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Platform Competition and Consumer Tracking

Charlotte B. Evensen
Hans Jarle Kind

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Charlotte B. Evensen,† and Hans Jarle Kind‡

Abstract

This paper examines the effects of tracking technologies on competition between digital platforms that generate revenue from both advertisers and readers in a two-sided market. Digital platforms sell audiences to advertisers, but the willingness to pay for reaching a consumer with an ad depends on whether he or she has already seen the ad elsewhere. High-value consumers are those who have not seen a specific ad before, while low-value consumers have. Tracking technologies can be utilized to distinguish between these consumer types. Our findings suggest that tracking might escalate competition among platforms in the consumer market to such an extent that it makes the platforms worse off, despite higher profits from advertising. The intense competition for consumers reduces consumer prices, leading more consumers to visit multiple media platforms compared to scenarios without tracking. This outcome could be beneficial from a policy perspective. Paradoxically, an increased valuation of low-value consumers might reduce overall platform profits, regardless of whether tracking is implemented.

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†Oslo Economics: cbe@osloeconomics.no

‡Norwegian School of Economics: hans.kind@nhh.no

1 Introduction

Consumers often visit multiple websites while browsing online. To gather information about their browsing history, tracking technologies like cookies are commonly used. Cookies are small text files that store information on a user's device. They come in two main varieties: first-party cookies, set by the website owner, and third-party cookies, set by external entities. First-party cookies generally enhance the user experience by retaining user preferences, while third-party cookies are an essential tool for tracking consumer activities across different websites, facilitating activities such as ad retargeting and frequency capping.[1]

With the use of third-party cookies, media platforms can capture more of the advertiser surplus. The technology facilitates monitoring of consumers as they navigate from one website to another, generating information that can be used to distinguish between consumers that see an ad for the first time (high-value consumers) and consumers that have already been exposed to it (low-value consumers). Platforms can charge a premium for the former when they sell eyeballs to advertisers. Thus, tracking makes the ad market more profitable for media firms. However, we also show that it incentivizes them to reduce consumer prices to attract a larger number of high-value consumers. This incentive might become so strong in a competitive environment that the ability to track consumers actually reduces platform profit. A further striking result is that while a higher worth of low-value consumers unambiguously would benefit a monopoly platform, because it increases advertising revenue, it can lower profits in an equilibrium with competing platforms.

Concerns about consumer privacy have grown in response to the widespread use of tracking on digital platforms. In response, regulators and web browsers have taken steps to protect privacy. The General Data Protection Regulation (GDPR), for instance, compels digital platforms to rethink their dependency on third-party data, forcing them to adapt to stricter privacy standards. This shift towards privacy-focused practices is reshaping the digital advertising landscape. However, these changes may come at a cost for consumers. Tracking enables platforms to attract high-value consumers by lowering consumer prices. Increased privacy might reduce this ability and therefore lead to higher prices. Higher prices limit consumers' affordability of access to multiple platforms. This might be particularly problematic when we consider media products such as newspapers, since it might be valuable both individually and socially for readers to be exposed to information from various sources.

[1] Frequency capping is a digital advertising strategy that limits the number of times a particular ad is shown to the same user within a specified time period, typically to prevent ad fatigue or annoyance. By setting frequency caps, advertisers can better manage their campaign reach and effectiveness while maintaining a balance between visibility and avoiding overexposure. See, e.g., https://en.wikipedia.org/wiki/Frequency_(marketing).

In setting up our model, we draw on the literature on two-sided markets with multihoming consumers and advertisers (Ambrus et al., 2016; Athey et al., 2018; and Anderson et al., 2018) and use a framework where platforms charge relatively high ad prices if they attract consumers who have not previously seen a specific ad. The existing literature typically treats multihoming consumers as a homogeneous group, in the sense that the value of a multihoming consumer for a media firm is independent of whether it reaches a given consumer with an ad before or after its rivals. This is a reasonable approach if consumer types are not observable, that is, if the platforms are unable to identify whether multihomers visit their platform first.

Tracking technologies might enable such identification. D'Annunzio and Russo (2020) show that tracking can reduce the risk of oversaturation, which arises when the same ad reaches a multihomer too frequently, resulting in inefficient use of the consumer's attention. The authors derive a model with two ad-financed platforms and an ad network. They show that it is profitable for the platforms to outsource advertising to the ad network when consumers multihome. This is because the ad network coordinates sales of ads, reducing competition between the platforms, and because the ad network tracks consumers across the two platforms, allocating ads more efficiently. They also demonstrate that it might not be profitable for platforms to allow pure tracking networks on their websites, which do not centralize ad sales. This could happen if tracking increases consumer disutility (for instance, by retargeting) and if multihomers are substantially more valuable to the platforms.[2]

Unlike D'Annunzio and Rosso (2020), we consider platforms that charge both consumers and advertisers. With consumer pricing, the platforms take into account how the consumer price affects the composition of demand and, in turn, advertising revenues. In this context, tracking gives the platforms stronger incentives to reduce the consumer price in order to persuade more consumers to visit them first, allowing them to sell more first impressions to advertisers.

The rest of this paper is organized as follows. In Section 2, we present the formal model. In Sections 3 and 4, we derive the equilibrium when tracking is unavailable and available, respectively. In Section 5, we compare the two equilibria and analyze the consequences of tracking for consumers and media platforms. Section 6 concludes.

2 The model

We consider a media market where two media platforms, labeled $i = 0, 1$, each offer their product to consumers and earn revenue through both consumer pay-

[2] D'Annunzio and Rosso (2023) extend their 2020 study by distinguishing between thin and thick advertising markets, where market thickness corresponds to the number of advertisers. They show that if the market is thin—meaning the number of advertisers is sufficiently small—it might not be profitable to outsource advertising to the ad network. The reason is that revealing ad exposure reduces bids from advertisers who reach consumers on more than one platform, leading to a drop in the price of impressions, especially when there are many multihoming consumers.

ments and advertising fees. The consumers are uniformly distributed along a unitary Hotelling line, and we normalize their number to 1. The platforms are located at the endpoints of the Hotelling line, with platform 0 on the far left and platform 1 on the far right.

The model is relevant for various digital media markets that combine user payments and advertising, such as newspapers, gaming platforms, and music, podcast, and TV streaming services. For concreteness, we refer to the platforms as (digital) newspapers from now on, assuming that their locations on the Hotelling line represent their political profiles. We set the newspapers' costs to zero.

The timing is as follows. At stage 1, newspapers noncooperatively set the prices they charge advertisers and readers. At the end of this stage, advertisers decide whether to purchase advertising slots. Then, at stage 2, each consumer decides whether to buy one of the newspapers. A consumer who decides to buy will choose the one that offers the most value for the money, given her subjective preferences. After reading that paper, she decides, at stage 3, whether to also buy a copy of the other newspaper.

2.1 The consumer side

Newspaper i charges consumers the price p_i. The intrinsic value of reading either of the newspapers (the newspapers' vertical quality level) is equal to v, but the net value is generally lower since a consumer incurs subjective mismatch costs if his or her preferences do not align with the political profile of the newspaper s/he buys. We capture this through modelling standard linear Hotelling transportation costs, denoted by the parameter t. Consumers are indifferent to the ad levels in the newspapers, and the net utility that a consumer located at x obtains from buying either newspaper 0 or 1, respectively, equals

$$u_0 = v - tx - p_0 \text{ and} \tag{1}$$

$$u_1 = v - t(1-x) - p_1. \tag{2}$$

In contrast to most of the literature, we allow for the possibility that consumers also buy and read their secondary choice (i.e., they can multihome). For simplicity, we assume that the utility from reading both newspapers is the sum of the utilities from reading each of them individually. Therefore, the utility of a multihomer is equal to

$$u_{ij} = 2v - t - p_i - p_j, \tag{3}$$

where the first subscript on u_{ij} denotes the consumer's most preferred newspaper (first choice) and the second subscript *her* secondary choice. All consumers for whom $u_{ij} \geq u_i$ will buy both newspapers (the incremental utility of buying the second newspaper is positive). Hence, each newspaper potentially serves two groups of consumers: exclusive readers and readers who are shared with the rival. Throughout, we focus on situations where there exits both exclusive and shared consumers (partial multihoming).

Let x_{01} represent the location of the consumer who is indifferent between buying just newspaper 0 and buying both newspaper 0 and newspaper 1 (see Figure 1). The location of this consumer can be found by solving $u_{01} = u_0$. Newspaper 0's exclusive demand (denoted by E_0) then arises from the consumers who are located to the left of x_{01}. Similarly, let x_{10} denote the location of the consumer who is indifferent between buying only newspaper 1 and both newspaper 1 and newspaper 0. It follows that the number of multihomers (M) is made up by the consumers located between x_{01} and x_{10}.

Figure 1: *Exclusive and multihoming consumers.*

Solving $u_{01} = u_0$ and $u_{10} = u_1$, we find that $x_{01} = (t - v + p_1)/t$ and $x_{10} = (v - p_0)/t$. We can now write newspaper i's exclusive demand as

$$E_i = \frac{t - v + p_j}{t}. \tag{4}$$

The larger the mismatch costs, and the smaller the intrinsic value of each product, the less attractive it is for consumers to multihome. This explains why $\partial E_i/\partial t > 0$ and $\partial E_i/\partial v < 0$. Note also that $dE_i/dp_j = 1/t > 0$. This simply reflects the fact that if newspaper j charges a higher price, then a larger number of consumers will only buy newspaper i.

The number of multihomers (which corresponds to the newspapers' shared demand) equals the total number of consumers minus the number of exclusive consumers, $M = 1 - E_0 - E_1$:

$$M = \frac{2v - p_i - p_j}{t} - 1. \tag{5}$$

Total demand for newspaper i is found by adding its number of exclusive consumers and multihomers ($T_i = E_i + M$):

$$T_i = \frac{v - p_i}{t} \tag{6}$$

Note that total demand for newspaper i is independent of the consumer price charged by the rival. This reflects that the *incremental* value of either newspaper for the consumers is independent of the price charged by the other newspaper. See Ambrus et al. (2016), Athey et al. (2018), and Anderson et al. (2018) for further discussions.

We assume market coverage, meaning that each consumer buys at least one of the newspapers. Given that both newspapers have positive market shares (which they will have in equilibrium, since the intrinsic value of the newspapers is identical), the consumer who is indifferent between the two newspapers is located at $\widetilde{x} \in (0,1)$. Solving $u_0(\widetilde{x}) = u_1(\widetilde{x})$ we find that $\widetilde{x} = 1/2 + (p_2 - p_1)/2t$. Consumers to the left of $\widetilde{x}$ have newspaper 0 as their first choice, while those to the right prefer newspaper 1. This determines the number of consumers who have newspaper i as their first choice:

$$F_i = \frac{1}{2} + \frac{p_j - p_i}{2t}. \tag{7}$$

2.2 The advertiser side

Let us now turn to the advertising side. Following Anderson et al. (2018), we assume that advertisers are homogeneous, and that each of them places either zero or one ad in each newspaper (zero ads if their reservation price is lower than the ad price). The number of advertisers is normalized to one. An advertiser is willing to pay a to reach a consumer in newspaper i if the newspaper can verify that the consumer has not been exposed to the ad previously on platform j. If this cannot be verified, an advertiser is only willing to pay σa, with $\sigma \in (0,1)$. This also implicitly determines the advertising prices that the newspapers will set at stage 1, since there is no reason to charge the advertisers less than their reservation prices. We classify consumers that are worth a on the advertising market as high-value consumers, and the others as low-value consumers.

3 No consumer tracking

In this section, we assume that newspapers cannot identify the browsing history of any individual consumer. One implication of this is that it cannot be uncovered whether a given consumer has previously seen a specific ad in the rival newspaper. However, advertisers rationally deduce that newspaper i has E_i exclusive consumers (high-value consumers) and M multihomers (low-value consumers), where E_i and M are given by equations (4) and (5), respectively. A profit maximizing newspaper will thus charge each advertiser $aE_i + \sigma aM$ for inserting an ad. Since the number of advertisers is normalized to one, it follows that newspaper i's advertising revenue equals

$$A_i = aE_i + \sigma aM. \tag{8}$$

Let $C_i = p_i T_i$ denote the revenue that newspaper i raises from the consumer side of the market. With newspaper costs normalized to zero, we can express its total profit level as

$$\pi_i = C_i + A_i. \tag{9}$$

Each newspaper maximizes profit with respect to own consumer price and by charging advertisers their reservation price. In Hotelling models in which all consumers are restricted to buy only product (singlehome), it is well known that consumer prices are strategic complements and that equilibrium prices are increasing in mismatch costs (because higher mismatch costs reduce a consumer's willingness to buy the least preferred newspaper, and thus reduces the competitive pressure between the newspapers). This is not the case when some consumers multihome; as noted above, the price charged by newspaper j only affects how many exclusive consumers newspaper i ends up with (E_i), not its total sales (T_i). Therefore prices are strategically independent under multihoming. This explains why marginal consumer revenue is independent of the rival's price:

$$\frac{dC_i}{dp_i} = T_i + p_i \frac{dT_i}{dp_i} = \frac{2}{t}\left(\frac{v}{2} - p_i\right). \tag{10}$$

If it were not for the advertising side of the market, consumers would be charged the monopoly price $p_i = v/2$ (making $dC_i/dp_i = 0$). This is inoptimal in a two-sided market, even though newspaper $i's$ price does not affect its number of exclusive readers (i.e., $dE_i/dp_i = 0$). The reason is that by reducing the consumer price p_i, it increases the number of consumers who buy newspaper i in addition to newspaper j (i.e., the number of multihomers); $dM/dp_i = -(1/t) < 0$. This raises advertising revenue for newspaper i (provided that $\sigma > 0$). Formally, from equation (8), we have

$$\frac{dA_i}{dp_i} = \sigma a \frac{dM}{dp_i} = -\frac{\sigma a}{t}. \tag{11}$$

Setting the sum of (10) and (11) equal to zero, we find the profit maximizing price. Since the newspapers are symmetric, we subsequently skip the subscript (but use the superscript N for No tracking). We can thereby write the equilibrium price and total sales of each newspaper (given by equation (6)) as

$$p^N = \frac{v - \sigma a}{2} \text{ and } T^N = \frac{v + \sigma a}{2t}. \tag{12}$$

Equation (12) reflects that each platform aims to enhance its attractiveness in the advertising market by increasing newspaper circulation (through setting a lower newspaper price), and more so the more valuable multihomers are on the advertising market.

Interestingly, equation (12) shows that the value of exclusive viewers is irrelevant for determining the optimal consumer price. This is because a newspaper's own price has no effect on number of exclusive consumers, as discussed above. It is also interesting to note that, in stark contrast to a context where all consumers singlehome, mismatch costs do not affect the equilibrium price. This again reflects the fact that prices are strategically independent under multihoming. However, total newspaper circulation deceases with the size of the mismatch costs.

It is crucial to recognize that even though consumer prices are strategically independent, newspapers impose negative externalities on each other. The reason is that if one newspaper reduces its consumer price, the rival will experience that some of its previously exclusive readers are transformed into less valuable multihomers. This represents a profit loss equal to $a(1-\sigma)$ for each reader that is transformed.

In equilibrium, the number of exclusive readers of each newspaper is

$$E^N = \frac{2t - \sigma a - v}{2t}. \tag{13}$$

while the number of multihomers equals

$$M^N = \frac{v - t + \sigma a}{t}. \tag{14}$$

In an equilibrium with partial multihoming, we must have $M^N \in (0,1)$. From equation (14) we find that this requires

$$t \in \left(t^N_{low}, t^N_{high}\right),$$

where $t^N_{low} = (v + \sigma a)/2$ and $t^N_{high} = v + \sigma a$. All consumers will multihome if mismatch costs are lower than t^N_{low}, while all consumers will singlehome if mismatch costs are higher than t^N_{high}.

The less willing a reader on one side of the political spectrum is to read a newspaper from the other side of the political spectrum, the fewer multihomers there will be, all else being equal. This explains why higher mismatch costs increase the number of exclusive readers ($dE^N/dt > 0$) and reduce the number of shared readers ($dM^N/dt < 0$). We also see from equation (12) that the total number of readers decreases with higher mismatch costs ($dT^N/dt < 0$).

At the outset one might expect that since higher mismatch costs reduce the size of the readership, it will also result in lower advertising revenue. However, matters are not that simple. To see the reason for this, note first that an increase in t reduces the number of multihomers by twice as much as it increases the number of exclusive readers for each newspaper; $\frac{dM^N}{dt} = -2\frac{dE^N}{dt}$.[3] If the value of a multihomer is worth less than half of the value of an exclusive reader, higher mismatch costs consequently increase advertising revenue (c.f. equation (8):

$$\frac{dA^N}{dt} = -2a\left(\sigma - \frac{1}{2}\right)\frac{dE^N}{dt} > 0 \text{ iff } \sigma < 1/2.$$

We can state:

Proposition 1: *No-tracking regime. Higher mismatch costs lead to greater advertising revenue if $\sigma < 1/2$, and lower advertising revenue if $\sigma > 1/2$.*

Proposition 1 posits that if multihomers are deemed 'valuable' ($\sigma > 1/2$), then higher mismatch costs lead to a reduction in advertising revenue. Conversely, if multihomers are not that valuable ($\sigma \leq 1/2$), advertising revenue increases despite a smaller readership. This is because each newspaper captures a larger number of exclusive readers.

[3] Formally, this is found from equations (13) and (14).

From equation (12) we find that newspaper revenue from the consumer side of the market equals

$$C^N = \frac{v^2 - a^2\sigma^2}{4t}. \tag{15}$$

Since the consumer price is independent of t, while total demand is decreasing in t, we unambiguously find that $dC^N/dt < 0$.

Using equations (8), (13) and (14) we further find that

$$A^N = a\frac{2t - a\sigma - v}{2t} + \sigma a\frac{v - t + \sigma a}{t}. \tag{16}$$

Equilibrium profit equals $\pi^N = C^N + A^N$. Differentiating this with respect to t yields

$$\frac{d\pi^N}{dt} = 3a\left(\frac{2a - v}{3a} - \sigma\right)\frac{v + a\sigma}{4t^2}.$$

We have:

Proposition 2: *No-tracking regime. Higher mismatch costs unambiguously decrease newspaper revenue from the consumer side of the market, but increase total newspaper profits if* $\sigma < (2a - v)/(3a)$.

An increase in t reduces newspaper circulation and thus lowers consumer revenues. However, it also prompts a shift towards fewer multihomers and more exclusive readers. If the latter are sufficiently valuable compared to multihoming consumers in the ad market, ad revenues increase to such an extent that total profits increase. This explains Proposition 2.

4 With consumer tracking

Let us now assume that the platforms use consumer tracking technologies to verify whether a given consumer has already been exposed to a specific ad at the rival.

Also in this section, we limit attention to a case with partial multihoming and where all consumers buy at least one newspaper. At stage 1, the newspapers set prices and advertisers purchase advertising space. Then, at stage 2, each consumer buys and reads her most preferred newspaper (the one she would buy under singlehoming). Finally, at stage 3, each consumer decides whether to buy a second newspaper, thus choosing between singlehoming and multihoming.

We use backward induction, and start with stage 3. A consumer will buy a second newspaper if this yields a positive incremental value. We can find the number of consumers who buy newspaper i as their second choice, S_i, by noting that this is equal to the total circulation of the newspaper minus the number of consumers who bought that newspaper as their first choice, F_i; $S_i = (E_i + M) - F_i$.

Inserting for equations (4), (5) and (7) into $S_i = (E_i + M) - F_i$ we find that $S_0 = S_1 = M/2$. Skipping the subscript, we can write:

$$S = \frac{2v - p_i - p_j}{2t} - \frac{1}{2}. \tag{17}$$

At the second stage, each consumer buys her most preferred newspaper. For convenience, we repeat equation (7) that determines the number of consumers who read newspaper i first (and who subsequently might read the other newspaper):

$$F_i = \frac{1}{2} + \frac{p_j - p_i}{2t}.$$

Figure 2 illustrates the relationship between the number of consumers who have newspaper 0 as their first and second choice and the number of exclusive readers and multihomers. To avoid too much cluttering, we have not marked the corresponding numbers for the other newspaper.

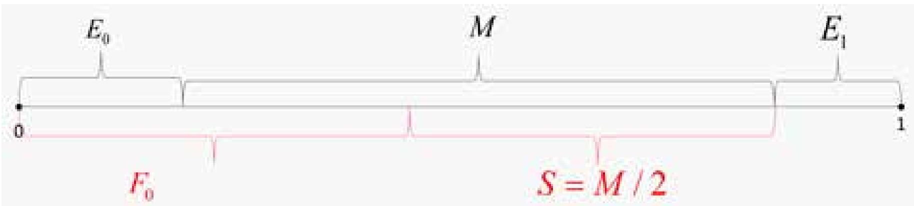

Figure 2: *First and second choice newspapers.*

With tracking, total ad revenue is given by (with superscript T for tracking)

$$A_i^T = aF_i + \sigma a S. \tag{18}$$

Total profit for newspaper i is

$$\pi_i^T = C_i + A_i^T, \tag{19}$$

where $C_i = p_i T_i$. Marginal consumer revenue, dC_i/dp_i, equals:

$$\frac{dC_i}{dp_i} = T_i + p_i \frac{dT_i}{dp_i} = \frac{2}{t}\left(\frac{v}{2} - p_i\right). \tag{20}$$

Note that equation (20) is equivalent to equation (10), which holds without tracking.

The effect on advertising revenue of increasing the consumer price under tracking is

$$\frac{dA_i^T}{dp_i} = a\frac{dF_i}{dp_i} + \sigma a \frac{dS}{dp_i}.$$

In the previous section we found that without tracking, a newspaper's own price has no effect on the number of high-value consumer that it attracts (it only affects advertising income through the number of multihomers). This is different with tracking; the consumer price directly affects both the number of consumers who are worth a (high-value consumers) on the advertising market and those who are only worth σa (low-value consumers): $dF_i/dp_i = dS/dp_i = -1/(2t)$. This implies that

$$\frac{dA_i^T}{dp_i} = -a\frac{1+\sigma}{2t}. \tag{21}$$

In contrast to the case without tracking (c.f., equation (11), we thus see that a higher consumer price reduces advertising revenue even if the value of a second impression on consumers should be zero.

Solving $d\pi_i/dp_i = 0$ we find

$$p^T = \frac{2v - a(1+\sigma)}{4}. \tag{22}$$

Inserting for (22) into (23) implies that the number of multihomers are

$$M^T = \frac{a\,(1+\sigma) + 2\,(v-t)}{2t}. \tag{23}$$

Partial multihoming, $M^T \in (0,1)$, requires

$$t \in \left(t_{low}^T, t_{high}^T\right),$$

where $t_{low}^T = \frac{2v+(1+\sigma)a}{4}$ and $t_{high}^T = \frac{2v+(1+\sigma)a}{2}$.

The number of first impressions is equal to $F^T = 1/2$ in a symmetric equilibrium. Since $S^T = M^T/2$ we can further write:

$$S^T = \frac{a\,(1+\sigma) + 2\,(v-t)}{4t}. \tag{24}$$

Total demand equals

$$T^T = \frac{a\,(1+\sigma) + 2v}{4t}, \tag{25}$$

and it follows that higher mismatch costs reduce both total sales ($dT^T < 0$) and the number of second impressions ($dS^T < 0$). We can thus immediately deduce:

Proposition 3: *Tracking regime. Higher mismatch costs reduce revenues from both the consumer side and advertising side of the market (*$dC^T/dt < 0$ and $dA^T/dt < 0$*), and harms the newspapers (*$d\pi^T/dt < 0$*).*

Note that this result is in sharp contrast to what we found under no-tracking; Proposition 2 tells us that higher mismatch costs might benefit the newspapers in that regime.

Using equation (18), (22), (24) and (25) we have:

$$C^T = \frac{4v^2 - a^2\,(1+\sigma)^2}{16t} \tag{26}$$

$$\text{and } A^T = \frac{a}{2} + a\sigma\frac{(1+\sigma)\,a + 2(v-t)}{4t} \tag{27}$$

5 Comparing tracking and non-tracking

As shown in Sections 3 and 4, newspapers can increase advertising revenue by reducing consumer prices, regardless of whether they use tracking technologies. However, there is an important difference regarding the incentives to use a price-reducing tool: With tracking, each newspaper can use it to attract high-value consumers to the advertising market. In contrast, the same tool can only attract low-value consumers in the absence of tracing. This difference suggests that the incentive to reduce consumer prices for the purpose of increasing advertising revenue is stronger with tracking than without it. As a result, we can expect tracking to lower consumer prices and increase advertising revenue. To confirm this, we use equations (15), (16), (26) and (27) to find that

$$C^T - C^N = -\frac{a^2(3\sigma+1)(1-\sigma)}{16t} < 0 \text{ for } \sigma < 1, \text{ and} \tag{28}$$

$$A^T - A^N = a(1-\sigma)\frac{2(v-t)+3a\sigma}{4t} > 0 \text{ for } \sigma < 1, \tag{29}$$

where the sign on $A^T - A^N$ follows from the assumption that $(v-t)+\sigma a > 0$, which ensures that we have (partial) multihoming in both regimes.[4]

Equations (28) and (29) are interesting, as they tell us that newspaper profits might be higher without tracking than with tracking. This is most easily seen by assuming that $(v-t) = 0$ and that the value of a second impression is only slightly positive, $\sigma = \varepsilon > 0$. Loosely speaking, advertising revenue is then approximately the same under tracking and no-tracking ($A^T - A^N \approx 0$), while revenue from the consumer side of the market is significantly lower with tracking ($C^T < C^N$). Formally, using equations (15), (16), (26) and (27) we find

$$\pi^T - \pi^N = \frac{9a^2}{16t}\left(\sigma + \frac{8(v-t)}{9a} - \frac{1}{9}\right)(1-\sigma), \tag{30}$$

from which it follows that $\pi^T > \pi^N$ if, and only if, $\sigma > \frac{1}{9} - \frac{8(v-t)}{9a}$. If σ is sufficiently low, newspaper profits might therefore be lower with tracking than without it, while the opposite is true for sufficiently high values of σ. Note, however, that it does not matter for the newspapers whether they have tracking technologies if $\sigma = 1$, because the worth of high-value and low-value types of consumers then coincide. This indicates that $\pi^T - \pi^N$ might be a hump-shaped function of the value of the second impression, as illustrated in Figure 3 (which measures σ on the horizontal axis and $\pi^T - \pi^N$ on the vertical axis, and where we have set $v - t = 0$). Solving $d\left(\pi^T - \pi^N\right)/d\sigma$ we further find that the benefit for the newspapers of using tracking technologies is maximized at an intermediate value σ; more precisely, at $\sigma = \frac{a-4(v-t)}{9a}$.

[4] From equations (14) and (23), the number of multihomers without and with multihoming are given by $M^N = \frac{v-t+\sigma a}{t}$ and $M^T = \frac{a(1+\sigma)+2(v-t)}{2t}$, respectively. We have $M^N > 0$ if $(v - t + \sigma a) > 0$. Whenever this inequality holds, it follows that $M^T > 0$.

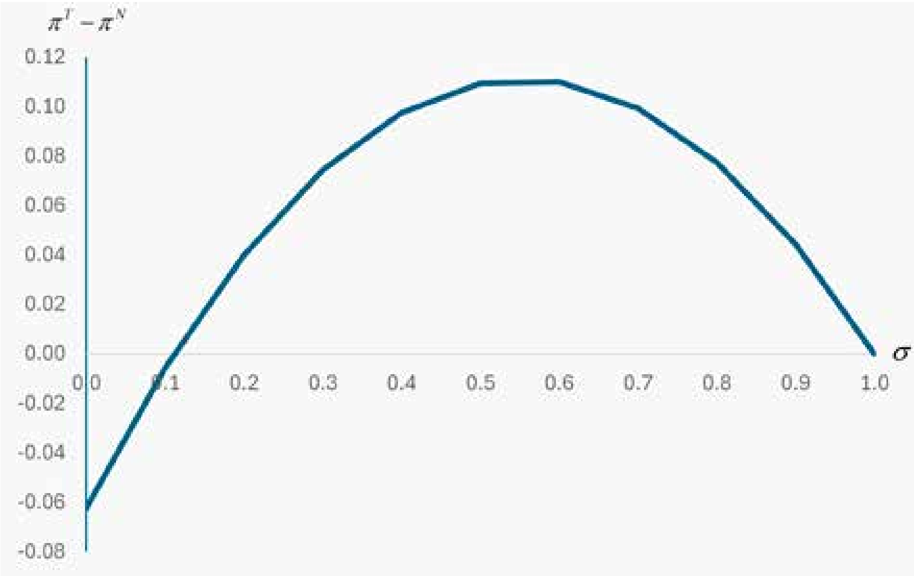

Figure 3: *The difference between newspaper profits with and without tracking.*

We can now conclude:

Proposition 4: *Newspapers make higher profit in the non-tracking regime than in the tracking regime if* $\sigma < \frac{1}{9} - \frac{8(v-t)}{9a}$*. Otherwise, the tracking regime yields the higher profit level, and the profit gain from using tracking is maximized at* $\sigma = \frac{a-4(v-t)}{9a}$.

5.1 The worth of low-value consumers: its effect on profits

Proposition 4 shows that a high worth of low-value consumers tends to make tracking technologies profitable. We shall now analyze how profits *within* each regime depend on σ.

We start with the non-tracking regime. An increase in σ makes it more profitable for the platforms to attract multihomers. Thus, they will reduce consumer prices ($dp^N/d\sigma < 0$) and accept lower revenues from the consumer side of the market:

$$\frac{dC^N}{d\sigma} = -\frac{\sigma a^2}{2t} < 0.$$

The relationship between σ and advertising revenue is more complex. Even though the direct effect of a higher σ is to increase advertising revenue, the net effect might be the opposite. The reason is that since a higher worth of low-value consumers reduces consumer prices, it must necessarily increase the number of low-value consumers (multihomers) and reduce the number of high-value consumers (exclusive readers) in equilibrium. More precisely, from equation (8) we have:

$$\frac{dA^N}{d\sigma} = a\frac{dE}{d\sigma} + \frac{d(\sigma a M)}{d\sigma}. \tag{31}$$

Using equations (13) and (14) we find that $adE/d\sigma = -a^2/(2t) < 0$ and $d(\sigma aM)/d\sigma = a(v - t + 2a\sigma)/t > 0$. Defining $\sigma_A^N \equiv (a - 2(v - t))/(4a)$, we can write:

$$\frac{dA^N}{d\sigma} = \frac{2a^2}{t}\left(\sigma - \sigma_A^N\right). \tag{32}$$

Equation (32) is striking: it shows that advertising revenue might decline if the worth of low-value consumers in the advertising market increases. This happens when $\sigma < \sigma_A^N$. Since we have previously established that $dC^N/d\sigma < 0$, it follows immediately that total newspaper profits could diminish with a rising worth of low-value consumers. Specifically, we have

$$\frac{d\pi^N}{d\sigma} = \frac{3a^2}{2t}\left(\sigma - \sigma^N\right) \gtreqless 0 \text{ if } \sigma \gtreqless \sigma^N,$$

where $\sigma^N = (a - 2(v - t))/(3a) > \sigma_A^N$.

We can state:

Proposition 5: *No-tracking regime. A higher worth of low-value consumers reduces newspaper profits if $\sigma < \sigma^N$ and even results in lower advertising revenue if $\sigma < \sigma_A^N$,* where $\sigma_A^N < \sigma^N$.

Now, let us investigate the relationship between σ and newspaper profits in the tracking regime. From equation (27), which shows equilibrium advertising revenue, we see that a higher worth of low-value consumers unambiguously increases advertising revenue if the newspapers use tracking. The intuition is straightforward: while the number of consumers who prefer reading newspaper i over newspaper j is independent of σ, a higher σ increases the value of second impressions. Formally, we have $dA^T/d\sigma = \frac{a+2(v-t+a\sigma)}{4t} > 0$. Nevertheless, the competitive externalities between the platforms imply that higher relative worth of low-value consumers might still reduce newspaper profits, despite increasing advertising revenue. More precisely, by defining $\sigma^T \equiv [4(t - v) - a]/(3a)$, we obtain:

Proposition 6: *Tracking regime. A higher worth of low-value consumers reduces platform profits if $\sigma < \sigma^T$, but advertising revenue unambiguously increases.*

Proof: Inserting for (26) and (27) into $\pi^T = C^T + A^T$, we find

$$\frac{d\pi^T}{d\sigma} = \frac{3a^2}{8t}\left(\sigma - \sigma^T\right).$$

Similar to the case without tracking, profits might thus fall if the worth of low-value consumers increases.[5] It is straight forward to show that this could never

[5] As an example, let $t = 1.1$, $v = 1.0$ and $a = 0.20$. Then $M^T > 0$ for $\sigma > 0$, with $d\pi^T/d\sigma < 0$ for $\sigma < 0.32$.

happen if the newspapers merged and maximized joint profit; an increase in σ increases the size of the negative pricing externalities between rival newspapers.[6]

5.2 The extent of multihoming with and without tracking

The lower consumer price under tracking leads to a larger total readership of each newspaper ($T^T > T^N$). This, in turn, implies that we will see multihoming (both partial and complete) for higher mismatch costs with tracking than without tracking. This is illustrated in Figure 4, which shows that at least some consumers will buy both newspapers if $t < 1.65$ with tracking, while there will be no multihoming unless $t < 1.30$ without tracking. To the extent that policymakers find it essential that consumers are exposed to different political perspectives or viewpoints, the fact that tracking leads to more multihoming is arguably important.

We state:

Proposition 7: *Multihoming occurs for higher levels of mismatch costs with than without tracking. Other things equal, tracking might therefore imply that consumers are exposed to a larger set of political perspectives than would otherwise be the case.*

The intrinsic value of the newspapers, v, can be taken as a proxy for how consumers perceive the (vertical) quality levels of the newspapers (a high intrinsic value signifies a high quality level). Since tracking reduces consumer prices, we have the following corollary to Proposition 7:

Corollary 1: *Multihoming occurs for lower levels of newspaper qualities with than without tracking.*

[6] If the newspapers merge, equilibrium is found by solving $\{p_0, p_1\} = \arg\max \{\pi_0 + \pi_1\}$. In the non-tracking regime we find $p^N_{merger} = p^N + \frac{1-\sigma}{2}a$, while we under tracking have $p^T_{merger} = p^T + \frac{1-\sigma}{4}a$. This shows that the pricing externalities between competing newspapers decrease with σ (and vanish at $\sigma = 1$).

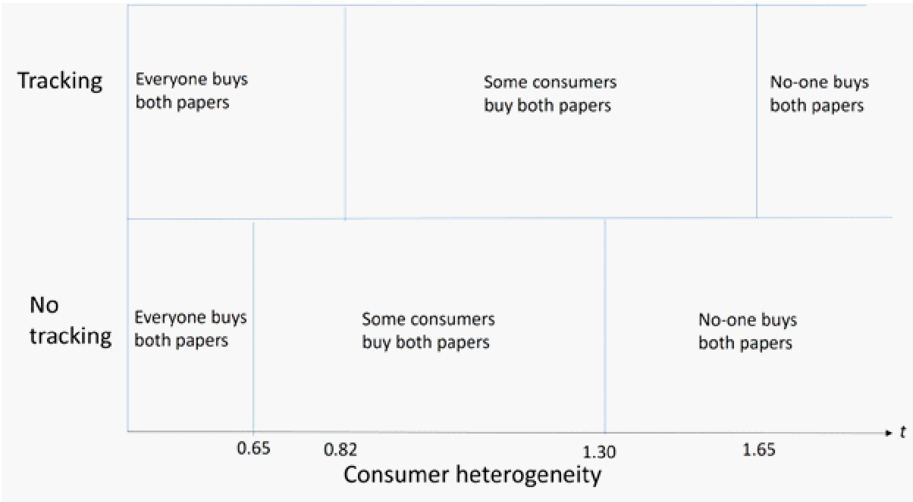

Figure 4: *Ranges of multihoming with and without tracking. Parameter values $v = 1, a = 1$ and $\sigma = 0.3$.*

We end this section by investigating the relationship between newspaper quality and revenue from the advertising side of the market. Using equations (16) and (27) we find :

$$\frac{dA^T}{dv} = \frac{a\sigma}{2t} > 0 \text{ and } \frac{dA^N}{dv} = a\frac{\sigma - 1/2}{t} < 0 \text{ iff } \sigma < 1/2.$$

We consequently have:

Proposition 8: *Higher newspaper qualities increase advertising revenue under tracking, but reduce it without tracking if the worth of low-value consumers is sufficiently small ($\sigma < 1/2$).*

Note that the results in Proposition 8 are reminiscent of those in Propositions 1 and 3, where we established that higher mismatch costs increase advertising revenue when newspapers use tracking but decrease it under non-tracking if $\sigma < 1/2$.

6 Concluding remarks

The privacy implications of tracking have been addressed in several papers. Goldfarb and Tucker (2011) point out that tracking contributes to consumers' privacy concerns, leading governments to consider stricter regulation. Choi et al. (2021) investigate the impact of regulations that enable consumers to opt in and out of tracking. D'Annunzio and Rosso (2020) show that the ability to block tracking might be harmful to consumers in scenarios where tracking reduces the provision of ads. This could occur if consumer preferences for different platforms are negatively correlated and tracking is used for targeting specific consumer types. In this paper, we focus on the idea that tracking might allow platforms to differentiate between high-value and low-value consumers. This differentiation enables media platforms to increase advertising revenue. However, it may nonetheless reduce their total profitability. The reason is that platforms respond to tracking possibilities by lowering consumer prices to attract more high-value consumers. In a competitive equilibrium, this leads to a situation where there are more low-value consumers, fewer high-value consumers, and prices that are too low from the platforms' perspective. In this context, privacy regulations, such as GDPR, might benefit media platforms by reducing their ability to utilize tracking technologies. If this occurs, it could result in higher consumer prices, potentially limiting consumers' access to multiple platforms. This may be perceived as problematic to the extent that it is important for consumers to be exposed to diverse viewpoints.

We have assumed that consumers are neutral towards both advertising and tracking. Relaxing these assumptions could affect the relative profitability of tracking. For instance, if consumers dislike advertising, platforms will have to charge lower prices to encourage consumers to visit them. If consumers also dislike tracking, the platforms will have to lower prices further. Against this background, it seems likely that the benefit of being able to distinguish between low-value consumers and high-value consumers will be lower if consumers dislike ads or tracking. If this is so, tracking becomes relatively less profitable.

Our analyses are based on the assumption that all consumers buy at least one of the platform products (market coverage). An interesting avenue for future research would be to explore uncovered markets, where the size of the market decreases with rising consumer prices. This could affect the profitability of tracking versus non-tracking.

In the current version, we have presumed that platforms compete on prices. An alternative setup could involve platforms competing on quality. Instead of attracting consumers by lowering prices, platforms could enhance their value proposition through higher quality. For example, news platforms might achieve this by investing in improved journalistic standards.

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This paper examines the effects of tracking technologies on competition between digital platforms that generate revenue from both advertisers and readers in a two-sided market. Digital platforms sell audiences to advertisers, but the willingness to pay for reaching a consumer with an ad depends on whether he or she has already seen the ad elsewhere. High-value consumers are those who have not seen a specific ad before, while low-value consumers have. Tracking technologies can be utilized to distinguish between these consumer types. Our findings suggest that tracking might escalate competition among platforms in the consumer market to such an extent that it makes the platforms worse off, despite higher profits from advertising. The intense competition for consumers reduces consumer prices, leading more consumers to visit multiple media platforms compared to scenarios without tracking. This outcome could be beneficial from a policy perspective. Paradoxically, an increased valuation of low-value consumers might reduce overall platform profits, regardless of whether tracking is implemented.

SNF

Samfunns- og næringslivsforskning AS
Centre for Applied Research at NHH
Helleveien 30
NO-5045 Bergen
Norway

P +47 55 95 95 00
E snf@snf.no
W snf.no

Trykk: MAKE!Graphics - avd. Bergen