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“Data, Targeted Advertising and Quality of Journalism: The Case of Accelerated Mobile Page (AMP)”

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Data, Targeted Advertising and Quality of Journalism: The Case of Accelerated Mobile Page (AMP)

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Abstract

This paper studies how newspapers' adoption of Google's Accelerated Mobile Page (AMP), a publishing format for mobile devices enabling instant loading of web pages, changes data allocation and thereby newspapers' incentive to invest in quality of journalism when consumer data is used for targeted advertising. The adoption of AMP allows Google to obtain consumer data from AMP articles and to combine it with other sources of consumer data to improve targeting of the advertisements served by Google on other websites. Even if such data combination increases static efficiency, it can reduce dynamic efficiency when it lowers the ad revenue per newspaper traffic and thereby reduces the quality of journalism. Newspapers face a collective action problem as a newspaper's adoption of AMP generates negative externalities to other newspapers through data leakage. In addition to leveraging its search monopoly power, Google can use a divide-and-conquer strategy to induce newspapers to adopt AMP. We provide policy remedies.

Key Words: Targeted Advertising, Data Combination, Data Leakage, Quality of Journalism, Search Engine

JEL: D21, L12, L15, L82, M37

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1 Introduction

There is a general tendency that major gatekeeping platforms use their power to channel consumer interactions with business users into their walled gardens. For instance, the development of Super Apps in China by the two major Chinese platforms (Alibaba and Tencent) is an extreme example of such tendency: within each Super App, a consumer can carry out almost all her activities such as shopping, ride hailing, reading news, gaming, money transfer, flight bookings that she barely needs to leave the Super App. Inspired by the Chinese Super Apps, Facebook and Uber adopted a similar business strategy. Another example is Google's tendency to "swallow web", about which Shira Ovide, who writes the On Tech newsletter of the New York Times, expresses her concern as follows:

"One longstanding issue is Google's evolution from a website that pointed people to the best links online to one that's swallowing the web. ... Now, Google is more likely to prominently show information or advertisements from its own computer systems or scraped from other companies' websites — and keep you within Google's digital walls. Google isn't a front door to the internet anymore. It's the house. (New York Times, On Tech newsletter, September 24, 2020)"

A main reason for which major platforms expand their walled gardens instead of embracing an open Internet is that they want to collect as much data as possible about consumers' various online activities, which allows them to infer consumers' preferences and to predict their behaviors. This motive is particularly relevant to ad-financed platforms such as Google and Facebook, of which the business model consists in harvesting consumer attention and data and monetizing them through targeted advertising (Zuboff (2019)). Platforms' access to business users' data raises a very important question: how does such data access affect the innovation of the platform ecosystem, in particular, the innovation incentives of business users?[1]

In this paper, we address the above question in a specific context of newspapers' adoption of Google's Accelerated Mobile Page (henceforth AMP), which is an open source publishing format for mobile devices enabling instant loading of web pages in mobile browsers. Both the CMA Report (2020) of UK and that of U.S. House of Representatives (2020) expressed concerns about the AMP.[2] We study how the adoption of AMP changes data allocation and thereby affects static and dynamic welfare when consumer data is used

[1] For instance, the question arises regarding Amazon's use of business data of independent sellers who sell on its marketplace, which is under investigation by the European Commission.

[2] See also Geradin and Katsifis (2019), Scott Morton and Dinielli (2020) and Srinivasan (2019).

for targeted advertising. In particular, we focus on the impact on newspapers' incentive to invest in quality of journalism. Whereas our model is setup in the context of AMP, we believe that the insights we obtain from our analysis can be applied more generally to situations when platforms combine different sources of data for targeted advertising. For instance, our results apply to Facebook as it offers Instant Articles (IA) format, which, like AMP, allows mobile pages to load faster.

There are two aspects of AMP that are noteworthy and relevant to this paper: (i) AMP articles are cached by Google and hence Google can collect data about consumers' browsing activities on AMP articles. (See Appendix S of the CMA Report (2020), p. 3 and p. 17): (ii) Google induces publishers to adopt AMP by leveraging its search monopoly power, namely by giving adopters prominent positions in its mobile search result pages. For instance, only news articles in the AMP format can appear in "Top Stories" carousel, which attracts a majority of users' attention. In addition, Google displays a "lightning" icon besides the link for AMP articles, to indicate that their pages can be loaded fast.

To answer the question of how AMP affects static and dynamic welfare, we build a model in which symmetric and ad-financed newspapers compete by choosing quality of journalism. Each consumer engages in two distinct online activities, activity A and activity B. Activity A represents news consumption activity, which is divided into two parts, direct visits and search-referral visits. By direct visits, we mean that each consumer regularly browses news from her (single) favorite news outlet. By search-referral visits, we mean that each consumer searches for news by using the monopolistic search engine (SE) and reads news from multiple newspapers depending on the search result. Activity B represents other web-browsing activities different from news consumption and it also involves display advertising. We use a reduced-form approach to model the sector related to activity B (called, sector B) and assume that the SE is the ad intermediary for the websites/apps related to activity B and thereby obtains consumer browsing data from them.

In our model, AMP affects both the product market (i.e. the newspaper market) and the advertising market. Regarding the product market, first, adopting AMP has the benefit of eliminating the loss of search referral traffic due to slow loading of pages. Second, the SE leverages its search monopoly power to encourage the adoption of AMP by promoting adopters' rankings and demoting non-adopters' rankings in search results.

A key component of our model consists in the link between data allocation and targeted advertising revenue, which in turn affects newspapers' investment incentive. In the baseline model, we assume that all newspapers partner with a third-party ad intermediary, T, to sell their ad inventories: hence, the SE has no access to newspaper-browsing data in the absence of AMP. In contrast, when newspapers adopt AMP, the SE obtains the browsing data from AMP articles, which it combines with its consumer data from activity B in order to improve targeting of the ads in sector B. Therefore, the SE's access to AMP data improves static welfare for given quality of each newspaper: it improves overall matching between ad inventories and advertisers. However this does not mean that the SE's access to AMP data improves dynamic welfare, which is our focus.

We assume that the ad revenue per newspaper traffic is increasing in the amount of consumer data T has, but decreasing in the extent of overlap between T's data and the SE's data. We find that the adoption of AMP creates two opposite effects for newspapers: (i) search traffic enhancing effect due to the fast-loading of articles, which is positive; (ii) data leakage effect[3] which reduces the ad revenue per (direct) traffic and thereby is negative. In a hypothetical benchmark in which AMP does not involve any change in data allocation, AMP induces newspapers to invest more in the quality of journalism. However, when the data leakage effect kicks in, AMP reduces the ad revenue per newspaper traffic and thereby could reduce the quality of journalism. By contrast, we find that the SE has no incentive to internalize the impact of its data combination on the quality of journalism.

We point out that newspapers face a collective action problem as a newspaper's adoption of AMP generates negative externalities to other newspapers through data leakage. This is because if a newspaper adopts AMP, it not only leaks browsing data of its own direct readers but also that of direct readers of other newspapers (Recall that a newspaper's search referral traffic is composed of readers from many different newspapers). As each individual newspaper doesn't internalize this negative externality on its competitors and the SE can leverage its market power in search to penalize non-adopters, we find that there always exists an equilibrium in which all newspapers adopt AMP. An equilibrium in which no newspaper adopts AMP exists only when the loss in ad revenue from "data leakage" is strong enough.

To further dig into this collective action problem, we consider an extension where we assume a fraction of newspapers uses the SE as their ad intermediary. In fact, Google's ad tech is the leader in ad intermediation for open display advertising (CMA, 2020). We show that combining its market power in ad intermediation with its search monopoly

[3] data are leaked from newspapers' point of view when the SE has access to browsing data from AMP articles.

power provides Google with an extra leverage to exploit the collective action problem. More precisely, we find that it is a dominant strategy for a newspaper relying on the SE as its ad intermediary to adopt AMP. Interestingly, we find that the adoption equilibrium is the unique equilibrium when the proportion of newspapers who partners with the SE is larger than a threshold. This result implies that the SE can employ a divide-and-conquer strategy to gain control of newspaper data.

As policy remedies, we propose that Google should treat in a non-discriminatory way, in its search results, all articles that meet an objective and neutral criterion of loading speed and should not host articles on its server to capture the browsing data. This will restore the equilibrium in the benchmark without change in data allocation, where newspapers invest more in journalism quality in response to faster page-loading speed .

1.1 Related Literature

Due to the unprecedented scale and scope of data collection, there is an emerging body of literature studying various economics issues related to the use of consumer data, including privacy, data ownership, data as barrier to entry, data being used for price discrimination etc. However, as far as we know, there has been no paper studying the data relationship between business users and a platform who organizes two-sided interactions within its walled garden, and how this affects the innovation in the platform's ecosystem. So our paper's contribution is to add a new perspective to the discussion of data related issues. In addition, by explicitly accounting for the role that consumer data allocation plays in competition among newspapers and quality of journalism, our paper adds insights to two following strands of literature.

Firstly, our paper is related to the literature which explores the impact of a news aggregator (or a large digital platform such as Facebok) on competition among newspapers and the quality of journalism. Dellarocas et al. (2013) considers a link economy in which a news aggregator provides links to the highest quality content and studies how its presence affects the equilibrium quality chosen by content providers depending on whether they can (can not) link to each other. Jeon and Nasr (2016) decomposes the effects of a news aggregator on newspaper traffic into a business-stealing effect and a readership-expansion effect and analyze how they in turn affect journalism quality. de Cornière and Sarvary (2020) explores how Facebook's bundling of news content with user-generated content impacts consumers' attention allocation between social media and news sites and its implication for the news industry. Jeon (2018) provides a survey which covers theoretical, empirical and experimental papers on news aggregators. These previous papers focus on the impact of aggregators on newspapers' traffic while taking the advertising revenue per traffic as given. In contrast, our paper makes the ad revenue per traffic endogenous to data allocation, which is in turn influenced by the search engine's strategy. So our contribution lies in offering a new channel through which large digital platforms can impact news industry.

Secondly, our paper is related to the literature on media competition in two-sided markets (Anderson and Coate (2005), Ambrus et al. (2016), Athey et al. (2018), Anderson et al. (2018), D'Annunzio and Russo (2019), Krämer et al. (2019) and Anderson and Peitz (2020)): they study static media competition both on the consumer side and on the advertiser side. Most of the previous literature considers an environment in which publishers directly contract with advertisers to sell ad inventories. They either use a price competition model in which ad prices are set by publishers or use a quantity competition model in which the advertising market is cleared à la Cournot. Neither approach captures the current situation in which the majority of online display advertising inventories are sold in a programmatic way, i.e. through real-time auctions mediated by a complex chain of ad tech service providers. D'Annunzio and Russo (2019) is an exception in exploring how the presence of ad networks impacts media competition for advertisers, although they adapt the quantity competition model of Ambrus et al. (2016). Furthermore, a common assumption in the above-mentioned papers (except for Krämer et al. (2019)) is that the boundary of the product (i.e. content) market coincides with that of the advertising market, which means that the same set of medias that compete for readership also compete for advertising dollars. However in reality, the boundary of online display advertising market is much broader than that of the newspaper market as not only newspapers but also other various types of content providers and social medias compete on the supply side by selling ad inventories. Our paper is closely related to Krämer et al. (2019), which explores how Facebook's social-login impacts both competition in content market and competition in advertising market. Social-login enables data sharing between a specific-interest content provider and a social network (say Facebook), which improves user experience of the content provider and ad targeting for both the content provider and the social network. Our paper is complementary to theirs for the following reasons. First, they perform a static analysis whereas we focus on dynamic efficiency in terms of quality choices. Second, they consider a setup of a representative advertiser in which each publisher chooses an ad price; we consider programmatic sale of display advertising through ad intermediaries which connect a large number of publishers to a large number of advertisers. Last, they consider data sharing which improves ad targeting of both parities who share the data; we consider data leakage from newspapers to the SE, which is facilitated by the exercise of search monopoly power through promotion and demotion decisions in search results.

The rest of paper is organized as follows. In section 2, we present the baseline model in which we assume all newspapers use ad tech service from a third-party ad intermediary. Then, we establish two benchmarks in section 3. In section 4, we analyze how AMP changes allocation of consumer data and consequently impacts the advertising revenue. By taking content quality as given, we show that in static case, data leakage improves social welfare. Then in section 5, we study how AMP changes the investment in content quality and give the welfare analysis taking into account dynamic efficiency. In section 6, we examine the existence of both a symmetric equilibrium in which all newspapers adopt the AMP format and another one in which none of newspapers adopt the format. In section 7, we relax the assumption that all newspapers use the third-party ad tech service by assuming that a fraction of newspapers use the SE's ad tech. We show that SE can use a divide-and-conquer strategy to induce the adoption of AMP. We propose a policy remedy in section 8. Section 9 provides the conclusion. Lastly, readers may refer to appendix A for an introduction to open display advertising market, which provides some stylized facts that guide our modeling choices.

2 Baseline Model

Figure 1 gives an overview of the industry structure in our model.

2.1 Newspaper market

There are n symmetric online newspapers competing: they have a symmetric demand and a symmetric cost. n is not a small number: the meaning of this assumption is clearer later on. The newspapers are horizontally differentiated and are financed by online advertising. Each newspaper i chooses quality q_i at a cost $c(q_i)$ which is strictly increasing and strictly convex with $c(0) = 0$. Let $\mathbf{q} \equiv (q_1, ..., q_n)$ and $\mathbf{q}_{-i} \equiv (q_1, ..., q_{i-1}, q_{i+1}, ..., q_n)$

There is a measure 1 of consumers. Consumers have heterogeneous taste for newspapers. Each consumer has a single preferred newspaper and divides her news reading time between reading by directly visiting her preferred newspaper's site and reading articles found by search. Search is mediated by a monopoly search engine (SE), which provides

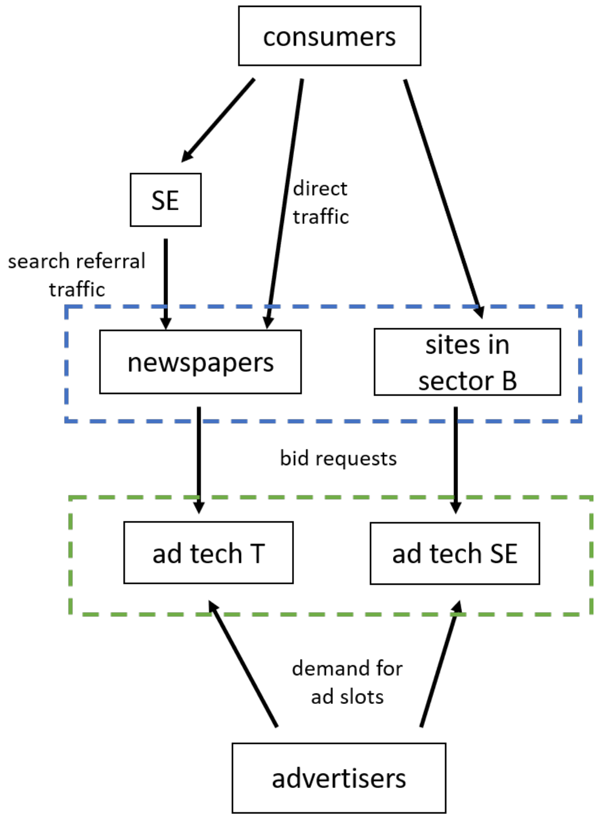

Figure 1: Industry Structure

Notes. The blue rectangle represents the content market in which newspapers compete in quality for both direct traffic and search referral traffic, but they don't compete with sites in sector B for visitors. The green rectangle represents the ad intermediation market where two ad intermediaries (SE and T) compete in bidding for ad impressions on behalf of advertisers.

personalized rankings of news articles in its search result. Therefore, each newspaper has direct traffic and search referral traffic.

Newspapers have symmetric demand functions. The direct demand for newspaper i is given by $D^{d,i}(\mathbf{q}) = D^{d,i}(q_i, \mathbf{q}_{-i})$. The search referral demand for newspaper i is given by $D^{s,i}(\mathbf{q}) = D^{s,i}(q_i, \mathbf{q}_{-i})$. Note that the search referral demand is conditional on having no distortion in search rankings of different articles. For simplicity, we consider that the two demands are separate.

Denote $D_j^{d,i} = \frac{\partial D^{d,i}}{\partial q_j}$, $D_{ij}^{d,i} = \frac{\partial^2 D^{d,i}}{\partial q_i \partial q_j}$. We make the following assumption on the newspaper demand.

Assumption A1 *(i)* $D_i^{d,i} > 0, D_j^{d,i} < 0$*, for* $j \neq i$ *and the same for* $D^{s,i}(\mathbf{q})$*;*

(ii) $\sum_{j=1}^{n} D_j^{d,i} \geq 0$ *when* $q = q_1 = ... = q_n$ *and the same for* $D^{s,i}(\mathbf{q})$*;*

(iii) $D_{ii}^{d,i} \leq 0, D_{ij}^{d,i} \leq 0, j \neq i$ *and the same for* $D^{s,i}(\mathbf{q})$*.*

A1 (i) means that an increase in q_i increases the demand for i, while an increase in q_j reduces the demand for i. A1 (ii) means that at symmetric quality, if all newspapers increase their quality, it at least weakly increases each newspaper's demand. This is the market expansion effect. The concavity of the demands in A1 (iii) is a sufficient condition to satisfy the S.O.C.of profit maximization of each newspaper. As long as the F.O.C. is a sufficient condition for profit maximization, we can dispense with it. The property of cross-derivative $D_{ij}^{d,i} \leq 0, j \neq i$ implies that quality choices are strategic substitutes.

The role of AMP. For search referral traffic, it is convenient to think that the demand is determined by two stages. In the first stage, consumers visit the SE to search for news and, given the search result, decide which links to click-through. The demand determined at this stage is captured by $D^{s,i}(\mathbf{q})$. In the second stage, consumers are directed by the SE to the news websites of which the links are clicked. In this process, consumers may suffer from slow loading of pages such that they decide not to read the news. We assume the loss rate is $\delta \in [0, 1]$. As a result, the final search referral traffic is $(1 - \delta)D^{s,i}(\mathbf{q})$. To overcome the slow loading issue, the SE introduces Accelerated Mobile Page (AMP) which enables instant loading of pages. We normalize the loss rate for AMP articles to zero. Similarly, we normalize the loss rate of direct traffic to 0.

2.2 Advertising market and consumer data allocation

In addition to news consumption activity (called activity A), each consumer also uses Internet to visit other ad-financed content providers' applications/websites. For simplicity, we aggregate all other websites different from newspapers into a single sector called B. Although the sites (or apps) in sector B don't compete with newspapers on the content side, they do compete with the latter on the advertising side by offering targeted advertising.

Both newspapers and sites in sector B sell their ad inventories through real time auctions mediated by ad tech service providers. We consider a duopoly ad tech market: there is competition between the ad tech system of the SE and an alternative system based on third-party ad intermediaries denoted T. We assume that the sites/apps in sector B use the ad tech service of the SE. By contrast, we assume in the baseline model that newspapers rely on the ad tech service of T. We later on extend the baseline model to a situation in which a fraction of them use the ad tech service of the SE.

An ad tech system's targeting ability and thereby advertising revenue depends on how much consumer data it has. We now first characterize data allocation between the two systems. Let Ω^x be the complete data set generated from all of consumer x's online activities. In our model, we have $\Omega^x = \omega^{x,d} \cup \omega^{x,s} \cup \omega^{x,B}$, where $\omega^{x,k}$ represents the set of browsing data generated by consumer x's activity $k \in \{d, s, B\}$. (Recall that a consumer's news browsing activity (A) is further divided into direct visit (d) and search-referral visit (s).)

Then let $\Omega^{x,h}$ be the set of data that ad intermediary $h \in \{SE, T\}$ has about consumer x. An ad tech system gains access to the data of a consumer's activity conducted on its customer's website/app if it is able to identify her. We assume in the benchmark case without AMP, ad tech T can perfectly identify consumers in direct traffic but cannot identify consumers in search traffic. Therefore, $\Omega^{x,T} = \omega^{x,d}$. Meanwhile, as ad tech SE has access to data generated by consumer's activity B, we have $\Omega^{x,SE} = \omega^{x,B}$. We will see later in section 4 how AMP affects data allocation.

Next we adopt a reduced-form approach in building the relationship between advertising revenue per traffic and data allocation, by abstracting away from the details of real-time auction. Let the advertising revenue associated with a unit of traffic in activity k where the ads are served by ad tech system h be

$$\alpha_{k,h}(\Omega^{x,h}, \Omega^{x,h} \cap \Omega^{x,-h})$$

where $k \in \{d, s, B\}, h \in \{SE, T\}$ and $-h$ represents the rival ad tech system. Therefore, we characterize the competition between two ad tech systems by letting the advertising revenue of an ad tech not only depend on the amount of data it owns, but also the extent of overlap between the two ad tech systems' data sets.

And we impose the following assumption on this advertising revenue function:

Assumption B1 $\alpha_{k,h}(\Omega^{x,h}, \Omega^{x,h} \cap \Omega^{x,-h})$ *increases with* $\Omega^{x,h}$ *given* $\Omega^{x,-h}$*, and decreases with* $\Omega^{x,h} \cap \Omega^{x,-h}$ *given* $\Omega^{x,h}$ *for each* $h \in \{SE, T\}$.[4]

What does this assumption mean? The first part says that the effect of increasing the amount of data held by ad tech system h on its advertising revenue is positive. Holding the

[4]We provide a microfoundation for this assumption in Appendix B.

effect of $\Omega^{x,h} \cap \Omega^{x,-h}$, this is intuitive as more data enables better targeting. Furthermore, this effect stays positive even if we take into account the effect through $\Omega^{x,h} \cap \Omega^{x,-h}$ (given $\Omega^{x,-h}$). To understand it, consider a data merger such that a subset of the rival's data, $\Omega^{x,-h} - \Omega^{x,h}$, is added to $\Omega^{x,h}$. This should increase the ad revenue of h even if the effect from better targeting is mitigated since this part of data is also possessed by the rival ad tech $-h$.

To explain the second part of B1, consider the case in which initially $\Omega^{x,h} \cap \Omega^{x,-h} = \varnothing$ holds and then $\Omega^{x,-h}$ expands from $\Omega^{x,-h}$ to $\tilde{\Omega}^{x,-h} = \Omega^{x,-h} \cup \Omega^{x,h}$. More precisely, suppose that consumer x is a direct reader of newspaper 1. Then, in the absence of AMP, $\Omega^{x,T} = \omega^{x,d}$ is the set of data that ad tech T has about the consumer and $\Omega^{x,SE} = \omega^{x,B}$ is the set of data that the SE has about the consumer from her activity B. If the two activities are completely uncorrelated (i.e. $\omega^{x,d} \cap \omega^{x,B} = \varnothing$), the product which appeals most to the consumer inferred from the data set $\omega^{x,d}$ will be different from the one inferred from $\omega^{x,B}$. If the quality of the data in $\omega^{x,d}$ is much better than the one in $\omega^{x,B}$, the ad revenue per direct traffic of consumer x to newspaper 1 would be much higher than advertising revenue per traffic of consumer x in sector B . However, in the presence of AMP, if the SE gets access to the consumer x's data $\omega^{x,s}$ generated by referring her search to AMP articles of numerous newspapers, then $\tilde{\Omega}^{x,SE} = \omega^{x,B} \cup \omega^{x,s}$. In addition, if $\omega^{x,s}$ is strongly correlated with $\omega^{x,d}$, this may allow the SE to infer the best match product that would be advertised by newspaper 1 alone in the absence of AMP. Hence, the SE can engage in *advertising arbitrage*, which reduces the advertising revenue of newspaper 1.

Note that the advertising revenue $\alpha_{k,h}(\Omega^{x,h}, \Omega^{x,h} \cap \Omega^{x,-h})$ also depends on the nature of ad inventories, i.e. with which activity k the ad impression is associated. First, even under a symmetric data allocation, α_d and α_B could still be different. This is because the nature of the site on which advertising is displayed affects the willingness to pay of advertisers and thereby the advertising revenue. For instance, reputable advertisers do not want to show their ads besides hate/racism content. Second, $\alpha_{d,T}$ is different from $\alpha_{s,T}$. As we assumed above that ad tech system T is unable to identify consumers in newspaper's search-referral traffic, $\Omega^{x,T} = \varnothing$ for ad inventories associated with activity s. This means that newspapers can only use contextual advertising for search referral traffic, which only uses context data but not consumer's behavioral data. Hence, we add a simplifying assumption:

Assumption B2 *All newspapers use contextual advertising for search-referral traffic such that ad revenue for search-referral traffic is constant and given by* $\alpha_s \equiv \alpha_{s,T}(\varnothing, \varnothing)$ *no mat-*

ter data allocation.

B2 allows us to focus on the substitution between the ad revenue from direct traffic and the ad revenue in sector B. It plays a role mainly in the extension in which we analyze a divide-and-conquer strategy and makes the analysis tractable. Due to assumption B1, the contextual advertising revenue α_s is lower than the revenue generated from personalized ad which allows for the use of consumer's behavioral data.[5]

Finally, we introduce the following shorthand notation for the advertising revenues in the absence of AMP.

$$\alpha_d^N \equiv \alpha_{d,T}(\Omega^{x,T}, \Omega^{x,T} \cap \Omega^{x,SE}) = \alpha_{d,T}(\omega^{x,d}, \omega^{x,d} \cap \omega^{x,B})$$
$$\alpha_B^N \equiv \alpha_{B,SE}(\Omega^{x,SE}, \Omega^{x,SE} \cap \Omega^{x,T}) = \alpha_{B,SE}(\omega^{x,B}, \omega^{x,B} \cap \omega^{x,d})$$

where the superscript N refers to no AMP.

2.3 Timing

We consider the following timing: Each newspaper simultaneously decides whether or not to adopt the AMP and chooses its quality.

3 Two Benchmarks

In this section, we study two benchmarks.

3.1 Benchmark of no AMP

Given $\mathbf{q}$, the profit of the newspaper i is given by

$$(1-\tau^T)\left[\alpha_d^N D^{d,i}(\mathbf{q}) + \alpha_s(1-\delta)D^{s,i}(\mathbf{q})\right] - c(q_i)$$

[5]For empirical evidence showing that advertisers bid more for impressions which enables identifying consumers than for those with only context information available, see Appendix F p. 29 of CMA Final Report, Beales (2010) and Srinivasan (2019). For instance, according to the CMA (2020)'s study of data generated by Google's Randomised Controlled Trial (RCT) of display advertising, UK publishers earned around 70 percent less revenue overall when they were unable to sell inventory using personalised advertising (i.e. when cookies were not available) but competed against others who could.

where τ^T in $(0,1)$ is the ad tech take of the ad tech system T. The F.O.C. is given by

$$(1-\tau^T)\left[\alpha_d^N D_i^{d,i}(\mathbf{q}) + \alpha_s(1-\delta)D_i^{s,i}(\mathbf{q})\right] - c'(q_i) = 0.$$

The S.O.C. is satisfied if

$$(1-\tau^T)\left[\alpha_d^N D_{ii}^{d,i}(\mathbf{q}) + \alpha_s(1-\delta)D_{ii}^{s,i}(\mathbf{q})\right] - c''(q_i) < 0,$$

which is satisfied under A1.

Proposition 1 *In the absence of AMP, the quality at the symmetric equilibrium, denoted by q^N, is characterized by*

$$(1-\tau^T)\left[\alpha_d^N D_i^{d,i}(q^N,...,q^N) + \alpha_s(1-\delta)D_i^{s,i}(q^N,...,q^N)\right] = c'(q^N) \text{ for all } i = 1,...,n.$$

3.2 Benchmark of AMP without changes in data allocation

Consider here a second benchmark in which we consider a situation in which all newspapers adopt the AMP format but there is no change in the allocation of data. In other words, the advertising revenue is still given by α_d^N and α_B^N.

AMP allows fast loading of articles referred by the SE. Hence, we assume that given $\mathbf{q}$, when all newspapers adopt the AMP format, the search-referral demand for newspaper i is given by $D^{s,i}(\mathbf{q})$ while AMP does not affect the demand for direct traffic.

Therefore, it is immediate that:

Proposition 2 *Consider the benchmark in which AMP is adopted by all newspapers but it does not affect the allocation of consumer data.*

(i) The quality at the symmetric equilibrium, denoted by q^*, is characterized by

$$(1-\tau^T)\left[\alpha_d^N D_i^{d,i}(q^*,...,q^*) + \alpha_s D_i^{s,i}(q^*,...,q^*)\right] = c'(q^*) \text{ for all } i = 1,...,n.$$

(ii) Hence, AMP increases the quality of journalism: $q^* > q^N$.

This second benchmark is very closely related to the policy remedy we propose at the end of this paper.

4 AMP with changes in data allocation: static analysis

Now we consider the main scenario in which AMP changes allocation of consumer data. In this section, we consider the static case in which AMP does not affect quality choices in any of the two sectors.

4.1 Data allocation under AMP and advertising revenue

The SE hosts in its own server AMP articles for search referral. Therefore, when a consumer clicks on an article, she consumes the article on the SE's site, implying that the SE collects the data generated by the consumer's reading/browsing. Suppose that all newspapers adopt the AMP format. We below present its consequences in data allocation and in advertising market.

(i) (**data leakage**) the SE has access to $\omega^{x,s}$ for any consumer x.

(ii) (**data combination**) the SE can combine $\omega^{x,s}$ with $\omega^{x,B}$ to build a more refined profile of each consumer x. We assume that the SE can identify each consumer when she uses either the search service or engages in activity B. This is possible since the SE has a good technology to track consumers across many sites/apps/devices.

(iii) (no loss of inventories) We assume that newspapers still have the control right over displaying advertising in articles of the AMP format.

(iv) (no data sharing) The SE does not share personal level data from search referral traffic, i.e. it shares the data with newspapers in a way that they cannot identify consumers.

Therefore, the ad revenue per unit of newspaper's direct traffic and the ad revenue in sector B respectively become:

$$\alpha_d^M \equiv \alpha_{d,T}(\Omega^{x,T}, \Omega^{x,T} \cap \Omega^{x,SE}) = \alpha_{d,T}(\omega^{x,d}, \omega^{x,d} \cap \{\omega^{x,B} \cup \omega^{x,s}\})$$
$$\alpha_B^M \equiv \alpha_{B,SE}(\Omega^{x,SE}, \Omega^{x,SE} \cap \Omega^{x,T}) = \alpha_{B,SE}(\omega^{x,B} \cup \omega^{x,s}, \{\omega^{x,B} \cup \omega^{x,s}\} \cap \omega^{x,d}).$$

where the superscript M refers to AMP (as we use A for activity A, we prefer using M).

Hence, we have

Lemma 1 *Suppose that all newspapers adopt the AMP format. This reduces the advertising revenue for direct traffic, does not affect the ad revenue for search referral traffic and increases the ad revenue for traffic related to activity B:*

$$\alpha_d^N > \alpha_d^M, \alpha_B^N < \alpha_B^M.$$

4.2 Static Welfare

Suppose that AMP does not affect quality choice in any of the two sectors. Assuming that all newspapers adopt the AMP format, we here study how AMP changes the static welfare. Hence, each newspaper chooses quality q^N and demand is given by $D^{d,1}(\mathbf{q}^N) = ... = D^{d,n}(\mathbf{q}^N) \equiv D^d(\mathbf{q}^N)$ for direct traffic and $D^{s,1}(\mathbf{q}^N) = ... = D^{s,n}(\mathbf{q}^N) \equiv D^s(\mathbf{q}^N)$ for search referral traffic where $\mathbf{q}^N = (q^N, ..., q^N)$. Regarding sector B, we use a reduced form approach: let $D^B(q_B^N)$ represent the total demand corresponding to a symmetric quality choice among competing websites $q_B^N(\alpha_B^N)$ in that sector. In addition, due to use of reduced form in constructing ad price, we put the following assumption on advertiser's surplus:

Assumption B3 *(i) Given total advertising inventory, improving targeting in a subset of inventory increases total advertising surplus. (ii) Advertisers retain a constant share β of the total advertising surplus regardless of the presence of AMP;*

This assumption implies that we can express the social surplus generated in advertising market as $\frac{1}{1-\beta}$ times the advertising industry profit, which is the joint advertising revenue of newspapers, sites in sector B and ad tech intermediaries:

$$n(1-\tau^T+\tau^T)\underbrace{\left[\alpha_d^N D^d(\mathbf{q}^N)+\alpha_s(1-\delta)D^s(\mathbf{q}^N)\right]}_{\text{a single newspaper's ad revenue}}+(1-\tau^{SE}+\tau^{SE})\underbrace{\alpha_B^N D^B(q_B^N)}_{\substack{\text{total ad revenue of}\\\text{sites in sector B}}}$$

The welfare change induced by AMP comes from: (i) the change in consumer welfare due to elimination of traffic loss, which is obviously positive; (ii) the change in the social surplus in the advertising sector which is also positive:

$$\begin{aligned}
&\frac{1}{1-\beta}\left[n\alpha_d^M D^d(\mathbf{q}^N)+n\alpha_s D^s(\mathbf{q}^N)+\alpha_B^M D^B(q_B^N)\right]-\frac{1}{1-\beta}\left[n\alpha_d^N D^d(q^N)+n\alpha_s(1-\delta)D^s(\mathbf{q}^N)+\alpha_B^N D^B(q_B^N)\right]\\
>&\frac{1}{1-\beta}\left[n\alpha_d^M D^d(\mathbf{q}^N)+n\alpha_s(1-\delta)D^s(\mathbf{q}^N)+\alpha_B^M D^B(q_B^N)\right]-\frac{1}{1-\beta}\left[n\alpha_d^N D^d(q^N)+n\alpha_s(1-\delta)D^s(\mathbf{q}^N)+\alpha_B^N D^B(q_B^N)\right]\\
>&0
\end{aligned}$$

The last inequality follows from B3 (i).

Proposition 3 *Under B1-B3, AMP strictly increases static welfare.*

AMP improves static welfare even if AMP does not affect the loss rate of search-referral traffic (which is equivalent to the case where loss rate $\delta \simeq 0$). This is because data leakage allows SE to use the data from search referral traffic to improve targeting efficiency in sector B, which in turn increases total surplus in advertising industry.

5 AMP with changes in data allocation: dynamic analysis

In this section, we assume that all newspapers adopt the AMP format and study how AMP changes investment in quality and thereby welfare. The analysis of each newspaper's incentive to adopt the AMP format is done in the next sections.

5.1 Quality choice

Given $\mathbf{q}$, the profit of the newspaper i is given by

$$(1-\tau^T)\left[\alpha_d^M D^{d,i}(\mathbf{q}) + \alpha_s D^{s,i}(\mathbf{q})\right] - c(q_i)$$

The F.O.C. is given by

$$(1-\tau^T)\left[\alpha_d^M D_i^{d,i}(\mathbf{q}) + \alpha_s D_i^{s,i}(\mathbf{q})\right] - c'(q_i) = 0.$$

The S.O.C. is satisfied if

$$(1-\tau^T)\left[\alpha_d^M D_{ii}^{d,i}(\mathbf{q}) + \alpha_s D_{ii}^{s,i}(\mathbf{q})\right] - c''(q_i) < 0.$$

Proposition 4 *When all newspapers adopt the AMP format, the quality at the symmetric equilibrium, denoted by q^M, is characterized by*

$$(1-\tau^T)\left[\alpha_d^M D_i^{d,i}(q^M,...,q^M) + \alpha_s D_i^{s,i}(q^M,...,q^M)\right] = c'(q^M) \text{ for all } i = 1,...,n.$$

In order to facilitate comparison between q^N and q^M, let us assume $D_i^{s,i}(q,...,q) = \gamma D_i^{d,i}(q,...,q)$ at any $q > 0$. Then, we have

Proposition 5 *The adoption of the AMP format reduces the quality of journalism ($q^N > q^M$) if and only if*

$$\alpha_d^N + \gamma(1-\delta)\alpha_s > \alpha_d^M + \gamma\alpha_s,$$

The above proposition shows a clear trade-off:

$$\underbrace{\alpha_d^N - \alpha_d^M}_{\substack{\text{reduction in ad revenue}\\ \text{from direct traffic}\\ \text{due to data allocation effect}}} \quad - \quad \underbrace{\gamma\delta\alpha_s}_{\substack{\text{increase in ad revenue}\\ \text{from search referral traffic}\\ \text{due to faster loading}}}$$

Let $q_B^M (> q_B^N)$ be the symmetric quality that prevails in sector B after all newspapers adopted the AMP format. This is because data leakage raises advertising revenue per traffic in sector B and in turn increases the marginal benefit of investing in quality.

5.2 Welfare analysis

5.2.1 SE's profit

We show below that the SE always has an incentive to induce newspapers to adopt the AMP format. Assuming that the SE has no consumer-facing services related to activity B, the SE's profit without AMP is

$$\Pi^N = \tau^{SE}\alpha_B^N D^B(q_B^N).$$

where $\tau^{SE} > 0$ is the ad tech tax of the SE.

After the adoption of AMP by all newspapers, the SE's profit becomes

$$\Pi^M = \tau^{SE}\alpha_B^M D^B(q_B^M).$$

AMP increases SE's profit by increasing the ad revenue per traffic in sector B and also by expanding the ad inventory in sector B as the increased ad revenue raises the symmetric quality that prevails in sector B after the adoption of AMP by newspapers.

Proposition 6 *The SE always gains from newspapers' adoption of the AMP format. Therefore, even if the adoption of the AMP format reduces the quality of journalism, the SE has no incentive to internalize it.*

We assumed that the SE has no consumer-facing services related to activity B. In reality, Google owns many consumer-facing services, which will even strengthen our results as Google will retain the whole benefit of data leakage instead of just having a fraction τ^{SE} of it.

5.2.2 Comparison of newspaper profit

When there is no AMP, equilibrium newspaper profit is:

$$\pi^N(\alpha_d^N, \delta) = (1-\tau^T)[\alpha_d^N D^d(\mathbf{q}^N) + \alpha_s(1-\delta)D^s(\mathbf{q}^N)] - c(q^N)$$

When there is AMP, equilibrium newspaper profit becomes:

$$\pi^M = (1-\tau^T)[\alpha_d^M D^d(\mathbf{q}^M) + \alpha_s D^s(\mathbf{q}^M)] - c(q^M)$$

To facilitate the comparison between these two profits, we introduce the following assumptions on newspaper profit π^N in the symmetric equilibrium without AMP: $\frac{\partial \pi^N(\alpha_d^N,\delta)}{\partial \alpha_d^N} > 0$ and $\frac{\partial \pi^N(\alpha_d^N,\delta)}{\partial \delta} < 0$. These two assumptions mean that the direct effect of a positive exogenous shock to the industry, such as increased ad price or reduced loss rate, dominates the negative effect of intensified competition on industry profit in symmetric equilibrium. For instance,

$$\begin{aligned}
-\frac{\partial \pi^N}{\partial \delta} &= -(1-\tau^T)[\alpha_d^N \Sigma_{j=1}^n D_j^{d,i}(\mathbf{q}^N) + \alpha_s(1-\delta)\Sigma_{j=1}^n D_j^{s,i}(\mathbf{q}^N) - c'(q^N)]\frac{\partial q^N}{\partial \delta} + (1-\tau^T)\alpha_s D^{s,i}(\mathbf{q}^N) \\
&= \underbrace{-(1-\tau^T)[\alpha_d^N \Sigma_{j\neq i} D_j^{d,i}(\mathbf{q}^N) + \alpha_s(1-\delta)\Sigma_{j\neq i} D_j^{s,i}(\mathbf{q}^N)]\frac{\partial q^N}{\partial \delta}}_{\text{the effect of intensified competition (-)}} + \underbrace{(1-\tau^T)\alpha_s D^{s,i}(\mathbf{q}^N)}_{\text{the direct effect of positive shock (+)}} \\
&> 0
\end{aligned}$$

Proposition 7 *Under the assumptions that* $\frac{\partial \pi^N(\alpha_d^N,\delta)}{\partial \alpha_d^N} > 0$ *and* $\frac{\partial \pi^N(\alpha_d^N,\delta)}{\partial \delta} < 0$, *(1) the presence of AMP reduces the newspaper industry profit when* δ *is close to zero; (2) When* a_d^M *is close enough to* a_d^N, *there exists a threshold* $0 < \tilde{\delta} < 1$ *determined by* $\pi^N(\tilde{\delta}) = \pi^M(\tilde{\delta})$, *such that AMP increases the newspaper industry profit if* $\tilde{\delta} < \delta < 1$.

Proof. (1) From the assumptions $\frac{\partial \pi^N(\alpha_d^N,\delta)}{\partial \alpha_d^N} > 0$ and $\frac{\partial \pi^N(\alpha_d^N,\delta)}{\partial \delta} < 0$, when $\delta = 0$, we have $\pi^N(\alpha_d^N, 0) > \pi^M$, which implies the presence of AMP reduces news industry profit. (2)

Taking the values of δ and α_d^N as given, we have $\lim_{\alpha_d^M \uparrow \alpha_d^N} \pi^M = \pi^N(\alpha_d^N, 0)$. This property together with the assumption $\frac{\partial \pi^N}{\partial \delta} < 0$ guarantees the existence of threshold $0 < \tilde{\delta} < 1$. ■

5.2.3 Comparison of consumer surplus in content market

To facilitate welfare analysis, in this section we impose a specific structure on demand functions. Regarding the demand for direct traffic, suppose that each consumer would read k^d news articles when she visits her favorite news outlet directly. Assume that q_i stands for the quality of a single article in newspaper i. Then newspaper i's overall quality is $k^d q_i$. As consumers single-homing on one newspaper in terms of direct traffic, we apply the standard discrete-choice Logit model: let consumer x's utility from direct visit to newspaper i be:

$$U_{x,i}^d = lnv^d(k^d q_i) + \varepsilon_{x,i}^d, \quad i = 0, 1, 2, ..., n$$

where "0" stands for the outside option whose quality is q_0. In addition, $\varepsilon_{x,i}^d$ is i.i.d. according to Type I Extreme Value distribution with scale parameter $\mu^d > 0$. Each consumer chooses the newspaper that delivers the highest utility.

This yields the following direct demand of newspaper i: $D^{d,i}(\mathbf{q}) = \frac{\tilde{v}^d(k^d q_i)}{\Sigma_{j=0}^n \tilde{v}^d(k^d q_j)}$, where $\tilde{v}^d(\cdot) = (v^d(\cdot))^{\frac{1}{\mu^d}}$. When we assume that $v^d(\cdot)$ is increasing and concave and that $\mu^d > 1$, this demand function satisfies the assumptions in A1. From this specification, we obtain the following consumer surplus from direct traffic: $CS^d = \mu^d ln(\sum_{i=0}^n \tilde{v}^d(k^d q_i))$.

In addition to direct demand, each consumer also has demand for k^s pieces of news via search. We assume that each consumer makes k^s independent search queries and that each query is associated with a separate discrete-choice problem. As a result, a consumer multihomes in terms of search-referral traffic in the sense that she would read articles from different newspapers in different searches. Let consumer x 's utility from reading an article of newspaper i discovered through the SE be $U_{x,i}^s = lnv^s(q_i) + \varepsilon_{x,i}^s, \ \ i = 0, 1, 2, ..., n$ in which $\varepsilon_{x,i}^s$ is i.i.d. according to Type I Extreme Value distribution with scale parameter $\mu^s > 0$. These preference shocks are independent across search queries and also uncorrelated with that of direct traffic. Therefore, the search-referral demand of newspaper i without AMP is $D^{s,i}(\mathbf{q}) = k^s(1-\delta)\frac{\tilde{v}^s(q_i)}{\Sigma_{j=0}^n \tilde{v}^s(q_j)}$, where $\tilde{v}^s(\cdot) = (v^s(\cdot))^{\frac{1}{\mu^s}}$.

Lastly, let consumer x's utility derived from activity B be $U_x^B = ln\big(v^B(q^B)\big) + \varepsilon_x^B$ and the utility derived from activity B's outside option be $U_{x,0}^B = ln\big(v^B(q_0^B)\big) + \varepsilon_{x,0}^B$, in which ε_x^B and $\varepsilon_{x,0}^B$ are as before i.i.d. according to Type I Extreme Value distribution with scale parameter $\mu^B > 0$. And accordingly $\tilde{v}^B(\cdot)$ denotes the normalized valuation on quality.

Therefore when there is no AMP, the equilibrium consumer surplus is:

$$CS^N = \mu^d ln\big(\tilde{v}^d(k^d q_0)+n\tilde{v}^d(k^d q^N)\big)+k^s(1-\delta)\mu^s ln\big(\tilde{v}^s(q_0)+n\tilde{v}^s(q^N)\big)+\mu^B ln\big(\tilde{v}^B(q_0^B)+\tilde{v}^B(q_B^N)\big)$$

Note that only the first two terms in CS^N depend on δ.

Lemma 2 *When there is no AMP, (1) the optimal quality q^N is decreasing in δ; (2) consumer surplus CS^N is decreasing in δ.*

Proof. Differentiating FOC in Proposition 1 with respect to δ on both sides, we get:

$$(1-\tau^T)\big[\alpha_d^N \Sigma_{j=1}^n D_{i,j}^{d,i}(\mathbf{q}^N) + \alpha_s(1-\delta)\Sigma_{j=1}^n D_{ij}^{s,i}(\mathbf{q^N})\big]\frac{\partial q^N}{\partial \delta} - (1-\tau^T)\alpha_s D_i^{s,i}(\mathbf{q_{-i}}) = 0$$

By assumption A1, we have $D_i^{s,i} > 0$, $D_{ij}^{d,i} < 0$ and $D_{ij}^{s,i} < 0$ for $i, j = 1, 2, .., n$, then $\frac{\partial q^N}{\partial \delta} < 0$.

As optimal quality is decreasing in the loss rate δ, it is immediate that CS^N is decreasing in δ. ■

When there is AMP, total consumer surplus is:

$$CS^M = \mu^d ln\big(\tilde{v}^d(k^d q_0)+n\tilde{v}^d(k^d q^M)\big)+k^s\mu^s ln\big(\tilde{v}^s(q_0)+n\tilde{v}^s(q^M)\big)+\mu^B ln\big(\tilde{v}^B(q_0^B)+\tilde{v}^B(q_B^M)\big)$$

Note that CS^M does not depend on δ.

Proposition 8 *(i) If $CS^N(\delta = 0) \leq CS^M$, consumer surplus is always higher with AMP; (ii) If $CS^N(\delta = 0) > CS^M$, there exists a threshold $\bar{\delta} > 0$ determined by $CS^N = CS^M$ such that when $0 \leq \delta \leq \min\{\bar{\delta}, 1\}$, consumer surplus is lower with AMP; when $\min\{\bar{\delta}, 1\} < \delta \leq 1$, consumer surplus is higher with AMP.*

Proof. (i). This is straightforward from part 2 of Lemma 2 that consumer surplus CS^N is decreasing in δ. (ii). Recall the condition determining $q^N > q^M$ is $(\alpha_d^N - \alpha_d^M) - \gamma\delta\alpha_s > 0$. Whenever δ satisfies $(\alpha_d^N - \alpha_d^M) - \gamma\delta\alpha_s < 0$, we have $q^M > q^N(\delta)$ such that the quality of newspapers and sites in sector B both improved. Then we have $CS^M > CS^N(\delta)$ under this condition. This result together with the condition $CS^N(\delta = 0) > CS^M$ and Lemma 2 implies there is a threshold $\bar{\delta}$, below which $CS^N > CS^M$ and above which $CS^N < CS^M$. ■

This proposition suggests that when AMP lowers the quality of journalism, AMP's impact on consumer surplus depends on the trade-off between the gain from higher quality of sites in sector B and the loss from lower quality of journalism. For instance, consider the case of $\delta \approx 0$, where AMP doesn't increase much loading speed but reduces the equilibrium quality of newspapers through data leakage. If AMP lowers consumer surplus in this case, then AMP reduces consumer surplus for any δ below a certain threshold.

5.2.4 Comparison of social welfare

As in our model newspapers and sites in sector B are ad-financed, they create values by providing content to consumers on the one side and by selling advertising inventories to advertisers through ad intermediaries on the other side. Under the assumption B3, the aggregate social welfare without AMP is:

$$W^N = \underbrace{CS^N - nc(q^N) - c^B(q_B^N)}_{\text{social surplus in content industry}} + \underbrace{\frac{1}{1-\beta}\left\{n\alpha_d^N D^d(\mathbf{q}^N) + n\alpha_s(1-\delta)D^s(\mathbf{q}^N) + \alpha_B^N D^B(q_B^N)\right\}}_{\text{social surplus in advertising industry}}$$

And the aggregate social welfare with AMP is:

$$W^M = CS^M - nc(q^M) - c^B(q_B^M) + \frac{1}{1-\beta}\left\{n\alpha_d^M D^d(\mathbf{q}^M) + n\alpha_s D^s(\mathbf{q}^M) + \alpha_B^M D^B(q_B^M)\right\}$$

We focus on situations where newspapers are sufficiently differentiated (i.e. μ^d and μ^s are sufficiently large) such that newspapers always underinvest in quality relative to a social planner who chooses a uniform quality level of newspapers to maximizes social welfare. For instance, in the case without AMP, the newspapers' private incentive of investing in quality is given by the first order condition in proposition 1.And the first order condition of social planner's problem is:

$$\begin{aligned}\frac{\partial W^N}{\partial q^N} =& \frac{\partial CS^N}{\partial q^N} - nc'(q^N) + \frac{1}{1-\beta}\left\{n\alpha_d^N \left(D_i^{d,i}(\mathbf{q}^N) + \Sigma_{j\neq i}^n D_j^{d,i}(\mathbf{q}^N)\right)\right. \\ &\left. + n\alpha_s(1-\delta)\left(D_i^{s,i}(\mathbf{q}^N) + \Sigma_{j\neq i}^n D_j^{s,i}(\mathbf{q}^N)\right)\right\} \\ =& 0\end{aligned}$$

So their difference in the incentives of investing in quality can be expressed as::

$$\frac{1}{n}\frac{\partial W^N}{\partial q^N} - \frac{\partial \pi^N(\mathbf{q}^N)}{\partial q_i} = \underbrace{\frac{1}{n}\frac{\partial CS^N}{\partial q^N}}_{(+)} + \underbrace{(\frac{1}{1-\beta} - 1 + \tau^T)\big[\alpha_d^N D_i^{d,i} + \alpha_s(1-\delta)D_i^{s,i}\big]}_{(+)}$$
$$+ \underbrace{\frac{1}{1-\beta}\big(\alpha_d^N \Sigma_{j\neq i}^n D_j^{d,i} + \alpha_s(1-\delta)\Sigma_{j\neq i}^n D_j^{s,i}\big)}_{(-)}$$

When newspapers are sufficiently differentiated, the third term, which is the business stealing effect, is weak and dominated by the first two positive terms. As a result, social planner has a higher incentive of improving newspaper's quality.

In the following proposition, we give a sufficient condition for the adoption of AMP to be socially efficient:

Proposition 9 *If $q^M > q^N$, then aggregate social welfare is higher with AMP (i.e., $W^M > W^N$).*

See proof in appendix.

In this case, the effect of AMP on social welfare can be decomposed into three parts: (1) the adoption of AMP directly creates more surplus by eliminating the loss of traffic due to slow loading; (2) a higher content quality in each sector improves consumer surplus in each sector and creates more advertising opportunities by expanding traffic to newspapers and sites in sector B; (3) data leakage to site B increases matching efficiency which further increases surplus in advertising market.

However if the equilibrium quality of newspapers is lower with AMP, the effect of AMP on welfare is ambiguous as it depends on:

(i) whether consumers are affected more by the decreased quality in journalism or by the increased quality in sector B;

(ii) whether the effect of eliminating the loss of search-referral traffic δ brought by AMP is large enough, which includes both consumer surplus increase and advertising surplus increase.

(iii) whether the effect of increased ad inventory in sector B is high enough relative to the effect of reduced inventory of newspapers;

(iv) to what degree data leakage improves matching efficiency of ad inventories in sector B.

Therefore, AMP is highly likely to reduce welfare when δ is close to zero, consumers value the quality of newspapers much more than that of sector B and advertisers value the ad inventory of newspapers much more than that of sector B.

The next proposition provides a sufficient condition for AMP to reduce welfare. In the proposition, we shut down both the effect on the traffic loss rate and the one on the quality in sector B in order to focus on the main trade-off but by continuity the result carries over even the two effects are small.

Proposition 10 *Suppose $\delta = 0$, $q_B^M = q_B^N \equiv q_B$ and $q^M \ll q^N$. Then, if the positive effect of data leakage on advertising surplus is dominated by the negative effect of lower quality of journalism on welfare, the aggregate social welfare is lower with AMP (i.e., $W^M < W^N$)*

Proof. Under the condition $\delta = 0$ and $q_B^M = q_B^N$,

$$W^M(q^M) - W^N(q^N, \delta = 0) = \underbrace{W^M(q^M) - W^N(q^M, \delta = 0)}_{\text{efficient effect of data leakage}} - \underbrace{\left[W^N(q^N, \delta = 0) - W^N(q^M, \delta = 0)\right]}_{\text{direct effect of lower quality}}$$

The main trade-off is captured by the above equation. By taking the quality of newspapers q^M as given, the first one represents the positive effect of data leakage which leads to improved matching in targeted advertising, as captured in the static welfare analysis. The second one captures the negative effect of lower quality on welfare. As assumptions on demand functions and cost functions guarantees that social surplus is concave in symmetric quality and q^N is assumed to be lower than the social optimum, any quality lower than q^N induces even lower welfare.

In sum, when the efficient effect of data leakage is dominated by the negative effect of lower quality, aggregate social welfare is lower. ■

6 Newspapers' Incentive to Adopt the AMP Format

In this section, we study the adoption choice of newspaper i given all the others' adoption choices.

Consider first the equilibrium in which all adopt the AMP format. Does newspaper i have an incentive to deviate by not adopting the AMP format when all other newspapers do? Let $D^{s,i}(q_i, \mathbf{q}_{-i}; i-) \equiv D^{s|i-,i}(q_i, \mathbf{q}_{-i})$ represent the demand from search referral for newspaper i when newspaper i is the only non-adopter and hence is demoted in search rankings by the SE. When n is not small, the demotion of newspaper i in search ranking implies that its articles almost never appear in the first page of search results and hence $D^{s|i-,i}(q_i, \mathbf{q}_{-i})$ is close to zero. Let α_d^- be the ad revenue per traffic for newspaper i: we have $\alpha_d^- \simeq \alpha_d^M$, since all direct readers of newspaper i are referred to AMP articles of other newspapers by the SE and then the SE can draw valuable insights from these consumers' browsing activities. Let $\mathbf{q}_{-i}^M \equiv (q_1 = q^M, ..., q_{i-1} = q^M, q_{i+1} = q^M, ..., q_n = q^M)$.

Formally, we assume:

Assumption A2 *n is not small such that demotion of newspaper i in search ranking makes $D^{s|i-,i}(q_i, \mathbf{q}_{-i}^M)$ close to zero for any $(q_i, \mathbf{q}_{-i}^M)$, which in turn implies that $\alpha_d^- (\geq \alpha_d^M)$ close to α_d^M.*

Let q^- be defined as

$$q^- = \arg\max_{q_i}(1-\tau^T)\left[\alpha_d^- D^{d,i}(q_i, \mathbf{q}_{-i}^M) + \alpha_s(1-\delta)D^{s|i-,i}(q_i, \mathbf{q}_{-i}^M)\right] - c(q_i).$$

Then, firm i has no incentive to deviate by not adopting the AMP format if the following inequality holds:

$$\begin{aligned} & (1-\tau^T)\left[\alpha_d^M D^{d,i}(q^M, \mathbf{q}_{-i}^M) + \alpha_s D^{s,i}(q^M, \mathbf{q}_{-i}^M)\right] - c(q^M) \\ \geq \;& (1-\tau^T)\left[\alpha_d^- D^{d,i}(q^-, \mathbf{q}_{-i}^M) + \alpha_s(1-\delta)D^{s|i-,i}(q^-, \mathbf{q}_{-i}^M)\right] - c(q^-). \end{aligned}$$

The inequality strictly holds since we have

$$\begin{aligned} & (1-\tau^T)\left[\alpha_d^M D^{d,i}(q^M, \mathbf{q}_{-i}^M) + \alpha_s D^{s,i}(q^M, \mathbf{q}_{-i}^M)\right] - c(q^M) \\ \geq \;& (1-\tau^T)\left[\alpha_d^M D^{d,i}(q^-, \mathbf{q}_{-i}^M) + \alpha_s D^{s,i}(q^-, \mathbf{q}_{-i}^M)\right] - c(q^-) \\ > \;& (1-\tau^T)\left[\alpha_d^- D^{d,i}(q^-, \mathbf{q}_{-i}^M) + \alpha_s(1-\delta)D^{s|i-,i}(q^-, \mathbf{q}_{-i}^M)\right] - c(q^-) \end{aligned}$$

where the last inequality holds from A2.

Proposition 11 *Under A1-A2 and B1-B2, there exists an equilibrium in which all newspapers adopt the AMP format.*

We emphasize that when $\delta \approx 0$, the SE's leverage of its search monopoly power through demotion of non-adopters' positions is crucial in sustaining the all-adoption equilibrium. As we can see in the above inequality, without the punishment in terms of ranking, non-adoption won't affect the search-referral traffic and remove the (small) negative impact of data leakage on the advertising revenue in direct traffic. This gives newspaper i an incentive not to adopt the AMP format.

Do we have an equilibrium in which no newspaper adopts the AMP format? Suppose that such an equilibrium exists. Consider the deviation of newspaper i: it becomes the only newspaper who adopts it such that the SE promotes its AMP articles in search results. Let $D^{s,i}(q_i, \mathbf{q}_{-i}; i+) \equiv D^{s|i+,i}(q_i, \mathbf{q}_{-i})$ represent the demand from search referral for newspaper i when newspaper i is the only adopter and hence is promoted in search rankings by the SE. Let α_i^+ be the ad revenue per traffic for newspaper i: we have $\alpha_d^+ \in (\alpha_A^M, \alpha_A^N)$ where $\alpha_d^N > \alpha_d^+$ is from the leakage of the browsing data on newspaper i's AMP articles and $\alpha_d^M < \alpha_d^+$ is because this data leakage is much smaller than the data leakage when all newspapers adopt the AMP format. Let $\mathbf{q}_{-i}^N \equiv (q_1 = q^N, ..., q_{i-1} = q^N, q_{i+1} = q^N, ..., q_n = q^N)$.

We assume

Assumption A3 *When newspaper i deviates by becoming the unique adopter of the AMP format, its demand has the following properties: (i)* $D_i^{s|i+,i}(q_i, \mathbf{q}_{-i}^N) > D_i^{s,i}(q_i, \mathbf{q}_{-i}^N)$*, where* $D_i^{s|i+,i} = \partial D^{s|i+,i}/\partial q_i$ *and* $D_i^{s,i} = \partial D^{s,i}/\partial q_i$*; (ii)* $D^{s|i+,i}(q_i, \mathbf{q}_{-i}^N) > D^{s,i}(q_i, \mathbf{q}_{-i}^N)$*.*

The first point says that the promotion in search ranking is a complementary input to investment in quality such that it increases i's marginal benefit of quality investment in terms of search-referral traffic. The second point means that this increases i's search referral demand given a quality vector.

Let q^+ be the quality choice of newspaper i after its deviation:

$$q^+ = \arg\max_{q_i} (1 - \tau^T) \left[\alpha_d^+ D^{d,i}(q_i, \mathbf{q}_{-i}^N) + \alpha_s D^{s|i+,i}(q_i, \mathbf{q}_{-i}^N) \right] - c(q_i).$$

Then, firm i has no incentive to deviate by adopting the AMP format if

$$\begin{aligned} & (1 - \tau^T) \left[\alpha_d^N D^{d,i}(q^N, \mathbf{q}_{-i}^N) + \alpha_s (1 - \delta) D^{s,i}(q^N, \mathbf{q}_{-i}^N) \right] - c(q^N) \\ \geq \;& (1 - \tau^T) \left[\alpha_i^+ D^{d,i}(q^+, \mathbf{q}_{-i}^N) + \alpha_s D^{s|i+,i}(q^+, \mathbf{q}_{-i}^N) \right] - c(q^+) \end{aligned} \tag{1}$$

A sufficient condition to satisfy the inequality is that the inequality holds when q^N is replaced by q^+: then, when we neglect $(1-\tau^T)$, the difference between the two can be decomposed as

$$\underbrace{(\alpha_d^N - \alpha_i^+)D^{d,i}(q^+, \mathbf{q}_{-i}^N)}_{\substack{\text{reduction in ad revenue} \\ \text{from data leakage}}} > \underbrace{\alpha_s \left[D^{s|i+,i}(q^+, \mathbf{q}_{-i}^N) - (1-\delta)D^{s,i}(q^+, \mathbf{q}_{-i}^N)\right]}_{\substack{\text{increase in search referral traffic} \\ \text{due to promotion and higher speed}}}$$

Proposition 12 *Under A1, A3 and B1-B2, there exists an equilibrium in which no newspaper adopts the AMP format if (1) is satisfied.*

In summary, the adoption equilibrium always exists and the no adoption equilibrium can also exist if the loss from data leakage is large enough relative to the expansion of search referral demand.

7 Extension: Divide-and-Conquer

In this section, we study how the SE can use a divide-and-conquer strategy to induce the adoption of AMP. Google has leading ad tech in ad intermediation for the open display advertising (CMA, 2020). We show that combining its market power in ad intermediation with its search monopoly power allows the SE to use a divide-and-conquer strategy so as to achieve the adoption equilibrium as the unique equilibrium. For this purpose, suppose now that $m(< n)$ number of newspapers use the ad tech service of the SE.

7.1 Without AMP

Let $\mathbf{q}^N$ represent the quality vector in the equilibrium without AMP. Consider consumer x, who is a direct reader of a newspaper which uses the ad tech service of T. When this consumer visits other newspapers who use the ad tech service of the SE via search, her browsing data is accessible to SE. Denote this data set as $\omega^{x,s}(m)$, which represents data leakage from the point of view of the newspaper, of which consumer x is a direct reader. Then, the ad revenue per traffic from this consumer is given as follows depending on whether it is a direct traffic to the newspaper or a traffic to a site in sector B:

$$\alpha_d^{N,T}(m) \equiv \alpha_{d,T}(\Omega^{x,T}, \Omega^{x,T} \cap \Omega^{x,SE}) = \alpha_{d,T}(\omega^{x,d}, \omega^{x,d} \cap \left\{\omega^{x,s}(m) \cup \omega^{x,B}\right\})$$
$$\alpha_B^{N,T}(m) \equiv \alpha_{B,SE}(\Omega^{x,SE}, \Omega^{x,SE} \cap \Omega^{x,T}) = \alpha_{B,SE}(\left\{\omega^{x,s}(m) \cup \omega^{x,B}\right\}, \left\{\omega^{x,s}(m) \cup \omega^{x,B}\right\} \cap \omega^{x,d})$$

With some abuse of notation, the superscript T in $\alpha_B^{N,T}(m)$ denotes the advertising revenue of a site in sector B per traffic from a consumer who is a direct reader of a newspaper that uses the ad tech T. Here T doesn't mean the ads of sites in sector B are served by T as they are always assumed to be served by the SE.

Assumption B1 implies that $\alpha_d^{N,T}(m)$ strictly decreases with m and $\alpha_B^{N,T}(m)$ strictly increases with m such that

$$\alpha_d^{N,T}(m) < \alpha_d^N = \alpha_d^N(0), \alpha_B^{N,T}(m) > \alpha_B^N = \alpha_B^{N,T}(0).$$

What is important to notice here is that the newspapers which use the ad tech service of the SE generate negative externalities to those which use the ad tech service of T through data leakage measured by $\omega^{x,s}(m)$.

Now consider consumer x', who is a direct reader of a newspaper which uses the ad tech service of the SE. The SE has access to both direct traffic data and search-referral traffic data of the newspaper. Therefore, the ad revenue per traffic from this consumer is given as follows depending on whether it is a direct traffic to the newspaper or a traffic to a site in sector B:

$$\alpha_d^{N,SE}(m) \equiv \alpha_{d,SE}(\Omega^{x,SE}, \Omega^{x,SE} \cap \Omega^{x,SE}) = \alpha_{d,SE}(\omega^{x,d} \cup \omega^{x,s}(m) \cup \omega^{x,B}, \omega^{x,d} \cup \omega^{x,s}(m) \cup \omega^{x,B})$$
$$\alpha_B^{N,SE}(m) \equiv \alpha_{B,SE}(\Omega^{x,SE}, \Omega^{x,SE} \cap \Omega^{x,SE}) = \alpha_{B,SE}(\omega^{x,d} \cup \omega^{x,s}(m) \cup \omega^{x,B}, \omega^{x,d} \cup \omega^{x,s}(m) \cup \omega^{x,B})$$

Recall that in Section 2, we define advertising revenue as $\alpha_{k,h}(\Omega^{x,h}, \Omega^{x,h} \cap \Omega^{x,-h})$. The reason that here we have $\alpha_d^{N,SE}(m) \equiv \alpha_{d,SE}(\Omega^{x,SE}, \Omega^{x,SE} \cap \Omega^{x,SE})$ instead of $\alpha_d^{N,SE}(m) \equiv \alpha_{d,SE}(\Omega^{x,SE}, \Omega^{x,SE} \cap \Omega^{x,T})$ is because both the ads for direct traffic and the ads for traffic in sector B associated with consumer x are served by the SE. So the "rival" ad tech $-h$ becomes the SE.

B1 implies that both $\alpha_d^{N,SE}(m)$ and $\alpha_B^{N,SE}(m)$ strictly increase with m.

The equilibrium in the absence of AMP is characterized by $\mathbf{q}^N = (q^{N,T}, \ldots, q^{N,T}, q^{N,SE}, \ldots, q^{N,SE})$ where $q_i = q^{N,T}$ satisfies

$$(1 - \tau^T) \left[\alpha_d^{N,T}(m) D_i^{d,i}(\mathbf{q}^N) + \alpha_s(1 - \delta) D_i^{s,i}(\mathbf{q}^N)\right] = c'(q_i);$$

and $q_i = q^{N,SE}$ satisfies

$$(1-\tau^{SE})\left\{\alpha_d^{N,SE}(m)D_i^{d,i}(\mathbf{q}^N)+\alpha_s(1-\delta)D_i^{s,i}(\mathbf{q}^N)\right\}=c'(q_i).$$

7.2 With AMP

Let l with $0 \leq l \leq n-m$ represent the number of the newspapers which adopt the AMP format among those who rely on the ad tech service of T. Then, the SE has access to the browsing data generated by search-referral to $m+l$ number of newspapers. Hence, given $\omega^{x,s}(m)$, the ad revenue per traffic is given as follows depending on the type of traffic:

$$\alpha_d^{M,T}(m,l)=\alpha_d^{N,T}(m+l),\quad \alpha_B^{M,T}(m,l)=\alpha_B^{N,T}(m+l)$$
$$\alpha_d^{M,SE}(m,l)=\alpha_d^{N,SE}(m+l),\quad \alpha_B^{M,SE}(m,l)=\alpha_B^{N,SE}(m+l)$$

However, the SE promotes AMP articles and demotes non-AMP articles, which makes the data leakage $\omega^{x,s}(m)$ larger when $l>0$ number of newspapers adopt the AMP format than when there is no AMP. When we take into account such distortion in search ranking, we have:

$$\alpha_d^{M,T}(m,l)<\alpha_d^{N,T}(m+l),\quad \alpha_B^{M,T}(m,l)>\alpha_B^{N,T}(m+l)$$
$$\alpha_d^{M,SE}(m,l)<\alpha_d^{N,SE}(m+l),\quad \alpha_B^{M,SE}(m,l)>\alpha_B^{N,SE}(m+l)$$

We first show that it is a dominant strategy for a newspaper using the ad tech service of the SE to adopt the AMP format. Consider newspaper i using the ad tech service of the SE. Consider a given quality vector $\mathbf{q}$ including q_i and suppose that the adoption decision of any newspaper different from i is also given. If newspaper i adopts the AMP, it improves its ranking and eliminates the traffic loss from slow loading and the SE keeps having access to the browsing data generated by search-referral to $m+l$ number of newspapers. So the only change in terms of data leakage is that i's adoption expands $\omega^{x,s}(m)$ as the SE promotes its AMP articles, which in turn increases $\alpha_d^{M,SE}(m,l)$ from B1. Therefore, it is a dominant strategy for newspaper i to adopt the AMP format.

Lemma 3 *Under A1 and B1-B2, it is a dominant strategy for a newspaper using the ad tech service of the SE to adopt the AMP format.*

Therefore, in what follows, we assume that all newspapers using the ad tech service of the SE adopt the AMP format.

From an argument analogous to the one used for Proposition 11, it is straightforward to see the existence of the adoption equilibrium in which all newspapers adopt the AMP format.

Proposition 13 *Under A1-A2 and B1-B2, the equilibrium in which all newspapers adopt the AMP format always exists.*

In what follows, we show that for m large enough, the adoption equilibrium is the unique equilibrium. Consider an equilibrium candidate in which no newspaper using the ad tech serive of T adopts the AMP format. Let $D^{s|-,i}(q_i, \mathbf{q}_{-i}; m)$ (respectively, $D^{s|+,i}(q_i, \mathbf{q}_{-i}; m)$) represent the demand from search referral when newspaper i is a non-adopter (respectively, an adopter) when there are m number of adopters.

The quality vector in the equilibrium candidate is characterized by $\mathbf{q}^M = (q^{M,T}, \dots, q^{M,T}, q^{M,SE}, \dots, q^{M,SE})$, where $q_i = q^{M,T}$ satisfies

$$(1-\tau^T)\left[\alpha_d^{M,T}(m,0)D_i^{d,i}(\mathbf{q}^M) + \alpha_s(1-\delta)D_i^{s|-,i}(\mathbf{q}^M; m)\right] = c'(q^{M,T});$$

and $q_i = q^{M,SE}$ satisfies

$$(1-\tau^{SE})\left\{\alpha_d^{M,SE}(m,0)D_i^{d,i}(\mathbf{q}^M) + \alpha_s D_i^{s|+,i}(\mathbf{q}^M; m)\right\} = c'(q^{M,SE}).$$

A newspaper using the service of T has an incentive to deviate by adopting the AMP format if the following inequality holds:

$$\begin{aligned} & (1-\tau^T)\left[\alpha_d^{M,T}(m,0)D^{d,i}(\mathbf{q}^M) + \alpha_s(1-\delta)D^{s|-,i}(\mathbf{q}^M; m)\right] - c(q^{M,T}) \\ \leq\ & (1-\tau^T)\left[\alpha_d^{M,T}(m,1)D^{d,i}(\widehat{q}, \mathbf{q}_{-i}^M) + \alpha_s D^{s|+,i}(\widehat{q}, \mathbf{q}_{-1}^M; m+1)\right] - c(\widehat{q}) \end{aligned}$$

where $\widehat{q}$ is defined as

$$\widehat{q} = \arg\max_{q_i}(1-\tau^T)\left[\alpha_d^{M,T}(m,1)D^{d,i}(q_i, \mathbf{q}_{-i}^M) + \alpha_s D^{s|+,i}(q_i, \mathbf{q}_{-1}^M; m+1)\right] - c(q_i).$$

A sufficient condition is that the inequality holds at $\widehat{q} = q^{M,T}$, which is equivalent to

$$\left[\alpha_d^{M,T}(m,1) - \alpha_d^{M,T}(m,0)\right]D^{d,i}(\mathbf{q}^M) + \alpha_s\left[D^{s|+,i}(\mathbf{q}^M; m+1) - (1-\delta)D^{s|-,i}(\mathbf{q}^M; m)\right] \geq 0.$$

Under A2, the inequality is satisfied in a straightforward way for $m = n - 1$. More generally, the externalities imposed by those m number of adopters on non-adopters are composed of two main elements. First, the SE's promotion of AMP articles and demotion of non-AMP articles mean that $D^{s|-,i}(\mathbf{q}^M; m)$ is pretty small for m large. Second, this in turn implies $\alpha_d^{M,T}(m, 1) - \alpha_d^{M,T}(m, 0)$ is small. Therefore, $\alpha_s D^{s|+,i}(\mathbf{q}^M; m+1)$ dominates all the other terms in the above inequality and hence it is satisfied. The same logic applies to an equilibrium candidate in which $l(< n - m)$ number of newspapers using the ad tech service of T adopt the AMP format in addition to the m number of newspapers.

Proposition 14 *When consumers click mostly on top search results, there exists a threshold $\widehat{m}$ such that for $m > \widehat{m}$, the unique equilibrium is such that all newspapers adopt the AMP format.*

The proposition shows that by using a divide-and-conquer strategy, the SE can leverage its search monopoly power to induce all newspapers to adopt the AMP format.

8 Policy Remedy

The policy remedy we propose is the following: (i) the SE should propose an objective criterion of loading speed and should treat all articles meeting such criterion in a non-discriminatory way and (ii) the SE should not host articles in its server. The second removes data leakage. If all newspapers adopt some technology meeting the speed criterion, the policy remedy leads to the equilibrium we described in the benchmark of AMP without change in data allocation (characterized in Proposition 2).

Part (i) of the policy remedy means that the SE can demote articles which do not meet the speed criterion. Such exercise of search market power is socially desirable as long as newspapers' adoption of speed-increasing technology improves welfare. If the SE does not discriminate articles at all, newspapers may not adopt the technology for instance when the adoption requires each newspaper to pay a fixed cost. This is because ad-financed newspapers insufficiently internalize consumer surplus generated by such adoption.

9 Conclusion

AMP allows Google to obtain data from articles stored in this format and to combine it with data from other sources in order to improve targeting of the ads served by Google.

Even if such data combination improves static welfare, we found that it can reduce dynamic welfare which accounts for the change in quality of newspapers. In particular, we showed that the search engine has no incentive to internalize the impact of its data combination on newspapers' incentive to invest in quality of journalism.

In this paper we considered only Google's serving ads for third-party sites/apps. However in reality Google owns many consumer-facing products and serves ads in these products as well. Considering Google-owned ad inventory will strengthen the dynamic conflict between data combination and investment in content that we identified.

Our paper compared two particular data combinations depending on whether AMP exists or not. Therefore, it calls for future research addressing a more fundamental and general question: what is the optimal scope of data combination that takes into account both static and dynamic efficiency?

If the optimal scope of data combination turns out to be narrower than the current practice of Google which combines a vast majority of data from third-party publishers with its own first-party data, a policy intervention would be required to implement the optimal scope, because a collective action problem would prevent publishers from maintaining proper control of their data. In particular, Google can leverage both its search monopoly power and its dominance in the ad intermediation for open display advertising in order to take advantage of the collective action problem.

References

Ambrus, Attila, Emilio Calvano, and Markus Reisinger (2016), "Either or both competition: A" two-sided" theory of advertising with overlapping viewerships." *American Economic Journal: Microeconomics*, 8, 189–222.

Anderson, Simon P and Stephen Coate (2005), "Market provision of broadcasting: A welfare analysis." *The review of Economic studies*, 72, 947–972.

Anderson, Simon P, Øystein Foros, and Hans Jarle Kind (2018), "Competition for advertisers and for viewers in media markets." *The Economic Journal*, 128, 34–54.

Anderson, Simon P and Martin Peitz (2020), "Media see-saws: Winners and losers in platform markets." *Journal of Economic Theory*, 186, 104990.

Athey, Susan, Emilio Calvano, and Joshua S Gans (2018), "The impact of consumer multi-homing on advertising markets and media competition." *Management Science*, 64, 1574–1590.

Beales, Howard (2010), "The value of behavioral targeting." *Network Advertising Initiative*, 1, 2010.

CMA Report (2020), "Online platforms and digital advertising market study final report." Report, Competition and Markets Authority, UK.

de Cornière, Alexandre and Miklos Sarvary (2020), "Social media and the news: Content bundling and news quality." Working paper, TSE Working Paper.

Dellarocas, Chrysanthos, Zsolt Katona, and William Rand (2013), "Media, aggregators, and the link economy: Strategic hyperlink formation in content networks." *Management Science*, 59, 2360–2379.

D'Annunzio, Anna and Antonio Russo (2019), "Ad networks and consumer tracking." *Management Science*.

Geradin, Damien and Dimitrios Katsifis (2019), "An eu competition law analysis of online display advertising in the programmatic age." *European Competition Journal*, 15, 55–96.

Jeon, Doh-Shin (2018), "Economics of news aggregators." In *Economic Analysis of the Digital Revolution* (Juan-José Ganuza and Gerard Llobet, eds.), 343–366, Funcas, Spain.

Jeon, Doh-Shin and Nikrooz Nasr (2016), "News aggregators and competition among newspapers on the internet." *American Economic Journal: Microeconomics*, 8, 91–114.

Krämer, Jan, Daniel Schnurr, and Michael Wohlfarth (2019), "Winners, losers, and facebook: The role of social logins in the online advertising ecosystem." *Management Science*, 65, 1678–1699.

Scott Morton, Fiona M and David C Dinielli (2020), "Roadmap for a digital advertising monopolization case against google." *Omidyar Network, May.*

Srinivasan, Dina (2019), "Why google dominates advertising markets."

U.S. House of Representatives (2020), "Investigation of competition in digital markets, majority staff report and recommendations." Report, Subcommittee on Antitrust, Commercial and Administrative Law of the Committee on the Judiciary, U.S.

Zuboff, Shoshana (2019), *The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power: Barack Obama's Books of 2019*. Profile Books.

Appendix

A Industry Background on Open Display Market

In this section, we briefly introduce how open programmatic display advertising market works to help readers get familiar with the context of our model and the motivation behind our modeling choices. For further references, see CMA Report (2020) Final Report and its online appendices for a detailed and comprehensive survey of digital advertising market. Also see Geradin and Katsifis (2019) and Srinivasan (2019) for their analysis of online display advertising issues from the angle of competition law.

Online display advertising market is composed of two segments, depending on whether ad inventories are sold through intermediaries. The first one involves own-and-operated platforms such as Google and Facebook, which sell a large amount of ad inventories from their consumer-facing services through their proprietary ad interfaces,.

The other segment, which is the focus of this paper, is open display advertising market, in which a large number of publishers (such as newspapers, blogs, app owners and any other content/service providers) sell their ad inventory to a large number of advertisers through a complex chain of third-party ad intermediaries. These intermediaries are also called ad techs and they organize and/or participate in real-time bidding auctions on behalf of publishers and advertisers. Examples of open display ads are the banner or video ads we frequently see on websites and apps.

How consumer data is used in personalized targeting? Display ads are usually personally targeted, thus consumer data plays an important role in determining what ads are relevant to a consumer and how much advertisers bid for ad impressions. To learn consumers' purchasing intents, ad techs track consumers' online activities across web and devices to infer what products might appeal to them. For instance, an ad intermediary can predict that a consumer may be interested in seeing the ad of latest iPhone if he spends a lot of time reading tech news and reviews on smart phones. Based on the collected data, the essential work of ad techs is to build consumer profiles each of which is a group of segments. Using the last example, the consumer profile could be {Male, France, Phone,...}, with each entry representing a segment. Accordingly, advertisers will create their audience by defining targeting criteria in terms of segments. For instance, a smart phone retailer can set her targeting audience as {location=France, monthly income > 1K, Phone}. Then when a consumer visits a publisher's website, the consumer data (including user identifiers, device info, URL) together with bid request will be passed through to advertisers or their agents. An advertiser will bid on a consumer if he belongs to predefined audience. The winner finally displays an ad of her product on the page the consumer is browsing.

Tracking.[6] In such an environment, an ad tech's success largely depends on how much consumer data it has, which in turn depends on the ability of tracking consumers across web and devices. To compile a certain consumer's browsing activities conducted on different sites, the tracker needs to: (i) learn that the consumer is visiting a web page when this happens; (ii) identify the consumer to associate his different browsing events together.

The first point is mostly realized by embedding third-party codes in first-party websites. When a consumer visits a web page of which the code writes that it needs content input from third party websites, her browser will send requests to both the first party (the website she is visiting) and the servers of the third-party websites. Information like referrer's URL, device info, IP addresses, etc can be passed along with the request. In this way, a third-party tracker learns that a consumer is visiting a website that contains its codes. The content fetched from a third party tracker's server could be a banner/video ad if the tracker provides ad serving service to the first-party website, or simply a 1x1 pixel transparent GIF which is invisible to visitors if the tracker provides analytic service to the first-party website. In web, these third-party codes are called tags and pixels. Their counterpart in mobile apps are Third Party Libraries (TPLs) or Software Development Kits (SDKs).

For a tracker to recognize that it is the same individual who visits a series of websites which embedded its codes, the request sent to the tracker needs to contain a unique user identifier attached to the consumer or to her browser. And this is mostly done via the best-known use of cookie. Cookies are small text files that a website's server drops in the browser when the server responds to the browser's request. Most importantly, it contains

[6]See a detailed explanation in online appendix G of the CMA Final report

a randomly generated string of letters and numbers to serve as an identifier. For example, suppose that both WSJ and NYT use the ad service of Google's DoubleClick (which would be a third-party tracker in the example). When a consumer visits WSJ for the first time, the browser will make requests to both WSJ and DoubleClick's servers as the page needs both the news content and ads to fill spaces. When sending back those required contents, WSJ and DoubleClick respectively set a cookie in the visitor's browser. WSJ's cookie is called first-party cookie as this belongs to the domain the consumer is visiting, while DoubleClick's cookie is called third-party cookie.

Cookies are private to domains such that only the domain which sets the cookies can read them. But cookies can be sent back whenever the browser requests content from their owners, as long as the user didn't delete it. Continuing with the above example, suppose now that the consumer visits NYT. As NYT also requests ad input from DoubleClick, the cookie set earlier by DoubleClick will be sent back along with this request. By reading the cookie identifier, DoubleClick knows it is the same consumer who previously visited WSJ now being on NYT. As a result, DoubleClick can compile consumer activities on these two websites together.

One issue with cookies is that as they are randomly generated, the identifiers in cookies set in a browser from different domains are different. As a consequence, when a publisher uses ad tech A to serve ad whereas an advertiser partners with ad tech B, the advertiser cannot identify the consumer of which the impression is on sale with the cookie ID set by ad tech A. Then, ad tech B engages in cookie matching (also called cookie syncing) during a real time bidding process in order to identify the same consumer in its own database and to evaluate the advertiser's willingness to pay for the impression. This process of cookie matching is prone to failure and can result in approximately 30 percent failed matching.

In addition to cookie IDs, trackers can also use email addresses, IP addresses, user account ID, device info etc. or the combination of them to identify consumers. In particular, trackers in mobile apps use mobile advertising ID (MAID) as user identifier, which is unique to mobile devices and shared with all apps. Therefore all tracking parties in mobile apps share a common identifier associated with each device and they save the trouble of cookie matching as in the web tracking case.

Finally, to build more complete user profiles, trackers need to do cross-device tracking and therefore to link MAIDs with cookie IDs. This can be greatly facilitated by IP address, email addresses or first-party login details/internal IDs.

A.1 Stylized Facts on the Competition in Ad Intermediation Market

Ad intermediation market consists of several layers along its complex value chain from publishers to advertisers. On the supply side, there are publisher ad servers and supply side platforms (SSPs) and on the demand side, there are demand side platforms (DSPs) and advertiser ad servers.

Because of various acquisitions and its leverage of data, advertising inventories and speed advantage, Google is currently the dominant player at each vertical layer of ad intermediation. We below report Google's market shares in the UK provided by the CMA (2020). The publisher ad server market is monopolized by Google as Google Ad Manager accounts for more than 90 percent of the display ads served in the UK. Google has 50-60 percent share in the SSP market in the UK. Google's DSP DV360 has a 30-40 percent market share. Google operates a DSP through Google Ads, which has a 10-20 percent market share. Hence, the combined market share in DSP becomes 40-60 percent in the UK. The advertiser ad server market is highly concentrated and Google accounts for approximately 80-90 percent of the ads served to UK users. We below describe in details how Google gains data advantage that can be leveraged in competition.

Sources of Google's Data Advantage:

- Google offers a wide range of leading consumer-facing services. For instance, Google provides more than 53 consumer-facing services and products in the UK, including Google Search, YouTube, Gmail etc (Appendix F of the CMA report, 2020, p. F8). This allows it to collect a vast amount of first-party consumer data and to derive valuable insights about users. For instance, search data is very useful to advertisers as a source of learning purchase intent.

- Google can leverage the first-party data it has to attract publishers and advertisers to use its own ad intermediary, by restricting the access to those valuable first-party data to its proprietary platforms. To provide services, Google places its trackers on customers' websites and apps. According to CMA report, Google was found to be present as a third-party in approximately 85% of websites.

- Because consumers, especially Android users, log-in their Google account on each of their device, Google has an advantage in cross-device tracking.

- Mainstream browsers are starting to ban the use of third-party cookies to protect consumer privacy. For instance, Apple's Safari and Mozilla's Firebox have blocked third party cookies by default and Google also plans to do so in Chrome in the following years. This will hurt rival ad techs more than Google, as the former ones rely more heavily on the use of third-party Cookies to collect information.

Implications for Competition Outcome. Lack of competition in ad intermediation translates into high ad tech fees, which is commonly referred to as "ad tech take". Ad tech take represents the difference between what advertisers pay and what publishers earn from digital advertising. The CMA report estimates that "on average publishers receive around 65% of initial advertising revenue that is paid by advertisers (i.e the overall 'ad tech take' is around 35%)". Another estimate on the ad tech tax from Wall Street Journal could be as high as 60%. [7].

B Micro-foundation of B1

Suppose that there are $N > 0$ advertisers who are interested in showing ads to consumer x.

Suppose that a given set of data about consumer x, Ω^x, is available to the advertisers. They use the data to estimate their willingness to pay. Their estimations generate a vector of the willingness to pay

$$\mathbf{v}(\Omega^x) = (\widetilde{v}_1(\Omega^x), \widetilde{v}_2(\Omega^x), ..., \widetilde{v}_N(\Omega^x))$$

where $\widetilde{v}_k(\Omega^x)$ is the kth-highest willingness to pay and is a random variable. In one extreme of $\Omega^x = \varnothing$, we assume that $\widetilde{v}_1(\varnothing) = \widetilde{v}_2(\varnothing) = ..., = \widetilde{v}_N(\varnothing) = v^e$ where v^e is a positive constant. In the other extreme of perfect information $\Omega^x = \mathbf{\Omega}^x$, $\widetilde{v}_i(\mathbf{\Omega}^x) = v_i$ for $i = 1, ..., N$ with

$$v_1 > v_2 > ...(> v^e >)... > v_{N-1} > v_N.$$

As Ω^x increases from $\varnothing$ to $\mathbf{\Omega}^x$, the expected values of $\widetilde{v}_1(\Omega^x)$ and $\widetilde{v}_2(\Omega^x)$ increase to v_1 and $v_2(>> v^e)$ whereas the expected values of $\widetilde{v}_{N-1}(\Omega^x)$ and $\widetilde{v}_N(\Omega^x)$ decrease to $v_{N-1}(<< v^e)$ and v_N.

We assume that the expected values of the three highest valuations $\widetilde{v}_1(\Omega^x), \widetilde{v}_2(\Omega^x), \widetilde{v}_3(\Omega^x)$ are increasing in Ω^x.

Consider two sets $\Omega^{x,A}$ and $\Omega^{x,B}$ such that $\Omega^{x,A} \cap \Omega^{x,B} = \varnothing$. Consider two independent second-price auctions, each selling one spot: auction A uses data $\Omega^{x,A}$ and auction B

[7] See `https://www.wsj.com/articles/behavioral-ad-targeting-not-paying-off-for-publishers-study-suggests-11559167195`

uses data $\Omega^{x,B}$. Then, we assume that the probability that the highest bidder of one auction will be also the highest bidder or the second-highest bidder of the other auction is zero. This in turn implies that the outcomes of the two auctions do not depend on the sequential order of the auctions.

Consider now expanding $\Omega^{x,B}$ to $\Omega^{x,B\prime}$ such that $\Omega^{x,A} \cap \Omega^{x,B\prime} \neq \varnothing$. If auction A runs before auction B, the change in $\Omega^{x,B}$ does not affect the outcome of auction A: we here make a simplifying assumption that advertisers are myopic and hence the advertiser with valuation $\widetilde{v}_1(\Omega^{x,A})$ prefers participating in the first auction instead of giving up the first auction in order to participate in the second auction). If auction B runs before auction A, there is a probability $p(\Omega^{x,A} \cap \Omega^{x,B\prime})$, which increases with $\Omega^{x,A} \cap \Omega^{x,B\prime}$, that the winner of auction B has either $\widetilde{v}_1(\Omega^{x,A})$ or $\widetilde{v}_2(\Omega^{x,A})$. In this case, the ad revenue of auction A will be $\widetilde{v}_3(\Omega^{x,A})$ instead of $\widetilde{v}_2(\Omega^{x,A})$.

Finally, assume that consumer x is reader of newspaper i. She visits everyday the site of newspaper i and another site for activity B. But the order of her visit is random: with equal probability, she visits each site first and then visits the other site. Each site sells one ad spot per day. Then, the expected ad revenue of the newspaper from direct visit is

$$\begin{aligned} & \alpha_A(\Omega^{x,A}, \Omega^{x,A} \cap \Omega^{x,B'}) \\ = & (1 - \frac{1}{2}p(\Omega^{x,A} \cap \Omega^{x,B\prime}))\widetilde{v}_2^e(\Omega^{x,A}) + \frac{1}{2}p(\Omega^{x,A} \cap \Omega^{x,B\prime})\widetilde{v}_3^e(\Omega^{x,A}) \\ = & \widetilde{v}_2^e(\Omega^{x,A}) - \frac{1}{2}p(\Omega^{x,A} \cap \Omega^{x,B\prime}) \left[\widetilde{v}_2^e(\Omega^{x,A}) - \widetilde{v}_3^e(\Omega^{x,A})\right] \end{aligned}$$

where the superscript e represents expectation. $\widetilde{v}_2^e(\Omega^{x,A})$ increases with $\Omega^{x,A}$. $\frac{1}{2}p(\Omega^{x,A} \cap \Omega^{x,B\prime})$ increases with $\Omega^{x,A} \cap \Omega^{x,B\prime}$ for given $\Omega^{x,A}$, which satisfies the second part of B1. In order to satisfy the first part of B1, either the second component $\frac{1}{2}p(\Omega^{x,A} \cap \Omega^{x,B\prime}) \left[\widetilde{v}_2^e(\Omega^{x,A}) - \widetilde{v}_3^e(\Omega^{x,A})\right]$ is weakly decreasing in $\Omega^{x,A}$ or the effect from the first component $\widetilde{v}_2^e(\Omega^{x,A})$ should dominate the effect from the second effect.

C Proofs

Proof of Proposition 9: Recall that we assume newspapers are sufficiently differentiated such that q^M is lower than the quality chosen by the social planner. Similarly, sites in sector B also have lower incentive of investing in quality than the social planner. As the model's assumptions on demand and cost functions guarantees that the social surplus function is concave, we have $W^M(q^M, q_B^M) > W^M(q^N, q_B^N))$. Under the second part of assumption of B3, we have $n\alpha_d^M D^d(\mathbf{q}^N) + n\alpha_s D^s(\mathbf{q}^N) + \alpha_B^M D^B(q_B^N) > n\alpha_d^N D^d(\mathbf{q}^N) + n\alpha_s D^s(\mathbf{q}^N) + \alpha_B^N D^B(q_B^N)$. Therefore, $W^M(q^M, q_B^M) > W^M(q^N, q_B^N) > CS^M(\mathbf{q}^N, q_B^N) - nc(q^N) - c^B(q_B^N) + \frac{1}{1-\beta}\left\{n\alpha_d^N D^d(\mathbf{q}^N) + n\alpha_s D^s(\mathbf{q}^N) + \alpha_B^N D^B(q_B^N)\right\} > W^N$