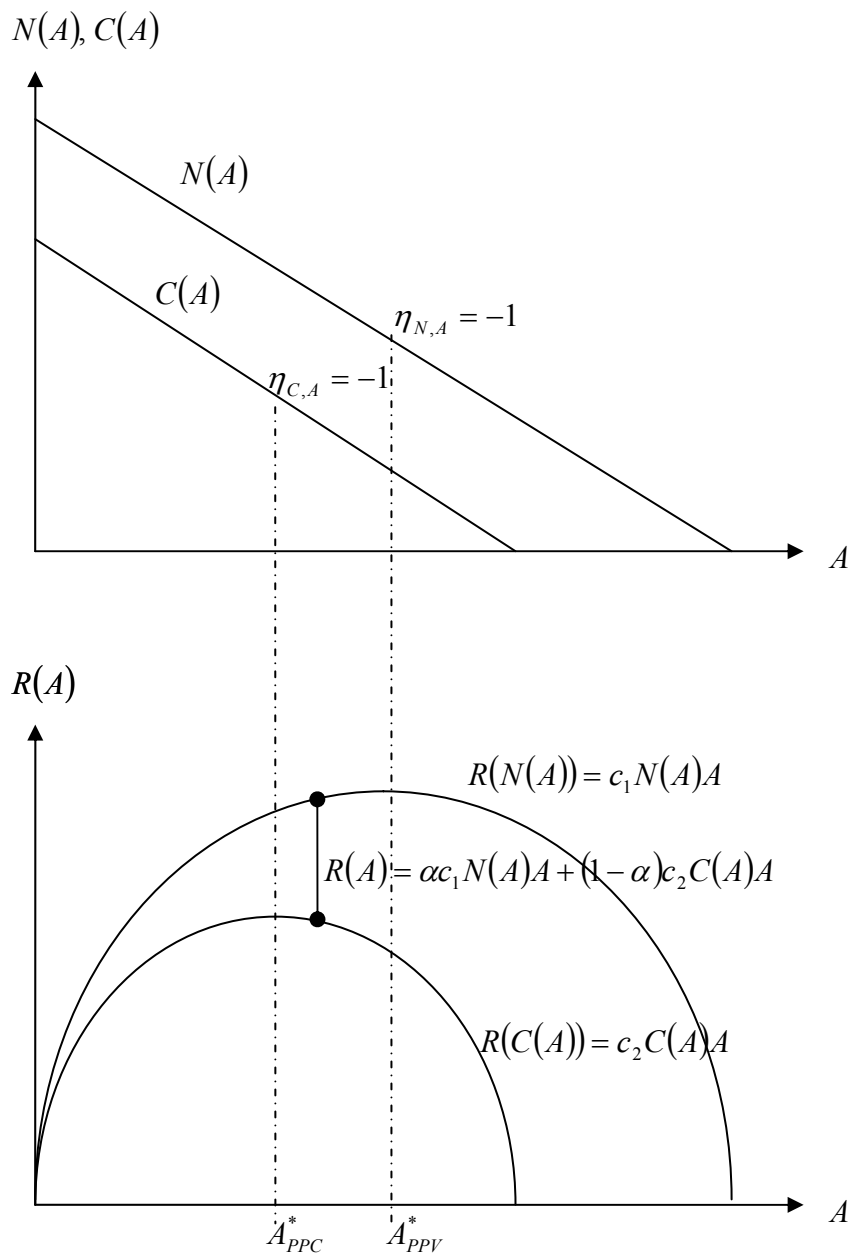
Figure 2 Visits and clicks are linear in advertising and click-through rate is decreasing.

4. References

Edelman, B., M. Ostrovsky, and M. Schwarz. 2007. "Internet Advertising and the Generalized Second-Price Auction: Selling Billions of Dollars Worth of Keywords", *American Economic Review,* vol. 97, no. 1, p. 242-259.

Mangani, A. 2004. "On-line advertising: Pay-per-view versus pay-per-click versus", *Journal of Revenue and Pricing Management, 2, 4, 295-302.*