December 31, 2009

The Impact of Targeting Technology on Advertising Markets and Media Competition

Susan Athey, *Harvard University*
Joshua S Gans

Title: The Impact of Targeting Technology on Advertising Markets and Media Competition

Authors:

Susan Athey (Corresponding)
Department of Economics,
Harvard University,
1805 Cambridge St.,
Cambridge, MA 02138.
Phone: 650-725-8696
Fax: 650-745-2498
Email: athey@fas.harvard.edu.

Joshua S. Gans
Melbourne Business School,
University of Melbourne,
200 Leicester St,
Carlton VIC 3053, Australia.
Phone: 617-901-9450
Fax: 650-745-2498
Email: j.gans@unimelb.edu.au.

Session: Designing Online Advertising Markets (L1)
Presiding: Michael Schwarz (Yahoo! Research)
Discussants: Scott Kominers (Harvard University); Michael Grubb (Massachusetts Institute of Technology)

This version: 11st January 2009

The Impact of Targeting Technology on Advertising Markets and Media Competition

by Susan Athey and Joshua S. Gans[1]

An important component of advertising effectiveness is the quality of the match between advertisers and the intended recipients of ads. Traditionally, media has been able to tighten such matches by providing content *tailored* for specific groups of consumers. For example, local media outlets attract audiences from their localities, ensuring that when local advertisers place ads, they are mostly viewed by their potential customer base. Recently, online advertising has afforded new technologies that target consumers directly rather than indirectly through tailored content. A leading example of such targeting is based on geographic location (as inferred from IP addresses). So while the *Boston Globe* may have had an advantage in selling ads to Boston advertisers, now the *New York Times* can offer Boston-based ads to consumers located in Boston. Industry speculation is that such technologies may spur higher demand for online advertising, but that these technologies will benefit general outlets more than local newspapers.[2] It may be problematic for the future of local news industry if general outlets gain at their expense.

To date there has been little analysis on how the market for advertising might be impacted by targeting.[3] Intuition suggests that in an outlet adopting targeting technologies will

---

[1] Athey: Department of Economics, Harvard University, 1805 Cambridge St., Cambridge, MA 02138. athey@fas.harvard.edu. Gans: Melbourne Business School, University of Melbourne, 200 Leicester St, Carlton VIC 3053, Australia. j.gans@unimelb.edu.au. For helpful comments we thank Emilio Calvano, Jonathan Levin, seminar audiences at Monash and the SIEPR/Microsoft Conference on Internet Economics, and especially Michael Grubb. We thank the Toulouse Network for Information Technology and the Australian Research Council for funding.

[2] "Behavioural targeting," *The Economist*, 5th June 2008.

[3] Some papers have explored the impact on product market competition (Ganesh Iyer, David Soberman and J. Miguel Villas-Boas (2005); Esther Gal-Or, Mordechai Gal-Or, Jerrold H. May and William E. Spangler (2006)) and

increase demand for advertising and with that prices (for impressions or clicks); see Ambarish Chandhra (2009). In this paper, however, we develop a formal model which identifies a separate supply-side impact of targeting. Specifically, targeting allows general outlets to more efficiently allocate scarce advertising space, resulting in an increase in the number of advertisers who can be accommodated. This increase in effective supply pushes prices downwards and will clearly affect the returns to adopting targeting technologies.

The resolution of these demand and supply effects depends upon how targeting alters the incentives of the general outlet in choosing its advertising space. When such space can be freely chosen (that is, there are no costs in expanding ad space or consumer disutility from ads) and when advertisers are not themselves capacity constrained, we demonstrate that an appropriately chosen expansion of ad space is a perfect substitute for targeting. That is, the adoption of such technologies does not alter prices or equilibrium profits. We then analyze three extensions of the model in which targeting does benefit general outlets: advertising space is limited or costly; there is heterogeneity across local media markets; or advertisers are capacity-constrained (creating competition between outlets on the advertising-side of the industry). Even in these cases, however, the impact of targeting is mitigated by the fact that when targeting is introduced, it is optimal for outlets to cut back on their supply of ad space.

Our formal analysis focuses on the case where the market shares of outlets are exogenous. Clearly, the higher are the profits per consumer, the more the outlets are willing to invest in their quality, expanding their market shares. When targeting increases general outlet

---

ad avoidance (Justin Johnson, 2009). An independent and complementary paper by Dirk Bergemann and Alessandro Bonatti (2009) is a notable exception; taking supply as exogenous, that paper develops a model of tailored media content and explores a number of comparative statics about the impact of targeting on advertising demand.

profits at the expense of local ones, we expect equilibrium market shares of outlets (and/or outlet survival, given the need to cover fixed costs) to move in the same direction as profits.

I. Baseline Model

Our model involves a set of localities $m \in \{1,\dots,M\}$ with N consumers in each locality, M local media outlets (one for each locality), and a single general outlet (g). Consumers (exogenously) visit only one outlet, either their own local outlet or the general outlet; in the terminology of the two-sided market literature, they *single-home*.[4] In local market, m, there are N consumers, where $n_{l,m}$ choose the local outlet. Our first results rely on a symmetry condition:

(S) *Market shares for the local and general outlet are symmetric across locations.*

Under condition (S), we let n_l denote each locality's readership for its local outlet.

Each advertiser i is also local and so it does not value advertising impressions for consumers outside its market. In our baseline case, we make the following assumption:

(CV) *Per-consumer advertiser value, v_i, is invariant to the number of consumers.*

This condition will hold if the advertisers are not capacity constrained and have constant marginal cost. Multiple impressions on the same consumer are wasted, but outlets track consumers so that only one impression per consumer is offered to each advertiser. There is a continuum of advertisers with values drawn from $[0,1]$ with distribution $F(v_i)$.

Each outlet $j \in \{l_1,..,l_M, g\}$ has a choice over the number of ads, a_j, that can be impressed on a consumer. Advertisers are assumed to bid for ad space and so will be rationed according to value with the marginal advertiser, v_j being defined by $1-F(v_j)=a_j$.

[4] This is a standard assumption in the media economics literature (Simon Anderson and Steven Coate, 2005), although in Susan Athey, Emilio Calvano and Joshua S. Gans (2009), we consider the implications of what happens when consumers can easily switch between outlets (i.e., some of them multi-home).

II. Tailoring versus Targeting in the Baseline Model

We now turn to solve for the equilibrium in the advertising market under condition (CV). Each outlet selects its supply of ad space.[5] Let p_j denote the impression price of outlet j. Note that (CV) implies that outlet decisions are independent of one another, so each outlet focuses on its own inventory decisions in isolation and our results are invariant to the number of outlets.

On the demand side, advertisers will purchase impressions on an outlet if $\theta_j v_i \geq p_j$. θ_j is the probability that a given impression is placed in front of a consumer in the advertiser's locality. For each local outlet, $\theta_l = 1$, since its content is tailored and only read by consumers in the advertiser's locality. In contrast, for the general outlet, condition (S) implies $\theta_g = 1/M$. An advertiser i on a general outlet reaches all consumers in its own locality (in addition to those in others), earning surplus of $n_g v_i - Mn_g p_g$. Using this, we establish a benchmark result.

Proposition 1. *Under (S) and (CV), the general outlet earns the same per consumer profit as local outlets regardless of whether it adopts targeting or not. Its advertising space in the absence of targeting is M times its advertising space with targeting.*

PROOF: Let $1-F(p_j/\theta_j)$ be the total demand for impressions in a locality to a given reader of outlet j. For a local outlet, l, in m, $p_{l,m}$ will be determined by the point where demand equals supply; that is, $1-F(p_{l,m}) = a_{l,m}$ or $p_{l,m} = F^{-1}(1-a_{l,m})$. For g, using (S), $M(1-F(Mp_g)) = a_g$ or, $p_g = (1/M)F^{-1}(1-(1/M)a_g)$. l solves: $\max_{a_l} a_l F^{-1}(1-a_l)$ while, if there is no targeting, g solves: $\max_{a_g} (1/M)a_g F^{-1}(1-(1/M)a_g)$. Note that these problems are the same but for a scaling factor, $1/M$. Thus, $Ma_l^* = a_g^*$ and $p_l^* = Mp_g^*$. Substituting these into profits, it is clear that per

[5] The industry refers to the choice of ad inventory as the "yield management problem" and numerous firms and products exist to help an outlet optimize its advertising output.

consumer profits are identical. If g adopts targeting, its problem becomes identical to l's problem but, since the maximized profits were identical, its profits do not change. By (CV), l's behavior does not change as a result of g's targeting. □

To understand this result, it is instructive to compare the impression prices for local and general outlets. First is the *demand-side efficiency effect*: advertisements in the general outlet are priced lower because they are less productive than those in the local outlet whose consumers all come from a particular locality. Second is the *supply-side scarcity effect:* without targeting, for a fixed level of advertising space, the supply of advertisements by the general outlet to a particular locality is reduced because a market's advertisers compete for that outlet's scarce advertising space with advertisers from other localities. This pushes up prices on the general outlet.

The balance of the effectiveness and scarcity effects determines whether tailoring is, indeed, a driver of greater profitability or not. Suppose for a moment that a_g is fixed and exogenous. Then, the global outlet earns higher prices (and profits) with targeting if

(1) $$F^{-1}(1-a_g) > \tfrac{1}{M}F^{-1}(1-\tfrac{1}{M}a_g)$$

To understand the condition, note that the first $1/M$ on the right-hand side reflects the *efficiency* effect. The factor $1/M$ in the second term reflects *scarcity*: without targeting, a_g / M advertisers from a given locality purchase advertisements, while with targeting, to fill the same space, a_g advertisers from a single locality purchase advertisements. If $F(v) = v$, (1) becomes $M/(M+1) > a_g$, and so that the targeting profits are higher unless a_g is fairly high (for the case of M=2, at least 2/3, which is higher than 1/2, the optimal level of a_g with targeting).

When the general outlet chooses its advertising space a_g in each case, in the absence of targeting it expands advertising space to M times what a local outlet would provide. Consequently, it serves the same range of advertisers, although to do this it charge a price of $1/M$

of the price it would charge with targeting. Although impressions are wasted on mis-matched consumers, the general outlet replicates the local outlet (monopoly, due to (CV)) outcomes.

III. Constraints or costs to the outlets of advertising space

Our baseline case demonstrates that targeting is not so much a substitute for tailoring (in terms of allowing more effective ads) but a mechanism that allows an outlet to achieve outcomes without wasted impressions. When there is no cost to providing those impressions, there is no return to adopting targeting. Of course, advertising space may be costly in terms of direct costs (e.g., printing and bandwidth) but also in terms of opportunity cost (e.g., deterrence of readers who may have a disutility associated with advertising clutter). In that case, targeting would save those costs. To keep things simple, we incorporate the costs of advertising space using a constraint, but the results are qualitatively similar when there is a cost of advertising space.

Proposition 2: *Suppose that advertising space on the general outlet is constrained to be no greater than* $\bar{a}$*. Then the adoption of targeting by the general outlet leads to higher impression prices, higher profits, and higher social welfare, relative to the case of no-targeting.*

The proof is a straightforward implication of the fact that the optimal levels of advertising for the global outlet with and without targeting are such that profits are equal between the two, but when the global outlet is too constrained to increase its output enough to compensate for the inefficiency of its impressions, its profits fall. The welfare implication arises from the fact that targeting allows more advertisers to be accommodated by the general outlet for a given advertising space constraint. This also means that the private return to adopting targeting technology is less than the social returns. This suggests issues for platforms trying to promote such technologies and their diffusion; something we leave for future research.

IV. Heterogeneous demand across localities

Consider what happens if our symmetry condition (S) does not hold, so that local outlet demand varying across localities. In this case, $\theta_{g,m} = n_{g,m} / \sum_{m'=1}^{M} n_{l,m'}$, so that an advertiser in a locality where the general outlet has a higher presence has a higher willingness to pay than in other localities. Without targeting, supply must be allocated across all advertisers: $M - \sum_{m=1}^{M} F(p_g / \theta_{g,m}) = a_g$. For a specific functional form, we show that targeting strictly helps.

Proposition 3. *Suppose that (CV) holds and that $F(v) = v^b$ for some $b > 0$ for $v \in [0,1]$. Then the adoption of targeting increases general outlet profits for all $(n_{l,1},..,n_{l,M})$. Its advertising space in the absence of targeting is M times its advertising space with targeting.*

PROOF: Let $\Phi = \sum_m \theta_{g,m}^{-b}$. Since there is no strategic interaction, we can model the choice of price. Without targeting, the general outlet solves: $\max_{p_g} p_g \left(M - p_g^b \Phi\right)$. With targeting, it solves $\max_{p_g} p_g(1 - p_g^b)$ in each market (where the objective is independent of the market identity). It is straightforward to show that per impression profits with targeting are equal to $\pi_g^T = b/(b+1)^{(b+1)/b}$ while without targeting they are $\pi_g^{NT} = \pi_g^T M^{(1+b)/b} \Phi^{-1/b}$. Since $\Phi \geq M^{1+b}$ (with $\Phi = M^{1+b}$ under (S)), the conclusion holds. □

No-targeting profits are proportional to with-targeting profits, and the size of the gain depends on the shape of the demand curve as well as the cross-market heterogeneity. Note that advertisers in some markets will be worse off as a result of targeting. In markets where the general outlet had a high readership share without targeting, advertising demand was relatively high. Targeting means some of those advertisers are no longer served. In effect, targeting makes it possible for the general outlet to price discriminate across markets.

V. Capacity-constrained advertisers

Condition (CV) implies that outlets do not compete for advertisers. In contrast, it may be that advertisers are *capacity constrained* and only wish to reach, at most, a specific number of consumers (for simplicity in the model, just one). With advertiser capacity-constraints, the general and local outlets will compete for advertisers at the margin. Consider this condition:

(CC) *Each advertiser i values at most one consumer impression from its own market.*

A local outlet can sell an advertiser, *i*, a single impression that will reach a relevant consumer; yielding surplus of $v_i - p_l$. For the general outlet, an impression has a $1/M^{\text{th}}$ chance of reaching a consumer in the advertiser's locality. Thus, the advertiser might want to purchase multiple impressions. Let $C(x) \equiv 1 - \left((M-1)/M\right)^x$ denote the probability that an advertiser who purchases x general outlet impressions reaches at least one relevant consumer; advertiser *i*'s payoff from x impressions is $C(x)v_i - xp_g$. Let

$$x^*(v_i; p_g) = \arg\max_x C(x)v_i - xp_g . \tag{2}$$

Note that $C(x)v - xp < v - p$; that is, for equal impression prices, any advertiser would prefer to be on the local outlet.[6] This means that, in equilibrium, $x^*(v)p_g < p_l$.

In effect, the local and general outlets are vertically differentiated in their offerings to advertisers. This means that high value advertisers, in the segment $[v_l, 1]$, will sort onto the local outlet, while the segment, $[v_g, v_l)$, advertises on the general outlet.

$$v_l - p_l = C(x^*(v_l))v_l - x^*(v_l)p_g \tag{3}$$

$$C(x^*(v_g))v_g = x^*(v_g)p_g \tag{4}$$

---

[6] In this section, we ignore the fact that impressing a consumer from a given market reduces slightly the likelihood that the next consumer comes from the same market; this effect is negligible with sufficiently many consumers.

The first condition states that the marginal advertiser on the local outlet is indifferent between purchasing an impression on that outlet or its optimal number of impressions on the general outlet. The second condition says that the marginal advertiser on the general outlet (and by implication in the market) earns no surplus when purchasing its optimal number of impressions on that outlet. The outlets' advertising space choices will impact on their impression prices which in turn will be constrained by the choices of their rival.

On the supply-side, the local and general outlet supply constraints are:

(5) $$1 - F(v_l) = n_l a_l$$

(6) $$\int_{v_g}^{v_l} x^*(v; p_g) dF(v) = n_g a_g / M \ ,$$

where the left-hand side of (6) is the total advertising demand in each market.

The two countervailing effects (the efficiency effect and the scarcity effect) that we found in the baseline model are still present here. On the efficiency side, targeting means that advertisers can achieve their desired quantity with certainty, and so they value a single impression from the local outlet more than an arbitrary number from the general outlet. However, there is also a third, *strategic* effect. A move to targeting removes the vertical differentiation between local and general outlets and there will be a single impression price, *p*, in the market determined by: $n_l a_l + n_g a_g = 1 - F(p)$. Our formal analysis shows that, like in the baseline model, the first two effects exactly balance out *within* the no-targeting regime: increasing the number of markets has no impact.

Proposition 4. *Suppose that (S) and (CC) hold. Then in the absence of targeting, both local and general outlet profits as well as the set of advertisers served by each are independent of M for* $M > 1$*, while the advertising space provided by the general outlet increases in M.*

PROOF: Since by (5), local outlet output has a one-to-one relationship with a_l that does not

depend on any general outlet choices or on M, we can consider the local outlet as directly choosing v_l rather than a_l. For fixed (v_g, v_l) and impression prices, the advertiser optimization constraints (2), (3), and (4) can be solved to express impression prices as a function of critical values: $p_g = v_g \ln[M/(M-1)]$ and $p_l = v_g(1 - \ln[v_g / v_l])$. In turn, these can be used to express profits as a function of (v_g, v_l). Crucially, we find that the left-hand side of (6) can be written $(1/\ln[M/(M-1)])(F(v_l) - F(v_g))\left(\mathbf{E}[\ln[v/v_g] \mid v_g < v < v_l]\right)$. This and the expression for p_g imply that general outlet profits are independent of M for given (v_g, v_l). Letting $\tilde{v}_g(a_g; v_l)$ be the value of v_g that satisfies (6), $\frac{\partial}{\partial v_l}\tilde{v}_g(a_g; v_l)$ does not depend directly on M. Substituting in p_l, local outlet profits are $n_l(1 - F(v_l))\tilde{v}_g(a_g; v_l)(1 - \ln[\tilde{v}_g(a_g; v_l)/v_l])$, which does not depend directly on M. Thus, if (v_g, v_l) is an equilibrium for some M, it will also be an equilibrium for $M' \neq M$. □

The proposition shows that, in the absence of constraints on advertising, the number of markets does not matter within the no-targeting regime. This somewhat counter-intuitive result follows because of the supply effect: the general outlet has the incentive to expand capacity to exactly offset the additional inefficiencies created by adding markets. With constraints on advertising capacity, increasing M does indeed cause the general outlet to suffer more from its inefficiency.

How do we compare outcomes with and without targeting? For a fixed (v_g, v_l), general outlet profits under no-targeting are less than under targeting by a factor of $\mathbf{E}[\ln[v/v_g] \mid v_g < v < v_l]$, which represents the average surplus extracted from inframarginal advertisers (higher-value advertisers purchase more impressions). Letting (v_g^T, v_l^T) be the equilibrium values with targeting (arbitrarily assigning the top advertisers to the local firm), and recognizing that $v_g^T = \left(F(v_l^T) - F(v_g^T)\right)/f(v_g^T)$, it is straightforward to show that if

$\mathbf{E}[\ln[v / v_g^T] \,|\, v_g^T < v < v_l^T] < 1$, then without targeting, the general outlet's best response to v_l^T is lower than v_g^T: the general outlet serves more advertisers. Its expands its advertiser base because it extracts more on average from inframarginal advertisers at a lower v_g^T. We explore the full equilibrium analysis and comparison of profits by solving the model for a functional form:

Example: Suppose that $F(v) = v^b$ ($v \in [0,1]$, $b > 0$). *When comparing equilibrium without targeting to that with targeting, the global (respectively local) outlet serves a larger (resp. smaller) set of advertisers but receives lower (resp. higher) profits.*

An expansion of advertising space cannot replicate fully the with-targeting profits for the general outlet because there is one impression price posted for all advertisers, with impression demand varying by advertiser value. With non-linear prices (e.g. the outlet sells only a large bundle rather than individual impressions), much or all of this inefficiency can be eliminated.

VI. Conclusions

We have established that when advertising space is unconstrained, general outlets can expand advertising space to mitigate most or all of the inefficiency that arises due to their heterogeneous audiences, so that targeting has little or no value. Although more realistic assumptions such as limits on advertising space or advertiser capacity constraints create a greater role for targeting, the supply effect still operates within the bounds of these constraints. Our analysis supports the broad intuition that advances in targeting technology will lead to the growth of general outlets at the expense of tailored outlets, but our findings qualify the extent of the impact and suggest that general outlets will adopt and utilize targeting technology more slowly than the technological efficiency improves. Of course, this does not rule out the possibility that industry structure will be greatly altered as a result of other technological changes in advertising or changes in consumer habits as a result of the internet (Athey, Calvano and Gans, 2009).

VII. References

Anderson, Simon P. and Steven Coate. 2005. "Market Provision of Broadcasting: A Welfare Analysis." *Review of Economic Studies*, 72(4): 947-972.

Athey, Susan, Emilio Calvano and Joshua S. Gans. 2009. "Will the Internet Destroy the News Media?" *mimeo*., Harvard.

Bergemann, Dirk and Alessandro Bonatti. 2009. "Targeting in Advertising Markets: Implications for Old and New Media?" *mimeo*., Yale.

Chandra, Ambarish. 2009. "Targeted Advertising: The Role of Subscriber Characteristics in Media Markets." *Journal of Industrial Economics*, 58(1): 58-84.

Gal-Or, Esther, Mordechai Gal-Or, Jerrold H. May, and William E. Spangler. 2006. "Targeted Advertising Strategies on Television." *Management Science*, 52(5): 713–725.

Goldfarb, Avi and Catherine E. Tucker. 2009. "Privacy Regulation and Online Advertising." *mimeo.*, Toronto.

Iyer, Ganesh, David Soberman, and J. Miguel Villas-Boas. 2005. "The Targeting of Advertising." *Marketing Science*, 24(3): 461–476.

Johnson, Justin. 2009. "Targeted Advertising and Advertising Avoidance." *mimeo*., Cornell.