WORKING PAPER NO. 758

Digital Ecosystems, the Adtech Tax and Content Quality

Anna D'Annunzio, Antonio Russo and Shiva Shekhar

September 2025

University of Naples Federico II | University of Salerno | Bocconi University, Milan

CSEF - Centre for Studies in Economics and Finance
DEPARTMENT OF ECONOMICS AND STATISTICS – UNIVERSITY OF NAPLES FEDERICO II
80126 NAPLES - ITALY
Tel. and fax +39 081 675372 – e-mail: csef@unina.it
ISSN: 2240-9696

WORKING PAPER NO. 758

Digital Ecosystems, the Adtech Tax and Content Quality

Anna D'Annunzio[*], Antonio Russo[†], and Shiva Shekhar[‡]

Abstract
The adtech industry plays a key role in connecting digital publishers and advertisers. This industry is dominated by integrated ecosystems. We study how integration between an adtech intermediary and a major digital publisher affects the ad market and content production. Integration enables the intermediary to leverage exclusive access to data to monopolize the intermediation market and inflate the adtech tax on independent publishers. This depresses investment in content by independent publishers, but boosts the integrated firm's investment. The net impact of integration on consumer surplus and welfare depends on which effect prevails. Prohibiting data sharing between firms within the ecosystem is not sufficient to restore the market outcome under vertical separation.

JEL Classification: D43, D62, L82, M37.

Keywords: Online advertising, intermediaries, vertical integration, adtech tax, content quality.

[*] Tor Vergata University of Rome, CSEF and Toulouse School of Economics. Email: anna.dannunzio@uniroma2.it

[†] Institut Mines-Telecom Business School. Email: antonio.russo@imt-bs.eu

[‡] Tilburg School of Economics and Management. Email: shiva.shekhar.g@gmail.com, s.shekhar1@tilburguniversity.edu

1 Introduction

The online advertising market is a major source of revenue for many digital publishers, including news and review websites, blogs and app developers. In this market, a complex chain of firms, referred to as adtech intermediaries, serves as the link between advertisers and publishers.[1] These intermediaries absorb a substantial share of the resources that advertisers spend on digital ads, in what is generally referred to as the *adtech tax*.[2] Despite its key role, the economics of the adtech industry and its impact on the production of digital content have not been fully explored to date. Our objective is to address this gap.

We focus on two issues that have drawn the attention of regulators and practitioners: the high level of concentration within the adtech intermediation market and the integration of adtech intermediaries with major publishers that provide content and consumer services (ACCC, 2019; CMA, 2020; Stigler Committee on Digital Platforms, 2019). A striking example is Google which dominates almost every link of the adtech value stack (IAB, 2017). Its adtech ecosystem includes indispensable adtech intermediation services, as well as highly popular services such as digital maps (Google Maps), and video streaming (YouTube). These aspects raise several mutually reinforcing concerns. First, an intermediary integrated with important publishers may force advertisers to use its own intermediation services to access its owned-and-operated ad inventory.[3] Moreover, the firm also has exclusive access to unique user data generated on its own websites (the "walled garden"). This exclusive access to data allows for more effective allocation of ads, not only when managing its own ad inventory but also that of third-party publishers. A direct consequence of this data advantage is that advertisers may be willing to pay more for placing ads to more precisely targeted consumers which compounds the advantages conferred on the integrated firm's services. These advantages translate into market power which enable the (integrated) firm to extract a significant adtech tax from advertisers and publishers.[4]

[1] This chain includes supply-side platforms (SSPs) that collect ad inventories from publishers and run ad auctions; demand-side platforms (DSPs) that allow advertisers to buy ad inventories; publisher ad servers, that manage publishers' inventory and decide which ad to serve, based on the bids received from SSPs and direct deals between the publisher and advertisers. See CMA (2020) for an analysis of this market.

[2] The ISBA and PwC estimate that roughly half of the value bid by advertisers in programmatic advertising auctions actually reaches the publishers carrying their impressions, see https://tinyurl.com/4995vd4w. A recent study by the Competition and Markets Authority on the digital ad market estimates that at least 35% of the value of the purchased advertising is captured by intermediary fees (CMA, 2020). Gordon et al. (2021) point out that the share of digital ad spend going to intermediaries is nearly triple the traditional agency commission.

[3] Google requires advertisers to use Google's own Ad Manager to display ads on YouTube, and allegedly favoring its own ad exchanges. For more details see, https://www.theverge.com/2021/6/22/22544921/european-commission-google-antitrust-investigation-ad-tech-advertising-services?utm_source=chatgpt.com

[4] In 2023, the U.S. justice Department sued Google for illegally monopolizing the digital advertising market (see https://tinyurl.com/mvy8r2d8). The European Commission has also recently raised

An emerging concern associated with the growing market power of integrated intermediaries is its broader effect on content provision by independent publishers (Cairncross, 2019). When independent publishers are subject to a higher adtech tax, their incentives to invest in content quality are reduced. At the same time, the additional revenue generated through the adtech tax may enable the integrated firm's own publishing arm to increase its investment in content quality. This, in turn, increases the proportion of single-homing consumers in the integrated firm's demand, thereby expanding the (integrated) firm's access to exclusive data. As a result, the integrated firm's dominance in the adtech intermediation market is strengthened, thereby enhancing its capacity to further raise the adtech tax.

To address the above concerns, in this paper we study the connection between the market power in adtech intermediation market and content creation. Our main contribution is to provide a framework to study the interplay between competition in adtech intermediation market and investment in content quality. In so doing, we analyze the determinants of the adtech tax and its impact on content provision.

We propose a model with two publishers and two competing adtech intermediaries. We first study the *Vertical Separation* case where all adtech intermediaries and publishers are separate firms. For each ad impression, a publisher sends a bid request to both intermediaries. In turn, the adtech intermediaries collect bids from the advertisers via first-price auctions. We model diminishing returns to advertising deriving from excessive repetition on multi-homing consumers.[5] In equilibrium, each advertiser acquires its impressions only via a single intermediary, which can thus fully control the frequency of impressions, avoiding repetition. Competition among advertisers ensures that the intermediaries extract all surplus from ads. However, the intermediaries must also compete among each other to distribute the impressions. This allows the publishers to capture the whole advertising surplus. Hence, the intermediaries cannot impose any adtech tax, given that they are on a level playing field.

We then consider the scenario where an intermediary and a publisher are integrated which we refer to as the *Vertical Integration* case. The integrated intermediary has exclusive access to the ad inventory of the integrated publisher, as well as to the data that consumers generate while browsing that publisher. Thus, the intermediary can leverage the information gathered from its integrated publisher to match consumers with advertisers and manage frequency more effectively than its rival. As a result, the integrated

concerns regarding Google's dominant position in the ad intermediation market, see https://tinyurl.com/3f748hzh. Furthermore, some U.S. States sued Google in 2020 for illegally monopolizing the digital advertising market, see https://casetext.com/case/texas-v-google-llc. Most recently, Google was the subject of a lawsuit launched by several media firms, claiming that "without Google's abuse of its dominant position, the media companies would have received significantly higher revenues from advertising and paid lower fees for ad tech services". See https://tinyurl.com/y2acf7e5.

[5] Decreasing returns in ad exposure imply that advertisers value the ability to manage the number of times a user is shown an ad over a period of time (CMA, 2020).

intermediary monopolizes the market and can now impose an adtech tax on the impressions displayed on the independent publisher. This tax increases with the share of multi-homing consumers because the integrated firm's competitive advantage stems from its unique ability to track consumers across outlets.

Using the above results, we examine the relation between vertical integration, the adtech tax and investment in content quality. The independent publisher invests less than in the separation scenario because the adtech tax reduces the revenue from attracting consumers. The effect on investment by the integrated publisher is more subtle. Although this publisher captures the full revenue from its own impressions in both scenarios, we find that its incentive to invest is stronger with integration. This is due to the effect of quality on the size of the adtech tax. By making its own content more attractive, the integrated publisher increases the share of multi-homers in the rival's audience. Hence, the adtech tax increases, to the benefit of the integrated intermediary. These results lend support to the concerns on integration that creates a feedback loop between market power in adtech and in content provision.

In our model, keeping quality investment constant, vertical integration does not affect total welfare, because the allocation of ads by the intermediaries is fully efficient in both scenarios. However, due to the higher adtech tax under vertical integration, the distribution of profits changes in favor of the integrated firm. When taking the effect on content quality into account, we find that the impact of integration on social welfare is mixed. Quality is under-provided under vertical separation, as each publisher only internalizes the effect of quality on advertising revenue, ignoring consumer surplus. Integration aggravates the under-provision for the independent publisher but alleviates it for the integrated firm. The net impact on welfare depends on which effect prevails (see Section 5).

We employ our framework to evaluate some policies intended to address the market imbalances caused by integration. Consistently with the provisions in the DMA (2022), we consider a policy forbidding data sharing among service inside an ecosystem.[6] Another possibility is to discourage self-preferencing inside the ecosystem by forbidding exclusive sale of own inventories. We find that neither measure would work by itself, but deploying them concurrently would restore the same market outcomes as with separation. This finding highlights a trade-off between reducing the adtech tax and consumer privacy, and points to a possible unintended consequence of privacy regulation, such as the GDPR (see European Parliament (2016)).

In the final part of the analysis, we extend the baseline model in several directions. We consider the possibility that independent publishers allocate their impressions through direct contracts with the advertisers, rather than online auctions, or impose a reserve

[6]The DMA (2022) prevents "gatekeepers from unfairly benefiting from their dual role" and emphasizes interoperability as a way to boost contestability of markets.

price. Both measures would reduce the adtech tax, and improve investment in content of the independent publisher, though they would not eliminate this tax completely. We also consider the effects of a merger between the independent publisher and intermediary, creating competing vertically integrated ecosystems. We show that, while this would eliminate the adtech tax, it would also reduce the overall efficiency of the ad market, by reducing the ability of the ecosystems to track consumers across outlets.

The remainder of the paper is structured as follows. In section 2, we discuss the related literature. In section 3, we present the model setup. In Section 4, we present the analysis for the vertical separation case and the vertical integration case. In Section 5 we derive the welfare effects of vertical integration. In Section 6, we study policy interventions. Section 7 provides some extensions. Then, Section 8 summarizes the conclusion of the analysis, the managerial implications (see Section 8.1) and the policy implications (see Section 8.2). The proofs are available in the Appendix.

2 Related Literature

This work contributes to the recent literature on intermediaries in the online advertising market. Sayedi (2018) studies the allocation of the ad inventories of digital publishers between real-time bidding through intermediaries and reservation contracts. D'Annunzio and Russo (2020) model an ad network with multi-homing consumers and advertisers, studying how the ad network affects the intensity of advertising on the publishers' content. Marotta et al. (2022) consider a platform that shares consumer information with advertisers and study its affects on competition in the product market.[7] This literature has also considered the incentives of intermediaries to retain information in ad auctions (Rafieian and Yoganarasimhan, 2021; Decarolis et al., 2023; D'Annunzio and Russo, 2023).

Only a few recent papers have considered competition among intermediaries. Sharma et al. (2025) consider two intermediaries that are horizontally differentiated (from the perspective of publishers). In such a setting, they consider the impact of data regulation on asymmetric intermediaries and publishers. Despotakis et al. (2021) considers how industry moves to header bidding encourages intermediaries to transition from second- to first-price auctions. Decarolis et al. (2024) study search auctions and find that advertisers find it profitable to use platforms with more data and more sophisticated algorithms. Zeithammer and Choi (2024) considers competing adtech intermediaries and elicit the (vertical) inefficiencies associated with the presence of intermediaries. We contribute to this literature by studying integration between an intermediary and a major digital publisher, considering the effects not only on competition in the adtech market but also on the market for content, and evaluating the impact on investment in quality by digital

[7] In related work, Bergemann et al. (2025) study the allocation of advertising budgets by firms using auto-bidding algorithms.

publishers. More specifically, our analysis characterizes the link between vertical integration and the adtech tax, the interplay between this tax and content quality, and the ensuing market outcomes.

Our work is also related to the literature on multi-homing in media and advertising markets (Ambrus et al., 2016; Athey et al., 2018; Amaldoss and Du, 2023). These papers are centered on the observation that ad campaigns exposing consumers to multiple ads on multiple publishers produce inefficiencies. We contribute to this literature by studying how multi-homing affects competition at multiple levels, i.e., among digital publishers as well as ad intermediaries. Moreover, we explore the key role of multi-homing by consumers and advertisers in driving the relationship between the adtech tax and investment in content quality.

Taking a broader perspective, there is a large body of literature on vertical integration and exclusive agreements in media and digital markets characterized by network effects (see, e.g., Weeds, 2016, D'Annunzio, 2017, and Carroni et al., 2023). We contribute to this literature by studying vertical integration in the adtech industry, which has so far been overlooked. In so doing, we focus on exclusive access to ad inventories and consumer data as key competitive advantages for an integrated ad intermediary. Moreover, we examine a novel link between integration and investment in quality. This relates to how quality affects the composition of audiences (single- vs. multi-homing consumers), and, through this, the adtech tax that the integrated firm can impose on independent publishers.[8]

Finally, our study contributes to the growing literature on regulation in the adtech sector. Witte and Krämer (2025) discuss multiple anti-competitive concerns associated with Google's dominance in the adtech market and propose regulatory remedies. Latham et al. (2021) considers the adtech market in stylized setting and discusses how anti-competitive conduct reinforces each other. Our paper builds on these ideas and formalizes them in a game theoretic model, which helps in evaluating the claims presented in these influential works.

3 The model

We consider a setting with two intermediaries, denoted by I_i, with $i \in \{1, 2\}$, and two digital publishers, denoted by P_p, with $p \in \{1, 2\}$. We study two market structures: one where each firm is independent (denoted by VS), and one where intermediary I_1 is integrated with publisher P_1 (denoted by VI) (see Figure 1).

[8]For earlier literature on vertical integration and exclusivity, see Mathewson and Winter (1987), Ordover et al. (1990), Hart et al. (1990), Bolton and Whinston (1991), Segal and Whinston (2000), and Spector (2011).

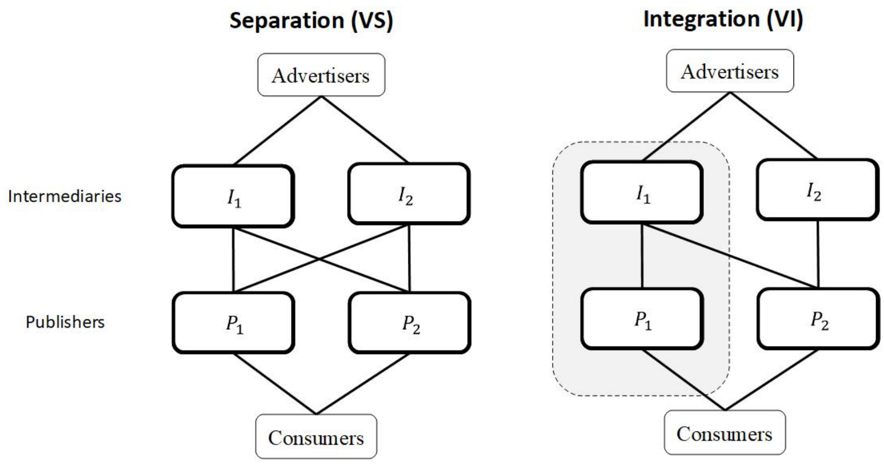

Figure 1: Market Structures

Consumers. There is a unit mass of consumers, who get the following net utility from visiting publisher $p \in \{1, 2\}$:

$$V_p(u_p, q_p) = u_p + \gamma q_p - c.$$

The parameters $u_p \geq 0$ capture the idiosyncratic preferences for publisher p, and are distributed according to a joint distribution with smooth density $h(u_1, u_2)$. The variable q_p is p's content quality, $\gamma > 0$ is the marginal value from each unit of quality and $c > 0$ is the cost of visiting (opportunity cost of time and/or nuisance from ads).

We denote as D_p the quantity of consumers who visit only publisher p (single-homers), as D_{12} the quantity of consumers who visit both (multi-homers) and as D_0 the quantity of consumers visiting no publisher (zero-homers). These demands are specified as follows[9]

$$D_p(q_p, q_{-p}) = Pr(V_p \geq 0, V_{-p} < 0) \text{ for } p, -p \in \{1, 2\} \text{ and } p \neq -p, \quad (1)$$

$$D_{12}(q_1, q_2) = Pr(V_1 \geq 0, V_2 \geq 0), \quad D_0(q_1, q_2) = Pr(V_1 < 0, V_2 < 0). \quad (2)$$

The demand system has the following notable properties. First, an increase in q_p attracts more consumers to p, who were either single-homing on the other publisher $-p$, or zero-homers. Formally, we have $\frac{\partial D_p}{\partial q_p} \geq 0$, $\frac{\partial D_{12}}{\partial q_p} \geq 0$ and $\frac{\partial D_{-p}}{\partial q_p} \leq 0$. Second, while the composition of publisher's $-p$ audience changes with q_p, its total size does not, i.e., $\frac{\partial D_{12} + D_{-p}}{\partial q_p} = 0$.

We assume each visit exposes the consumer to one ad. Hence, single-homers see one

[9]In the following, we omit the arguments of the demand functions for ease of exposition, unless strictly necessary.

ad, whereas multi-homers see two ads, one on each publisher. Each consumer is characterized by a type, θ, summarizing a set of characteristics, such as interests, demographics and location, which determines her/his relevance to the advertisers. The parameter θ is distributed according to a smooth distribution $F(\theta)$, which is independent of the distribution of (u_1, u_2).

Advertisers. We refer to each θ as an *advertising market.* In each advertising market, there are $n \geq 6$ identical advertisers.[10] For each θ, the advertisers have a message that generates a positive return only if it reaches consumers of the right type (e.g., information about a product or deal that type-θ consumers care for). The return from informing consumers in ad market θ with the proper message is $v(\theta) \in [0, v_H]$, which is private information of the advertisers. There is no return from informing consumers with the wrong message. Let $v \equiv \int_0^{v_H} v(\theta)\, dF(\theta)$ be the mean value of $v(\theta)$. We assume one impression is enough to inform a consumer. Hence, impressing the same consumer twice with the same ad is wasteful (Ambrus et al., 2016).

Publishers. At the start of the game, each publisher chooses the quality of its content, q_p, while facing an increasing and convex cost $k_p(q_p)$. The publishers are entirely ad-financed and must rely on an intermediary to sell their impressions. In the baseline model, we assume the publishers allocate their impressions to the intermediaries via auctions.[11] In the VS scenario, every publisher makes each impression available (i.e., sends a bid request) to both intermediaries. In the VI scenario, P_1 makes its impressions available only to I_1 while P_2 makes its impressions available to all intermediaries.

Intermediaries. When receiving a bid request from a publisher, each intermediary collects bids from the advertisers, and then sends its own bid to the publisher. All auctions are first-price. The publisher assigns the impression to the intermediary submitting the highest bid, and the latter allocates the impression to the advertiser sending the highest bid. If the top bids are equal, the impression is allocated randomly among the top bidders. Let b_p^i be an advertiser's bid for an impression on publisher p auctioned by intermediary i, and B_p^i be the bid that intermediary i sends to publisher p for that impression.

When auctioning an impression, the intermediaries disclose the information they possess about the consumer to the advertisers. We assume that if the intermediary receives bid requests from *both* publishers, it can track the activity of each consumer on both websites (e.g., with third-party cookies). That is, the intermediary can observe whether

[10] We assume $n \geq 6$, so that there is always an equilibrium with at least three advertisers bidding for impressions on each intermediary. This assumption ensures that intermediaries prefer to fully reveal consumer information to advertisers, despite the market-thinning effect (Levin and Milgrom, 2010 and D'Annunzio and Russo, 2023).

[11] In an extension, we consider a setting where publishers can directly contract with intermediaries instead of auctions (see Subsection 7.2).

the consumer is a single- or multi-homer and control which other impression (if any) she receives when visiting the other publisher. However, an intermediary cannot observe which ad a consumer is exposed to if delivered by the other intermediary.[12] Moreover, the ability to track consumers on both publishers allows an intermediary to identify the type θ of the consumer and get an expected return $v(\theta)$.

In the VI scenario, the data generated by consumers visiting P_1 is unavailable to I_2, which cannot track them across outlets. This puts I_2 at a disadvantage compared to I_1. First, I_2 cannot distinguish between single- and multi-homing consumers. Moreover, as I_2 has access to fewer data about consumers, it can identify their type with less precision. Accordingly, the expected return from an impression sold by I_2 is $z \times v(\theta)$, with $z < 1$. This parameter captures the reduced ability to identify consumers with a lower amount of data.[13]

Timing. We summarize the model by describing the timing of moves:

- t=1 The publishers set q_p.
- t=2 Consumers visit the publishers and all impression opportunities are generated simultaneously. In VS, each publisher sends a bid request for each impression to both intermediaries I_1 and I_2. In VI, only P_2 does that.
- t=3 For each impression, the advertisers submit a bid b_p^i to the intermediary.
- t=4 For each impression, the intermediaries submit a bid B_p^i to publisher p.
- t=5 All payments are made and consumers are exposed to ads.

Equilibrium concept and multiplicity. The equilibrium concept we adopt is Subgame-Perfect Nash Equilibrium. To avoid equilibrium multiplicity at stage 3, we assume that (i) when choosing between multiple strategies that yield identical profit, the advertisers prefer *one-stop shop* campaigns, i.e., to acquire impressions from a single intermediary;[14] (ii) if still indifferent among these strategies, advertisers prefer to acquire the largest

[12] This assumption captures the difficulty of managing the frequency of exposure to ads for multi-outlet advertising campaigns when using multiple intermediaries.

[13] There are other factors that may make the advertisers to value impressions delivered by integrated intermediaries such as Google at a premium. These include data advantage, ease of use, access to advertising slots on highly popular websites (e.g.,Youtube), integration with Google's Analytics tools and the ability to de-duplicate data from across the Google stack (Witte and Kraemer, 2023; Aridor et al., 2024). We do not consider these factors for simplicity but incorporating them in the model would not affect our results.

[14] This assumption is consistent with the difficulties that advertisers face when running campaigns using multiple platforms. CMA (2020) reports in paragraph 5.219 that using a single demand side platform (DSP) allows advertisers to manage frequency caps over the entire campaign and facilitates audience management and reporting.

volume of impressions. These assumptions are inconsequential for the results. Their purpose is only to rule out equilibria where advertisers acquire impressions on single- and multi-homers via multiple intermediaries in the VS scenario. These equilibria yield the same prices and revenues for all parties as the equilibria we characterize below.

3.1 Discussion of the setup

Our focus is on the fully automated segment of the advertising market, in which the allocation of impressions takes place through subsequent online auctions. This part of the market is populated by relatively large publishers.[15] In the VI scenario, we assume there is "self-preferencing" by the integrated publisher, that makes its impressions available only within its own adtech ecosystem. This captures the current market configuration regarding "owned and operated" advertising inventories of large ecosystems like Google. See Section 7 for a version of the model where the publishers engage in direct contracting with the intermediaries, rather than sell their impressions via auctions.

Unlike the intermediaries, publishers cannot track consumers across outlets and lack the necessary information to match them to the advertisers. In addition, publishers have no visibility on the outcome of the auctions run by the intermediaries. These assumptions reflect typical information asymmetries between publishers and intermediaries. However, the publishers may have aggregate information about the distribution of advertising returns, which they can use to set a reservation price. We allow for this possibility in an extension (See Section 7).

We assume diminishing returns to advertising to focus on the inefficiencies generated by imperfect frequency capping and excessive repetition.[16] In some markets the advertisers may want to place multiple ads on the same consumer to ensure she retains their message. Moreover, returns from informing a consumer may depend on whether she is exposed to ads by competitors. We ignore these possibilities for simplicity but incorporating them would not qualitatively affect our results.

4 Analysis

We begin by studying stages 3 and 4, taking the outcome of the previous stages as given. In so doing, we focus on the effects of integration on publishers and intermediaries given the quality of content. We then study the choice of content quality at Stage 1. Consumer demands at stage 2, given q_1 and q_2, are as characterized in equations (1) and (2).

[15] See CMA (2020), Appendix M, and https://www.publift.com/blog/google-adx-vs-google-adsense.

[16] For anecdotal evidence on the relevance of this issue to the advertising industry, see https://tinyurl.com/ycyfphk4. On the concerns expressed by industry bodies see (https://tinyurl.com/48wec992), and on those expressed by ad agencies see (https://tinyurl.com/bdh4hc5a).

4.1 Stages 3 and 4: the effect of VI on the ad market

4.1.1 VS scenario

Stage 4

Consider an impression on publisher $p \in \{1, 2\}$ and let $\overline{b}_p^i$ be the top bid received at stage 3 by I_i for this impression. This is also I_i's willingness to pay to acquire the impression from p at stage 4. The impression is won by the intermediary with the highest willingness to pay, and the equilibrium price paid by the winning intermediary to publisher p, $\overline{B}_p$, equals the second-highest value of $\overline{b}_p^i$, for $i \in \{1, 2\}$.

Lemma 1 *In the VS scenario, at stage 4 each impression on publisher p is acquired by the intermediary that receives the highest bid from the advertisers (i.e., $\max(\overline{b}_p^2, \overline{b}_p^1)$) at a price $\overline{B}_p = \min(\overline{b}_p^2, \overline{b}_p^1)$.*

Stage 3

Consider the willingness to pay of an advertiser for an impression in market θ that takes place on P_p and is auctioned by I_i. If the impression falls on a single-homer, all advertisers are willing to pay $v(\theta)$ for it. Hence, we have $\overline{b}_p^i = v(\theta), \forall i, p$.

Now suppose the impression falls on a multi-homer. I_i can inform each advertiser if it is already sending an impression to the same consumer when she visits the other publisher, P_{-p}, provided this impression is also distributed by I_i. If the advertiser knows the impression is repeated, its willingness to pay for it is zero. Hence, if the advertiser acquires all its impressions via the same intermediary, there is no possibility that it buys repeated impressions on the same consumer. However, if the advertiser acquires some impressions via the other intermediary, I_{-i}, there is such possibility. This is due to the lack of information sharing between the intermediaries. More precisely, even if it is not sending an impression to the same consumer via I_i, the advertiser's willingness to pay for an impression auctioned by this intermediary is $v(\theta)(1-\delta_{-p}^{-i}(MH))$, where $\delta_{-p}^{-i}(MH)$ is the share of impressions on multi-homers taking place on $-p$ acquired by the advertiser via I_{-i}. This equals the probability that the consumer is already exposed to the advertiser's message on the other publisher.

The above discussion establishes that, due to the risk of repetition, impressions on multi-homers sold by different intermediaries are perceived as substitutes by the advertisers. Given this substitutability, we show in Appendix A.1 that in equilibrium each advertiser acquires impressions only via one intermediary: some advertisers place winning bids only on I_1 and others only on I_2. By so doing, each advertiser ensures that its impressions are allocated efficiently, because the intermediary can fully control the frequency of exposure on multiple publishers. Indeed, there is no repetition in equilibrium and all impressions generate the maximum advertising surplus in each market, $v(\theta)$.

Furthermore, $v(\theta)$ is the equilibrium price of each impression. Even for impressions on multi-homers there are at least two advertisers who are willing to bid this much, as they cannot already be impressing the same consumer when she/he visits the other publisher.[17]

Lemma 2 *In the VS scenario, in each ad market some advertisers acquire all their impressions from I_1 and some from I_2. No advertiser acquires impressions from both. Each impression generates the full value $v(\theta)$ to the advertisers, that pay a price $\overline{b}_p^i(VS) = v(\theta)$, $\forall i, p$ to I_i.*

Combining the above with Lemma 1, and recalling that $v \equiv \int_0^{v_H} v(\theta)\, dF(\theta)$, we establish the following:

Proposition 1 (No adtech tax with VS) *In the VS scenario, $\overline{b}_p^i(VS) = \overline{B}_p(VS) = v(\theta)$ for each impression in each market. Hence, there is no adtech tax. The publishers obtain the full revenue from their impressions:*

$$R_p = v(D_p + D_{12}), \quad p \in \{1, 2\},$$

while intermediaries and advertisers make zero profits.

In the VS scenario, intermediaries are on a level playing field, because they have equal access to ad inventories and consumer data. As a consequence, when bidding to acquire the right to distribute the impressions, the intermediaries compete away all the revenue they extract from the advertisers, to the benefit of the two publishers.

4.1.2 VI scenario

Stage 4

The analysis of this stage is very similar to the VS scenario, except that only P_2 makes its ad inventory available to both intermediaries (see Figure 1). Instead, impressions on P_1 are sold exclusively by I_1. We can therefore state the following:

Lemma 3 *In the VI scenario, any impression generated on P_2 is acquired by the intermediary that collects the highest bid from the advertisers (i.e., $max(\overline{b}_2^2, \overline{b}_2^1)$) at a price equal to* $\min(\overline{b}_2^2, \overline{b}_2^1)$.

[17]The advertisers could avoid repetition also by acquiring their impressions via a single intermediary for multi-homers, and another intermediary (or both) for single homers, or by acquiring impressions only on a single publisher. As we show in Appendix A.1 these equilibria would all be such that all impressions are sold at $v(\theta)$. Therefore, they all yield the same revenue and profits for each party. Our equilibrium refinements rule these equilibria out.

Stage 3

We first describe the advertisers' willingness to pay for each impression, depending on the intermediary that makes them available. Next, we describe the equilibrium bidding strategies of the advertisers.

Consider an advertiser's willingness to pay for an impression auctioned by I_2 (on P_2) in market θ. We have

$$w_2^2 = \underbrace{zv(\theta)\frac{D_2}{D_2 + D_{12}}}_{\substack{\text{Exp. value} \\ \text{on single-homer}}} + \underbrace{zv(\theta)\left(1 - \delta_1^1(MH)\right)\frac{D_{12}}{D_2 + D_{12}}}_{\substack{\text{Exp. value} \\ \text{on multi-homer}}} = \\ = zv(\theta)\left(1 - \frac{D_{12}}{D_2 + D_{12}}\delta_1^1(MH)\right). \quad (3)$$

To understand this expression, consider that the advertiser cannot condition its valuation on whether the consumer is a single- or a multi-homer, as this information is unavailable to I_2. If the consumer is a multi-homer, she may already be exposed to the same message when visiting P_1. The probability of repetition equals the share of impressions on multi-homers in the same market that visit P_1 and that the advertiser acquires via I_1. We denote the latter by $\delta_1^1(MH)$. A larger share of multi-homers in the audience of P_2 therefore lowers the advertisers' willingness to pay for the impressions auctioned by I_2, all else given. In addition, the accuracy of I_2 when identifying θ is lower due to the intermediary's inability to collect data on P_1. This is captured by the parameter z.

Unlike its rival, I_1 can distinguish between single- and multi-homers and inform each advertiser about whether it is buying an impression on a multi-homer when she visits P_1, because I_1 has exclusive control over these impressions. I_1 is also better able to identify θ. Hence, the advertiser's willingness to pay for an impression auctioned by I_1 on P_2 is $w_2^1(SH) = v(\theta)$ if the consumer is a single-homer, and $w_2^1(MH) = v(\theta)$ if the consumer is a multi-homer and the advertiser knows it is not repeating the impression on P_1 (otherwise, $w_2^1(MH) = 0$).

The above discussion implies that leveraging the exclusive access to data of P_1 puts I_1 at an advantage when auctioning the impressions on P_2. This intermediary can generate higher top bids for P_2's impressions than I_2. This is especially true if the advertisers run multi-publisher campaigns and thus place some ads on P_1 as well.

Let us now turn to the advertisers' willingness-to-pay for impressions on P_1. This equals $v(\theta)$ if the consumer is a single-homer. If the consumer is a multi-homer, I_1 can observe whether it is delivering to her an impression from the same advertiser on P_2 but not if the impression is delivered by I_2. Consequently, we have $w_1^1(MH) = v(\theta)\left(1 - \delta^2\right)$, where δ^2 is the share of impressions acquired by the advertiser on P_2 via I_2.

In light of the above discussion, we obtain again that impressions auctioned by different intermediaries on different publishers are perceived as substitutes by the advertisers, due to the risk of wasteful repetition on multi-homers. However, I_1 is now the only intermediary that allows the advertisers to allocate their impressions efficiently, thanks to its exclusive access to P_1's consumer data. If the advertisers run multi-publisher campaigns and intend to place ads on P_1, I_1 is the only intermediary that allows them to avoid repetition on P_2. Moreover, even if some advertisers forgo impressions on P_1 entirely, they still discount impressions auctioned by I_2 due to its lesser ability to identify the consumers' type. Consequently, as we show in Appendix A.2, in equilibrium I_1 monopolizes the market and distributes all the impressions on either publisher.[18]

Nevertheless, like in the VS scenario, the equilibrium is efficient: I_1 can manage the frequency of impressions to avoid repetition and match them efficiently to consumers. In each market, therefore, each impression generates the full value $v(\theta)$. This is also the equilibrium price paid by advertisers, because for each impression there are at least two advertisers willing to pay $v(\theta)$. Hence, each advertiser makes zero profit.[19] Combining this information with Lemma 3, we can claim the following.

Lemma 4 *In the VI scenario, for every impression auctioned by I_1 in each market the winning bid is $\overline{b}_p^1 = v(\theta)$, whereas I_2 receives the following top bid for each impression on P_2*

$$\overline{b}_2^2(VI) = zv(\theta)\left(1 - \frac{D_{12}}{D_2 + D_{12}}\frac{1}{n}\right). \tag{4}$$

Thus, in each market the impressions on P_2 are distributed by I_1, that pays $\overline{B}_2(VI) = \overline{b}_2^2(VI) = zv(\theta)\left(1 - \frac{D_{12}}{D_2+D_{12}}\frac{1}{n}\right)$ to the publisher.

In the VI scenario, competition among the intermediaries for P_2's impressions is not as strong as in the VS scenario. This is because in each market the advertisers discount their bids on I_2, due to its informational disadvantage. I_1 can therefore pay each impression to P_2 less than the price collected from the advertisers. That is, I_1 "shades" its bids to P_2, imposing an adtech tax of $v(\theta) - \overline{B}_2(VI) = v(\theta)\left(1 - z\left(1 - \frac{D_{12}}{D_2+D_{12}}\frac{1}{n}\right)\right)$ for each such impression. This tax increases in the share of multi-homers in P_2's audience. The intuition is that I_1's informational advantage stems from its ability to track consumers *across* outlets. The tax also decreases with z, because a greater z implies a smaller gap in the ability to identify the consumers' type.

[18]If we allow for $z = 1$, potentially there exist other equilibria where some advertisers only acquire ads via I_2 and bid $v(\theta)$ for them. The advertisers would earn the same profit (zero) as when buying ads only via I_1. We could rule this equilibrium out by assuming that, when indifferent, the advertisers prefer to place ads via an intermediary that connects them to both publishers. This is consistent with the observed preference of advertisers for integrated intermediaries like Google (see footnote 13).

[19]No advertiser can profitably deviate from this equilibrium by acquiring ads only via I_2 and paying less than v. Such a deviation would be detected by I_1, who would respond by raising its bid $\overline{B}_2^1$ at Stage 4 accordingly.

Proposition 2 (Integration and adtech tax) *In the VI scenario, I_1 collects an adtech tax on each impression on P_2, that is equal to $v(\theta)\left(1 - z\left(1 - \frac{D_{12}}{D_2+D_{12}}\frac{1}{n}\right)\right)$. As a result, the P_2 and the integrated firm respectively earn the following revenues:*

$$\begin{aligned} R_2 &= zv\left(D_2 + D_{12}\right) - \frac{zv}{n}D_{12}, \\ R_1^1 &= v\left(D_1 + D_{12}\right) + \underbrace{\left(v - \overline{B}_2(VI)\right)\left(D_2 + D_{12}\right)}_{\textit{Adtech tax revenue}} \\ &= v\left(D_1 + D_{12}\right) + (1-z)v\left(D_2 + D_{12}\right) + \frac{zv}{n}D_{12}. \end{aligned}$$

The advertisers and I_2 make zero profit.

In the above expression, the revenue for the integrated firm, R_1^1, is made of three components. The first is the ad revenue generated from the "owned-and-operated" impressions, $v\left(D_1 + D_{12}\right)$. The second and third terms reflect the revenue from the adtech tax, collected from distributing the impressions of the independent publisher, P_2. Part of this revenue (i.e., $(1-z)v\left(D_2 + D_{12}\right)$) is due to I_1's superior ability to identify the consumers' type, and the remainder (i.e., $\frac{zv}{n}D_{12}$) is due to its ability to avoid repetition on multi-homers.

Before proceeding, note that P_2 could potentially avoid the adtech tax by setting a reservation price for its impressions. We consider this possibility in Section 7.3. As we show there, because the publisher cannot observe the realization of $v(\theta)$ in each market, this instrument is too blunt to eliminate the adtech tax completely.

4.2 Stage 1: the effect of VI on content quality

Now we consider the choice of quality levels at stage 1. In the VS scenario, each publisher maximizes its profit net of the cost of quality. Given Proposition 1, profit is

$$\pi_p(VS) = v(D_p + D_{12}) - k_p(q_p), \quad p \in \{1, 2\}. \tag{5}$$

Differentiating the above profit expression with respect to q_p yields the following first order conditions:

$$\frac{\partial \pi_p(VS)}{\partial q_p} = v\left(\frac{\partial D_p}{\partial q_p} + \frac{\partial D_{12}}{\partial q_p}\right) - \frac{\partial k_p(q_p)}{\partial q_p} = 0, \quad p \in \{1, 2\}. \tag{6}$$

Observe that, given $\frac{\partial(D_p+D_{12})}{\partial q_{-p}} = 0$, the terms in each first-order condition do not depend on the quality set by the other publisher, q_{-p}. Solving the above system gives the equilibrium quality levels, that we denote by $q_p(VS)$.

Consider now the VI scenario. Given Proposition 2, the profit of the vertically integrated firm and P_2 respectively are

$$\begin{aligned}\pi_1^1(VI) &= v(D_1+D_{12}) + \overbrace{(v-\overline{B}_2(VI))}^{\text{Adtech tax}}(D_2+D_{12}) - k_1(q_1), \\ &= v(D_1+D_{12}) + v(1-z)\,(D_2+D_{12}) + vz\frac{D_{12}}{n} - k_1(q_1), \end{aligned} \tag{7}$$

$$\pi_2(VI) = zv\,(D_2+D_{12}) - vz\frac{D_{12}}{n} - k_2(q_2). \tag{8}$$

The following first-order conditions that characterize the equilibrium quality levels $q_p(VI)$ (where we have used again the property that $\frac{\partial(D_2+D_{12})}{\partial q_1}=0$):

$$\frac{\partial \pi_1(VI)}{\partial q_1} = v\left(\frac{\partial D_1}{\partial q_1} + \frac{\partial D_{12}}{\partial q_1}\right) + \frac{vz}{n}\frac{\partial D_{12}}{\partial q_1} - \frac{\partial k_1(q_1)}{\partial q_1} = 0. \tag{9}$$

$$\frac{\partial \pi_2(VI)}{\partial q_2} = zv\left(\frac{\partial D_2}{\partial q_2} + \frac{\partial D_{12}}{\partial q_2}\right) - \frac{zv}{n}\frac{\partial D_{12}}{\partial q_2} - \frac{\partial k_2(q_2)}{\partial q_2} = 0. \tag{10}$$

The key difference between expression (9) and (6) is the term $\frac{vz}{n}\frac{\partial D_{12}}{\partial q_1}$, which captures the effect of quality investment on the size of the adtech tax. This effect is positive because the tax increases the share of multi-homers in P_2's audience, which increases in q_1. Similarly, expression (10) contains an extra negative term compared to (6), which captures the part of the adtech tax due to the perceived risk of repetition. Moreover, the first term in (10) indicates that the average revenue from each impression is zv and not v. While investing in content quality increases P_2's audience, the adtech tax reduces the net marginal revenue generated from such increase.

We are now in a position to study how integration affects the investment in content quality. The equilibrium quality levels, $\mathbf{q(VI)} \equiv (q_1(VI), q_2(VI))$ solve the system of first-order conditions in (9) and (10). Comparing these to $\mathbf{q(VS)} \equiv (q_1(VS), q_2(VS))$, we obtain the following result (see Appendix A.3 for the proof).

Proposition 3 (Quality levels.) *Investment in quality by P_1 (resp., P_2) is higher (resp., lower) under VI than under VS — i.e., $q_1(VI) > q_1(VS)$ and $q_2(VI) < q_2(VS)$.*

As we have seen in Proposition 2, the integrated firm can capture part of the revenue generated by ads shown on the independent publisher, P_2, through the adtech tax. This reduces the publisher's ability to monetize its investment in quality. Thus, q_2 decreases with respect to the VS scenario.

The effect on q_1 is more subtle and entirely due to the adtech tax imposed on P_2. To see this, consider that P_1 retains the entire revenue from its own impressions in both the VS and VI scenarios (Proposition 1 and 2). Hence, without the adtech tax, integration would have no effect on q_1. However, through this tax, P_1 internalizes the effect of its own quality investment on the ad revenue generated by P_2. While q_1 does not affect P_2's total audience, it does change its composition by increasing the share of multi-homers. Therefore, although the total ad revenue generated by P_2 does not change, the share that the integrated firm captures via the adtech tax increases with q_1. Proposition 3 thus characterizes a novel mechanism whereby vertical integration drives content quality investment in the context of ad-funded digital ecosystems.

5 Welfare analysis

We now study the effect of vertical integration on the surplus of consumers and advertisers, as well as social welfare. We first consider exogenous quality levels, then consider the implications of the changes in quality levels as presented in Proposition 3.

The following expressions describe consumer surplus for single-homers and multi-homers

$$
\begin{aligned}
CS_1(q_1, q_2) &\triangleq \int_0^{c-\gamma q_2} \int_{c-\gamma q_1}^{\infty} (u_1 + \gamma q_1 - c) h(u_1, u_2) du_1 du_2, \\
CS_2(q_2, q_1) &\triangleq \int_0^{c-\gamma q_1} \int_{c-\gamma q_2}^{\infty} (u_2 + \gamma q_2 - c) h(u_1, u_2) du_1 du_2, \\
CS_{12}(q_1, q_2) &\triangleq \int_{c-\gamma q_1}^{\infty} \int_{c-\gamma q_2}^{\infty} (u_2 + \gamma q_2 - c + u_1 + \gamma q_1 - c) h(u_1, u_2) du_1 du_2.
\end{aligned}
$$

Total consumer surplus, CS, is given by the sum of the above components, i.e., $CS = CS_1 + CS_2 + CS_{12}$. This sum depends on the quality levels q_p. Given these levels, there is no effect of VI on consumers.

Because payments among firms cancel out, total profit coincides with the total surplus from advertising (denoted by AS), net of the cost of quality investment. Recall from Lemma 2 and Lemma 4 that in both scenarios each impression generates the full value $v(\theta)$. Considering all ad markets, we get therefore that

$$AS = v(D_1 + D_2 + 2D_{12}).$$

As a consequence, given the quality levels, switching from VS to VI only changes the distribution of surplus among firms, not its total size. It follows that social welfare, defined as

$$W = AS + CS - k_2(q_2) - k_1(q_1). \tag{11}$$

is also invariant in the VS and VI scenarios, given the quality levels.

However, we know from Proposition 3 that integration increases (resp. reduces) the quality of content on P_1 (resp. P_2). Intuitively, the net effect on advertising and consumer surplus can be positive or negative. Consequently, the net effect on welfare is also a priori ambiguous.

To get a better sense of the effect of vertical integration on social welfare, it is useful to compare the socially optimal quality levels to the equilibrium ones. The quality levels that maximize (11), denoted by the vector $\mathbf{q}^* \equiv (q_1^*, q_2^*)$, satisfy the following system of equations

$$v\left(\frac{\partial D_i}{\partial q_i} + \frac{\partial D_{12}}{\partial q_i}\right) + \frac{\partial CS}{\partial q_i} - \frac{\partial k_i}{\partial q_i} = 0, i \in \{1,2\}, \tag{12}$$

where we have used again the property that $\frac{\partial D_{12}+D_{-i}}{\partial q_i} = 0$. Let us compare $\mathbf{q}^*$ to $\mathbf{q}(\mathbf{VS})$. Evaluating the system of first-order derivatives of (12) with the investment levels under vertical separation $\mathbf{q}(\mathbf{VS})$ (characterized by expression (6)), we find that:

$$\left.\frac{\partial W}{\partial q_i}\right|_{\mathbf{q}(\mathbf{VS})} = \left.\frac{\partial CS}{\partial q_i}\right|_{\mathbf{q}(\mathbf{VS})} > 0. \tag{13}$$

Quality is under-provided under VS. The reason is that, because the publishers do not charge consumers for accessing their content, they fail to internalize the effect of quality provision on consumer surplus.

Turn now to the comparison with quality in the VI scenario. Evaluating the system (12) at the quality levels $\mathbf{q}(\mathbf{VI})$ characterized in (9) and (10), we have:

$$\left.\frac{\partial W}{\partial q_1}\right|_{\mathbf{q}(\mathbf{VI})} = \left.\left(-\frac{zv}{n}\frac{\partial D_{12}}{\partial q_1} + \frac{\partial CS}{\partial q_1}\right)\right|_{\mathbf{q}(\mathbf{VI})} \lesseqgtr 0, \tag{14}$$

$$\left.\frac{\partial W}{\partial q_2}\right|_{\mathbf{q}(\mathbf{VI})} = \left.\left(\frac{v}{n}\frac{\partial D_{12}}{\partial q_2} + \frac{1-z}{z}\frac{\partial k_2}{\partial q_2} + \frac{\partial CS}{\partial q_2}\right)\right|_{\mathbf{q}(\mathbf{VI})} > 0. \tag{15}$$

The under-provision by publisher P_2 worsens with VI (this follows from $q_2(VI) < q_2(VS)$). Instead, the quality provided by publisher P_1 may exceed or fall short of the socially optimal level. That is, $q_1(VI) \lesseqgtr q_1^*(q_2(VI))$, where $q_1^*(q_2(VI))$ denotes the optimal quality when $q_2 = q_2(VI)$.

Proposition 4 (Integration and welfare.) *For given quality levels, VI redistributes profit from P_2 to the integrated firm, but does not affect social welfare. Considering the effect on quality, VI can affect positively or negatively consumer surplus and total welfare.*

At this level of generality, we cannot establish whether integration increases total surplus. In the following, we present three examples demonstrating how the welfare properties of the equilibrium depend on the distribution of consumer preferences.

5.1 Examples

We assume consumer preferences for the two publishers, u_p, follow a uniform distribution and consider three cases: (i) independent, (ii) negatively correlated, and (iii) positively correlated preferences. For simplicity, we focus on the case where $z \to 1$ and that the convex investment cost is $k_p(\cdot) = \frac{q_p^2}{2}, \forall p \in \{1, 2\}$. We report below the main results, while the formal details are in Appendix B.

A. Independent preferences. Suppose consumer preferences for publishers are independent: $u_1 \sim \mathcal{U}[0,1]$ and $u_2 \sim \mathcal{U}[0,1]$. The increase in investment by the integrated publisher is always lower than the decrease by the independent one, i.e., $|q_2(VI) - q_2(VS)| - |q_1(VI) - q_1(VS)| > 0$, leading to reduced total quality, consumer surplus, and welfare under vertical integration. Consumer surplus falls (i.e., $CS(VS) - CS(VI) > 0$) because the gain in quality at the integrated publisher is smaller than the loss at the independent one. Welfare also declines (i.e., $W(VS) - W(VI) > 0$) because total demand and impressions are higher under vertical separation, outweighing any increased investment costs.

B. Negatively correlated preferences. Preferences follow $u_1 \sim \mathcal{U}[0,1]$ and $u_2 = 1 - u_1$, forming a variant of the well-known Hotelling setup where P_1 is located at 1 and P_2 at 0.[20] Consumers have unit valuation for content with a per-unit transportation cost of one (see Figure 2 in Appendix B).

Under vertical integration, the increase in investment by the integrated publisher exactly offsets the decrease by the independent publisher, i.e., $|q_2(VI) - q_2(VS)| - |q_1(VI) - q_1(VS)| = 0$, a standard Hotelling result. Consumer surplus rises, while total surplus may increase or decrease: $CS(VS) - CS(VI) < 0$, and $W(VS) - W(VI) = \frac{v^2\gamma^2(1-\gamma^2)}{n^2}$. Multi-homers' surplus remains unchanged, while single-homers shift—those on P_2 shrink and lose, while those on P_1 increase and gain, leading to a net consumer surplus rise.

Welfare is more nuanced: advertising surplus is higher under vertical separation as vertical integration does not increase total impressions but raises investment costs due to convexity.[21] If consumer sensitivity to quality is high ($\gamma > 1$), consumer surplus gains can offset these costs, increasing welfare under integration. Otherwise, for $\gamma \leq 1$, welfare declines.

C. Positively correlated preferences. Suppose $u_2 = \alpha u_1$ with $u_1 \sim \mathcal{U}[0,1]$ and $u_2 \in [0, \alpha]$. Consumers visit publisher p if $V_p \geq 0$, with threshold consumers $\bar{u}_1$ and $\bar{u}_2$ defining demand: (i) if $\bar{u}_1 < \bar{u}_2$, then $D_2 = 0$; (ii) if $\bar{u}_1 > \bar{u}_2$, then $D_1 = 0$.

Case (i) $0 < \bar{u}_1 \leq \bar{u}_2$. P_1's investment remains unchanged, so its single-homers' utility is unaffected. However, P_2's investment falls under vertical integration, reducing multi-homers' utility and causing some to switch to single-homing on P_1. This decreases both

[20] See Jullien et al. (2023) for details.

[21] See Appendix B for the advertiser surplus expression.

consumer and total surplus under VI, i.e., $CS(VS) - CS(VI) > 0$ and $W(VS) - W(VI) > 0$.

Case (ii) $\bar{u}_1 > \bar{u}_2$. P_2's investment remains constant, while the integrated retailer invests more, increasing total value creation. Multi-homers gain surplus, encouraging some single-homers to multi-home, leading to higher consumer surplus, i.e., $CS(VS) - CS(VI) < 0$ The impact on welfare depends on the number of advertisers: $W(VS) - W(VI) = \frac{\gamma^2 v\left(v(1-\gamma^2)-2n(1+\gamma^2 v-c)\right)}{2n^2}$. Welfare increases under vertical integration if the number of advertisers, denoted by n, is sufficiently large — i.e., $n > \max\{2, \frac{v(1-\gamma^2)}{2(1-c+\gamma^2 v)}\}$. In this case, the positive effect on consumer surplus dominates the negative effect on profits (due to increased investment cost).

6 Policy interventions in the adtech market

The previous section has shown that the effects of vertical integration on consumer surplus and welfare can be positive or negative. In particular, the effect is negative whenever integration causes a substantial reduction in the quality provided by the independent publisher compared to the increase in quality of the integrated content provider. However, vertical integration always generates imbalances in the content and adtech markets, implying a reduction in profits for the independent publisher and the exclusion of the independent intermediary. Under these conditions, there is a rationale for restoring the same market outcomes as in the VS scenario. Several regulators have indeed expressed concerns about the dominance of integrated ecosystems in the digital market. An example is the recent European regulation of the digital market (see DMA, 2022, and DSA, 2022), which prescribes asymmetric regulation for ecosystems and dominant firms to restore a level playing field and foster competition. Accordingly, we now consider some policy interventions aimed at restoring the VS market outcomes and evaluate their effectiveness.

Prohibiting data combination within ecosystems. Ecosystems typically exploit large volumes of consumer and advertisers data, gathered from the multiple services they provide. Accordingly, we assumed that the integrated firm can exploit data generated by consumers on P_1 when selling ad impressions as an intermediary on both publishers.

Suppose now that a regulator mandates that the data generated on P_1 cannot be transferred to I_1 and used to identify consumers to sell ads. This would be consistent with the EU's Digital Market Act (DMA), which regulates the combination of data on users gathered from different services provided by the same firm.[22] However, this regulation

[22]The DMA states that "to prevent gatekeepers from unfairly benefitting from their dual role, it is necessary to ensure that they do not use any aggregated or non-aggregated data, which could include anonymised and personal data that is not publicly available to provide similar services to those of their business users."

does not forbid I_1 from collecting data on the publishers it serves as an intermediary. Hence, if I_1 distributes exclusively P_1's impressions, consumer data generated on its domain would still be available exclusively to I_1. By itself, the policy would be ineffective in restoring the VS outcomes and the same equilibrium outcome as in Section 4.1.2 occurs.

Prohibiting exclusive access to ad inventories. Firms that run ecosystems tend to bundle multiple services together. For instance, to place ads on Youtube, advertisers must use Google's adtech services. Accordingly, we assumed that in the VI scenario only I_1 can distribute the impressions generated on P_1. A possible regulatory intervention is to ban this exclusivity. Suppose, however, that the integrated firm maintains exclusive access to consumer data generated on P_1.[23] The willingness to pay for impressions auctioned by I_1 on P_1 would be the same as in Section 4.1.2. The main difference is that now the integrated I_1 cannot observe which ads a multi-homing consumer is exposed to when visiting P_1, if those ads are served by I_2. Hence, we have $w_p^1 = v(\theta)(1 - \delta_{-p}^2)$ for any impression that is not repeated, where δ_{-p}^2 is the share of impressions on multi-homers visiting $-p$ that the advertiser acquires via I_2. Nevertheless, I_1 still retains the main information advantages with respect to I_2, as the latter is unable to track consumers across outlets. As we show in Appendix A.4, the equilibrium has the same features as in our baseline model: the integrated firm monopolizes the ad market and imposes an adtech tax on impressions on P_2.

Combining the above policies. Suppose now that the regulator forbids exclusive access to P_1's ad inventory to the integrated intermediary *and* ensures that each intermediary serving such ads can collect consumer information on that domain. In this case, the intermediaries are effectively on a level playing field, as in the VS scenario. Each intermediary can control the frequency of impressions on both publishers and thus maximize their value to the advertisers. It can be easily shown that, under these conditions, the same market equilibrium as in the VS scenario would emerge.

Proposition 5 (Policy interventions) *Prohibiting the combination of datasets inside the ecosystem does not change the market outcome under vertical integration. Combining this intervention with a prohibition on exclusive access to ad inventories within the ecosystem allows to restore the market outcome under vertical separation.*

To summarize, applying measures preventing data sharing *within* the ecosystem is not effective on its own. Similarly, removing exclusive access to ad inventories is not

[23] This could be the result of a strict privacy policy by the ecosystem. For instance, Google recently launched the Privacy Sandbox initiative, with the intent of phasing out third-party cookies. These cookies are essential for third-party intermediaries to provide targeted advertising and collect data on campaign performance.

effective if the ecosystem retains exclusive control of the consumer data generated on its own websites. To be effective, these measures should be adopted jointly. Our findings thus point to increased data sharing *across* ecosystems as a way of inducing the same market outcomes as in the VS regime.

The analysis also highlights a trade-off between, on one side, restoring a level playing field in the adtech and content markets and, on the other side, the protection of consumer privacy. The latter could be significantly more difficult with greater data sharing across ecosystems. Stricter privacy rules that limit data access to rival intermediaries can result in a higher adtech tax, to the benefit of large integrated platforms and to the detriment of third-party publishers and third party intermediaries. This observation also speaks to the ongoing debate on the impact of privacy regulation such as the GDPR (Dubé et al., 2025).[24]

Finally, the analysis points to two caveats regarding any policy intervention designed to restrain the market power of integrated ecosystems: first, even if the policy is successful in restoring the VS market outcomes, it would not address the underinvestment in content quality by the publishers (see Section 5). Moreover, such policies would most likely have a negative effect on the investment in quality by the integrated firm. These caveats suggest that any policy intended to address the imbalances on the adtech market would have to be complemented by policies aimed at stimulating quality investment.

7 Extensions

7.1 Competition among ecosystems

Faced with market monopolization by the integrated firm, the independent publisher (P_2) and intermediary (I_2) may decide to merge and form a competing ecosystem.[25] We now briefly evaluate the effects of such a merger.

Suppose that these two firms become a single entity and retain the assumption that each publisher p makes its impressions and the data generated in its domain available only to the integrated intermediary. Assume also that each intermediary cannot observe which ads are being served to a consumer if these are delivered by the other intermediary. Hence, neither is able to track consumers across outlets. As a result, the willingness to pay of any advertiser in a given market for any impression auctioned by I_i on its integrated publisher is

$$w_p^i = zv(\theta)\left(1 - \frac{D_{12}}{D_2 + D_{12}}\delta_{-p}^{-i}\right), \quad \forall p, i \tag{16}$$

where δ_{-p}^{-i} is the share of impressions acquired on the other integrated firm. This indicates

[24]For more discussion on this topic see recent works such as Peukert et al. (2020), Choi et al. (2023), Lefrere et al. (2025), Choe et al. (2025), Sharma et al. (2025) among others.

[25]This can be seen as a form of Private Exchange as discussed in Choi and Sayedi (2023).

that impressions on the two publishers are perceived as substitutes by the advertisers. Hence, as we show in Appendix A.6, the equilibrium is such that advertisers place winning bids on only one integrated chain (in other words, they single-home at the ecosystem level). No advertiser acquires impressions on both publishers. Given $\delta_{-p}^{-i} = 0$, we have

$$\overline{b}_p^i = zv(\theta), \quad \forall p, i. \tag{17}$$

Comparing this expression to (4) and to $\overline{b}_p^1(VI) = v(\theta)$, for $p \in \{1, 2\}$, we see two main differences. First, there is no risk of repetition on P_2, which has a positive effect on the advertisers' valuation for impressions auctioned by I_2. On the other hand, both I_1 and I_2 now suffer from a loss in precision when identifying the consumers' types, as they cannot access each other's data. This reduces the advertisers' expected return for impressions. Thus, the merger eliminates the adtech tax on P_2's impressions, but also reduces the overall advertising surplus.

The equilibrium total profit of the two ecosystems are

$$\pi_1^1 = zv(D_1 + D_{12}) - k_1(q_1), \quad \pi_2^2 = zv(D_2 + D_{12}) - k_2(q_2). \tag{18}$$

Again, the advertisers make zero profit. Considering the profits under VS and VI (see (5), (7) and (8)), these expressions show that, overall, the merger reduces the total profit of firm 1, but increases the aggregate profit of P_2 and I_2. The first-order conditions derived from the above expressions imply that the investment by firm 1 is smaller than in both scenarios. However, investment by firm 2 is now larger than under VI, though still smaller than under VS. We summarize these results in the following Proposition.

Proposition 6 (Merger and competing ecosystems.) *A merger between I_2 and P_2 eliminates the adtech tax and increases the total revenue of both firms, but reduces the total advertising surplus for given quality levels. The merger also increases quality investment by P_2, compared to VI, but reduces investment by P_1. Overall, therefore, the net effect on welfare is ambiguous.*

This result indicates that mergers between (large) independent publishers and intermediaries can be a viable strategy to counterbalance the power of the integrated ecosystem. The merging firms would increase their joint profit, not only by reducing the size of the adtech tax, but also by making greater quality investment viable, expanding the audience of publisher P_2.

7.2 Direct Contracting between publishers and intermediaries

We have so far assumed that the publishers make their impressions available to the intermediaries via auctions. Although this is a common practice, a possible alternative for larger publishers is to award to an intermediary an exclusive contract for their ad inventories, in exchange for part of the revenue collected.[26] We now evaluate whether P_2 can eliminate or reduce the adtech tax by switching to this strategy.[27]

Assume that after stage 1 each intermediary can make a take-it-or-leave-it offer to P_2 for its entire ad inventory, in exchange for a lump-sum payment (this could also be formulated as a fixed share of the revenue per-impression). We suppose without loss that the offers are sequential, with I_1 presenting its offer first. If P_2 rejects both offers, the game then develops as in the VI scenario analyzed in Section 4.

Proceeding backwards, consider the offer by I_2. We know from Proposition 2 that I_2 would earn zero profit if this offer was rejected, because then the game would unfold as in the baseline model. Instead, if I_2 gets to distribute P_2's impressions exclusively (as in the case of competing vertical structures analyzed in Section 7.1), each intermediary would distribute the impressions of only one publisher, so neither would have access to the data generated by consumers on the other. Hence, the equilibrium bids collected by the intermediaries for each impression would be equal to (17), and I_2's profit would equal $zv(D_2 + D_{12})$, as in (18). This is the maximum amount that I_2 would offer to P_2 for its ad inventory. Noting that this amount exceeds the revenue that P_2 gains in the baseline setting under VI (see Proposition 2), we conclude that, P_2 would strike an agreement with I_2 if failing to reach an agreement with I_1.

Consider now the offer that I_1 would be willing to make. Should its offer be rejected, I_1 would earn the same revenue, $zv(D_1+D_{12})$, as in (18), because then I_2 would distribute P_2's impressions, as we have just established. However, if I_1 obtains the exclusive control of those impressions, it can extract the same bids from the advertisers as in the VI scenario of the baseline model (see Lemma 4). Hence, it would earn a total revenue $R^1 = v(D_1+D_2+2D_{12})$. It follows that I_1 would be willing to offer as much as $R^1 - R_1 = v(D_2 + D_{12}) + v(1-z)(D_1 + D_{12})$ to P_2. This exceeds the amount that I_2 is willing to offer, $zv(D_2 + D_{12})$. Hence, in equilibrium I_1 still acquires all P_2's impressions.

We have thus established that, as in the baseline model, the integrated firm monopolizes the adtech market. However, to acquire P_2's impressions, this firm would have to pay as much as I_2 is willing to pay, i.e., $R_2^d = zv\,(D_2 + D_{12})$. Comparing this to P_2's revenue in the VI scenario (see Proposition 2) indicates that the adtech tax would be smaller. The intuition is that, with direct contracting, the advertisers who place ads on P_2 do not acquire any impression on the other publisher, and thus do not discount the impressions auctioned by I_2 due to the risk of repetition. A direct consequence of the

[26]For an example of these agreements, see the conditions offered by Google's AdSense (https://support.google.com/adsense/answer/180195?hl=en).

[27]In principle, P_2 could also run auctions for its impressions but send bid requests to a single intermediary. In our setting, this alternative is dominated because, without a competitor, the intermediary would bid zero for the impressions (recall that P_2 has no visibility on the bids collected by the intermediary).

reduction in the adtech tax is that quality investment by P_2 increases.[28]

Proposition 7 (Direct contracting.) *Suppose P_2 allocates its impressions via exclusive contracts with the intermediaries. In equilibrium, I_1 distributes the ads exclusively and P_2 gains $R_2^d = zv\left(D_2 + D_{12}\right)$. Compared to the VI scenario, the adtech tax imposed on P_2's impressions is reduced, though not fully eliminated. Moreover, q_2 is higher, though q_1 decreases.*

7.3 Reserve prices by the publishers

As we have seen, the integrated firm is able to extract the adtech tax on P_2's impressions because, due to its informational disadvantage, I_2 is unable to generate high enough bids to compete. Recognizing the integrated firm's ability to shade its bids, the publisher could respond by setting a reserve price for its impressions. Accordingly, let us assume that the publishers can set a reserve price r_p in the auctions at Stage 4.

Given Proposition 1, the publishers have no use for r_p under VS as they obtain the full value, $v(\theta)$, for every impression.[29] In the VI scenario, though, there is potentially scope for P_2 to impose a reservation price and alleviate the adtech tax imposed by I_1. We analyze this setup in Appendix A.5, and present here the main results. Although the reserve price r_2 can increase the revenue captured by P_2 for each impression, its effectiveness is limited by the fact that P_2 cannot observe the realization of θ or $v(\theta)$ in each ad market, nor the outcome of the auctions run by either intermediary. Hence, the publisher must apply the same reserve price to all markets, which makes this instrument too blunt to fully remove the adtech tax. Even in ad markets where r_2 is binding (i.e., $r_2 > \overline{B}_2(VI) = zv(\theta)\left(1 - \frac{D_{12}}{D_2+D_{12}}\frac{1}{n}\right)$), it is still below the top bid received by I_1, which equals $v(\theta)$. Therefore, we find that Propositions 2 and 3 continue to hold qualitatively.

8 Concluding remarks

We studied how integration between an adtech intermediary and a major digital publisher affects the online advertising market and the quality of digital content. We have shown that integration enables the intermediary to leverage exclusive access to data to monopolize the intermediation market and impose an adtech tax on independent publishers. We explored the relation between the adtech tax and investment in content by publishers, demonstrating that the independent publisher invests less, while the integrated firm invests more. The net effect of integration on consumer surplus and welfare was found to be

[28] As for firm 1's quality investment, its revenues are $R1^d = v\left(D_1 + D_2 + 2D_{12}\right) - zv\left(D_2 + D_{12}\right) = v\left(D_1 + D_{12}\right) + (1-z)v\left(D_2 + D_{12}\right)$. Because $\left(D_2 + D_{12}\right)$ is independent of q_1, we can conclude that the investment in quality is the same as under VS, and thus lower than with VI.

[29] Similarly, I_1 and I_2 have no need for reserve prices, as they extract the full willingness to pay from the advertisers in both scenarios.

ambiguous. The analysis provides a foundation for the adtech tax, suggesting that this tax is directly related to vertical integration and to the informational advantage conferred to the integrated firm by consumer and advertiser multi-homing.

Using the insights from our findings, in the following we present the main managerial and policy implications of the analysis.

8.1 Managerial Implications

Propositions 2 and 3 characterized an interesting relation between investment in content quality and the adtech tax. This has implications for content strategy, not just in terms of the investment in quality, but also in terms of which type of content to prioritize. For the integrated firm, investment in quality is a means to extract more revenue from ad intermediation, by increasing the share of multi-homers. Although the adtech tax may discourage the independent publishers from investing in quality overall, these publishers should prioritize content that attracts and retains single-homers, as doing so should reduce the adtech tax. Examples include content that enables them to retain time-constrained users on their platforms. This objective may also be achieved by prioritizing content differentiation and variety.

We also found that the independent publisher and intermediary may benefit from merging to compete with the integrated ecosystem (Proposition 6). This merger would reduce the size of the adtech tax and stimulate investment in quality of the newly integrated entity, thereby expanding its audience. However, we also found that this merger would reduce the effectiveness of ad campaigns, as it would reduce the extent to which the intermediaries can combine information from multiple publishers and track consumers. As a result, a possible consequence is an overall reduction in the profits from advertising.

The independent publisher may reduce the adtech tax also by contracting directly with the intermediaries, rather than relying on the automated segment of the advertising market (Proposition 7). As in the case of a merger, this would result in higher quality investment by the independent publisher, and less investment by the integrated firm, thereby decreasing the quality gap in the market. This strategy may be more easily implementable than pursuing a merger with the intermediary. However, direct contracting would still imply that the integrated firm monopolizes the market. Hence, this strategy does not benefit the independent intermediary, suggesting that this firm would be better off pursuing a strategy of downstream integration in the content market, possibly by acquiring a major publisher.

Finally, our findings indicate that independent publishers and intermediaries should support policies that allow data sharing across firms. Moreover, they should support tougher policies that tackle self-preferencing (implemented through exclusivity or bundling) inside the competing ecosystem, to establish a level playing field in the adtech sector.

8.2 Policy implications

Our analysis informs the current debate on regulating ecosystems and dominant firms to foster competition in the digital market. This regulation may have the added benefit of stimulating investment in quality by independent publishers, but it may also reduce the investment of the integrated firm (Proposition 3). Seen from this perspective, its effect on social welfare depends on the relative size of the publishers' audiences and the magnitude of changes in investment. Hence, policies aiming to correct imbalances in the adtech sector may need to be accompanied by policies that stimulate investment in quality, because quality is undersupplied even in the VS scenario (Section 5).

If the goal is to level the playing field in the adtech market, we have found that policies that just prohibit the transfer of data among different services within an ecosystem (see, e.g., the provisions in the DMA (2022)) would be ineffective. These provisions could easily be circumvented by the integrated firm through applying self-preferencing and exclusivity. Similarly, prohibiting self-preferencing by itself would also be insufficient. To effectively level the playing field, a regulation prohibiting self-preferencing should be accompanied with ensuring equal access by competing intermediaries to the data generated by consumers on all publishers (Proposition 5). This finding points to a tension between protecting consumer privacy and correcting the current imbalances in the adtech and content markets. Also, it suggests that ecosystems such as Google may support the adoption of stricter privacy rules as a means to entrench their competitive advantage.

Proposition 6 offers some interesting implications for merger policy, suggesting that a merger between independent publishers and intermediaries can foster competition in the adtech sector, by providing an alternative to existing dominant ecosystems. However, this may reduce total advertising surplus, by limiting the intermediaries' ability to track consumers across outlets. As an alternative, a regulator may discourage the publishers from relying on automated auctions as a channel to sell impressions, encouraging direct contracting with the intermediaries instead. As we have seen, while this policy reduces the adtech tax and stimulates investment by the non-integrated publishers, it would not overturn the monopolization of the market by the integrated firm.

References

ACCC (2019) "Digital Platforms Inquiry," Australian Competition and Consumer Commission Inquiry.

Amaldoss, Wilfred and Jinzhao Du (2023) "How can publishers collaborate and compete with news aggregators?" *Journal of Marketing Research*, 60 (6), 1114–1134.

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 (3), 189–222.

Aridor, Guy, Yeon-Koo Che, Brett Hollenbeck, Daniel McCarthy, and Maximilian Kaiser (2024) "Evaluating the impact of privacy regulation on e-commerce firms: Evidence from apple's app tracking transparency."

Athey, Susan, Emilio Calvano, and Joshua S Gans (2018) "The impact of consumer multihoming on advertising markets and media competition," *Management science*, 64 (4), 1574–1590.

Bergemann, Dirk, Alessandro Bonatti, and Nicholas Wu (2025) "Bidding with budgets: Data-driven bid algorithms in digital advertising," *International Journal of Industrial Organization*, 103172, https://doi.org/10.1016/j.ijindorg.2025.103172.

Bolton, Patrick and Michael D Whinston (1991) "The" foreclosure" effects of vertical mergers," *Journal of Institutional and Theoretical Economics (JITE)/Zeitschrift für die gesamte Staatswissenschaft*, 147 (1), 207–226.

Cairncross, Frances (2019) "The Cairncross Review: a sustainable future for journalism," UK Department for Digital, Culture, Media and Sport.

Carroni, Elias, Leonardo Madio, and Shiva Shekhar (2023) "Superstar exclusivity in two-sided markets," *Management Science*.

Choe, Chongwoo, Noriaki Matsushima, and Shiva Shekhar (2025) "The bright side of the GDPR: Welfare-improving privacy management," *Management Science*, 71 (8), 6836–6858.

Choi, W Jason, Kinshuk Jerath, and Miklos Sarvary (2023) "Consumer privacy choices and (un) targeted advertising along the purchase journey," *Journal of Marketing Research*, 60 (5), 889–907.

Choi, W Jason and Amin Sayedi (2023) "Open and private exchanges in display advertising," *Marketing Science*, 42 (3), 451–475.

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

Decarolis, Francesco, Tommaso Pellegretti, Gabriele Rovigatti, Michele Rovigatti, and Ksenia Shakhgildyan (2024) "Algorithmic Competition and Informational Advantage in Digital Markets: Evidence from Search Auctions."

Decarolis, Francesco, Gabriele Rovigatti, Michele Rovigatti, and Ksenia Shakhgildyan (2023) "Artificial Intelligence Data Obfuscation: Algorithmic Competition in Digital Ad Auctions," https://ssrn.com/abstract=4660391.

Despotakis, Stylianos, Ramamoorthi Ravi, and Amin Sayedi (2021) "First-price auctions in online display advertising," *Journal of Marketing Research*, 58 (5), 888–907.

DMA (2022) "Digital Market Act, Regulation (EU) 2022/1925," https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R1925.

DSA (2022) "Digital Service Act, Regulation (EU) 2022/2065," https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R2065.

Dubé, Jean-Pierre, John G. Lynch, Dirk Bergemann et al. (2025) "Frontiers: The Intended and Unintended Consequences of Privacy Regulation for Consumer Marketing," *Marketing Science*, 0 (0), null, 10.1287/mksc.2024.0901.

D'Annunzio, Anna (2017) "Vertical integration in the TV market: Exclusive provision and program quality," *International Journal of Industrial Organization*, 53, 114–144.

D'Annunzio, Anna and Antonio Russo (2020) "Ad networks and consumer tracking," *Management Science*, 66 (11), 5040–5058.

——— (2023) "Intermediaries in the online advertising market," *Marketing Science*, 43 (1), 33–53.

European Parliament (2016) "General Data Protection Regulation," Regulation 2016/679.

Gordon, Brett R, Kinshuk Jerath, Zsolt Katona, Sridhar Narayanan, Jiwoong Shin, and Kenneth C Wilbur (2021) "Inefficiencies in digital advertising markets," *Journal of Marketing*, 85 (1), 7–25.

Hart, Oliver, Jean Tirole, Dennis W Carlton, and Oliver E Williamson (1990) "Vertical integration and market foreclosure," *Brookings papers on economic activity. Microeconomics*, 1990, 205–286.

IAB (2017) "IAB Europe Report: European Programmatic Market Sizing 2017," available at https://iabeurope.eu/research-thought-leadership/iab-europe-report-european-programmatic-market-sizing-2017/.

Jullien, Bruno, Markus Reisinger, and Patrick Rey (2023) "Personalized pricing and distribution strategies," *Management Science*, 69 (3), 1687–1702.

Latham, Oliver, Mikaël Hervé, and Romain Bizet (2021) "Antitrust concerns in Ad-Tech: formalizing the combined effect of multiple conducts and behaviours," *European Competition Journal*, 17 (2), 353–390.

Lefrere, Vincent, Logan Warberg, Cristobal Cheyre, Veronica Marotta, and Alessandro Acquisti (2025) "Does privacy regulation harm content providers? a longitudinal analysis of the impact of the gdpr," *Management Science*.

Levin, J. and P. Milgrom (2010) "Online Advertising: Heterogeneity and Conflation in Market Design," *American Economic Review*, 100, 603–07.

Marotta, Veronica, Yue Wu, Kaifu Zhang, and Alessandro Acquisti (2022) "The welfare impact of targeted advertising technologies," *Information Systems Research*, 33 (1), 131–151.

Mathewson, G Frank and Ralph A Winter (1987) "The competitive effects of vertical agreements: Comment," *The American Economic Review*, 77 (5), 1057–1062.

Ordover, Janusz A, Garth Saloner, and Steven C Salop (1990) "Equilibrium vertical foreclosure," *The American Economic Review*, 127–142.

Peukert, Christian, Stefan Bechtold, Michail Batikas, and Tobias Kretschmer (2020) "European privacy law and global markets for data," *Center for Law & Economics Working Paper Series*, 1.

Rafieian, Omid and Hema Yoganarasimhan (2021) "Targeting and Privacy in Mobile Advertising," *Marketing Science*, 40 (2), 193–218, 10.1287/mksc.2020.1235.

Sayedi, Amin (2018) "Real-Time Bidding in Online Display Advertising," *Marketing Science*, 37, 553–568, 10.1287/mksc.2017.1083.

Segal, Ilya R and Michael D Whinston (2000) "Naked exclusion: comment," *American Economic Review*, 91 (1), 296–309.

Sharma, Priyanka, Yidan Sun, and Liad Wagman (2025) "The Effects of Privacy Protections on Publishers in Digital Ad Markets,"Technical report, Working Paper, Illinois Institute of Technology.

Spector, David (2011) "Exclusive contracts and demand foreclosure," *The RAND Journal of Economics*, 42 (4), 619–638.

Stigler Committee on Digital Platforms (2019) "Final Report," https://research.chicagobooth.edu/stigler/media/news/committee-on-digital-platforms-final-report.

Weeds, Helen (2016) "TV wars: Exclusive content and platform competition in pay TV," *The Economic Journal*, 126 (594), 1600–1633.

Witte, Alexander and Jan Kraemer (2023) "The Open Display Advertising Ecosystem: Competition Concerns and Policy Interventions."

Witte, Alexander and Jan Krämer (2025) "Evaluating structural and behavioral remedies for anticompetitive conducts in the ad tech ecosystem," *Telecommunications Policy*, 49 (5), 102955, https://doi.org/10.1016/j.telpol.2025.102955.

Zeithammer, Robert and W Jason Choi (2024) "Auctions of Auctions," *Management Science*.

A Proofs Omitted in the Text

A.1 Proof of Lemma 2 (bids under vertical separation)

We determine the equilibrium allocation and prices of impressions for a given advertising market. The equilibrium is isomorphic in all markets, so we can just focus on a single market.

STEP 1: We denote advertiser k's willingness-to-pay for an impression on publisher p delivered by intermediary i as $w^i_{p,k}$. If the impression falls on a single-homer, then $w^i_{p,k} = v(\theta)$. This holds for any k, so $\overline{b}^i_p = \overline{B}^i_p = v(\theta)$. Consequently, the advertisers cannot make any profit from such impressions.

STEP 2: Focus now on impressions on multi-homers. k has $w^i_{p,k} = v(\theta)(1-\delta^{-i}_{-p,k})$, for any non-repeated impression auctioned by i on p, where $\delta^{-i}_{-p,k}$ is the share of impressions k acquires through $-i$ on $-p$. We can have $\delta^{-i}_{-p,k} > 0$ only if $w^{-i}_{-p,k} \geq w^{-i}_{-p,-k}$ for all $-k \neq k$. That is, k has the highest WTP (possibly tied with other advertisers). Suppose this holds and let $n^m \in [1, n]$ be the number of advertisers for which $w^{-i}_{-p,k} = w^{-i}_{-p,-k}$, including k, and suppose $n > n^m$. The other $n - n^m$ advertisers get $\delta^{-i}_{-p} = 0$ and so must have $w^i_p = v(\theta)$ for any non-repeated impression by i on p. Given $\delta^{-i}_{-p,k} > 0$, this WTP exceeds that of k, $w^i_{p,k} = v(\theta)(1 - \delta^{-i}_{-p,k})$. It is thus impossible to have $\delta^i_{p,k} > 0$ and $\delta^{-i}_{-p,k} > 0$. Suppose now that $n^m = n$. This can only hold if $\delta^i_{p,k} = \delta^{-i}_{-p,k} = \frac{1}{n}$, and $w^i_{p,k} = w^{-i}_{-p,k} = v(\theta)\left(1 - \frac{1}{n}\right)$, for any k. Any advertiser could profitably deviate by bidding $v(\theta)\left(1 - \frac{1}{n}\right) + \epsilon$ for impressions on p and zero on $-p$. We conclude that there cannot be equilibria where any advertiser acquires ads on multi-homing consumers on both publishers via different intermediaries.

STEP 3: Given the previous step, we restrict attention to equilibrium candidates such that each advertiser acquires impressions on multi-homers only via a single intermediary. Given a large number of advertisers ($n \geq 6$), all these candidates must be such that at least 3 advertisers acquire ads on multi-homers via one intermediary, I_i. Therefore, at least 2 advertisers have $w^i_p = v(\theta)$ for each impression auctioned by i, so $\overline{b}^i_p = v(\theta)$. Hence, none of the advertisers that acquire ads via i make any profit on such impressions. The advertisers who acquire impressions via $-i$ must be paying v as well (otherwise, $\overline{b}^i_p = v > \overline{b}^{-i}_p$), and thus make zero profit. Combining these observations with Step 1, we conclude that in all the candidate equilibria the advertisers make zero profit.

STEP 4: Consider now an equilibrium candidate where any advertiser acquires ads on multi-homers from a single publisher. The advertiser must have WTP of v. Hence, if the price of these impressions is less than $v(\theta)$, there is a profitable deviation for at least one advertiser. Thus, any equilibrium candidate of this kind must also be such that the advertisers make no profit.

STEP 5: We can rule out all equilibria where advertisers use a different intermediary to acquire impressions on single-homers to the intermediary used for impressions on multi-homers. Given they make zero profit, in any such equilibrium the advertisers would prefer to deviate and acquire all impressions via a single intermediary by assumption (i).

STEP 6: We rule out equilibria where $\tilde{n} < 3$ advertisers acquire their impressions from the same intermediary, i. In these equilibrium candidates, intermediary $-i$ must sell all its impressions at price $v(\theta)$, so if some advertisers acquire their impressions via i, $\overline{b}_p^i = \overline{b}_p^{-i} = v(\theta)$ must hold. Because all advertisers have the same WTP for non-repeated impressions, $v(\theta)$, each advertiser acquiring impressions via $-i$ (resp., via i) would receive a share $\delta_p^{-i} = \frac{1}{2}\frac{1}{n-\tilde{n}}$ (resp., $\delta_p^i = \frac{1}{2}\frac{1}{\tilde{n}}$). Hence, an advertiser on $-i$ can deviate by bidding $v(\theta)$ for the impressions auctioned by i and zero on $-i$. The advertiser would earn the same profit but obtain a share $\delta_p^i = \frac{1}{2}\frac{1}{\tilde{n}+1}$ of impressions. Since $n \geq 6$ and $\tilde{n} < 3$, we have $\tilde{n} + 1 < n - \tilde{n}$. So the deviation is profitable by assumption (iii).

STEP 7: We have thus shown that, under our assumptions, any equilibrium must be such that at least three advertisers place a bid $v(\theta)$ for all impressions marketed by I_1 and I_2. The lemma follows.

A.2 Proof of Lemma 4 (bids under vertical integration)

We determine the equilibrium allocation and prices of impressions for a given advertising market. Because the equilibrium is isomorphic in all markets, we can just focus on a single one.

STEP 1: We denote advertiser k's willingness-to-pay for an impression on publisher p delivered by intermediary i as $w_{p,k}^i$. Suppose the impression is auctioned by I_1 and falls on a single-homer. Then $w_{p,k}^1 = v(\theta)$ for any k and so $\overline{b}_p^1 = v(\theta)$. Consequently, the advertisers make zero profit from such impressions.

STEP 2: Focus now on impressions on multi-homers auctioned by I_1 on P_1 and impressions auctioned by I_2 on P_2 (which cannot be distinguished between single- and multi-homers). Advertiser k has WTP $w_{2,k}^2 = v(\theta)z\frac{D_2}{D_2+D_{12}} + v(\theta)z\frac{D_{12}}{D_2+D_{12}}(1-\delta_{1,k}^1)$ for any impression auctioned by I_2. We can have $\delta_{2,k}^2 > 0$ only if $w_{2,k}^2 \geq w_{2,-k}^2$ for all $-k \neq k$. That is, k has the highest WTP (possibly tied with other advertisers) for these impressions. Suppose this holds and let $n^m \in [1, n]$ be the number of advertisers for which $w_{2,k}^2 = w_{2,-k}^2$, including k. Suppose also that $n > n^m$. The $n - n^m$ remaining advertisers get $\delta_2^2 = 0$. Hence, they have $w_1^1 = v(\theta)$ for non-repeated impressions on multihomers auctioned by I_1 on P_1. Given $\delta_{2,k}^2 > 0$, this WTP exceeds that of k, $w_{1,k}^1 = v(\theta)\left(1 - \delta_{2,k}^2\right)$, for those impressions. It is thus impossible to have $\delta_{1,k}^1 > 0$ and $\delta_{2,k}^2 > 0$. Suppose now that $n^m = n$. This can only hold if $\delta_{1,k}^1 = \delta_{2,k}^2 = \frac{1}{n}$, and $w_{1,k}^1 = v(\theta)\left(1 - \frac{1}{n}\right)$ and $w_{2,k}^2 = zv(\theta)\left(1 - \frac{D_{12}}{D_2+D_{12}}\frac{1}{n}\right)$, for any k. Any advertiser could profitably deviate, for instance, by bidding slightly more than $v(\theta)\left(1 - \frac{1}{n}\right)$ for the impressions on P_1 and zero for the others. We conclude that there cannot be equilibria where any advertiser acquires impressions on multi-homers on P_1 and impressions auctioned by I_2.

STEP 3: We now show that, whenever $z < 1$, there cannot be an equilibrium where any advertiser acquires impressions auctioned by I_2. Suppose $\tilde{n}$ advertisers acquire some impressions via I_2. Consider first the case where $\tilde{n} \geq 2$. We know from Step 2 that these advertisers cannot acquire impressions on multi-homers on P_1, i.e., $\delta^1_{1,k} = 0$ for any advertiser k in this group. This implies that these advertisers have $w^1_{2,k} = v(\theta)$ for any impression on P_2 auctioned by I_1, as these cannot be repeated. Hence, we have $\bar{b}^1_2 = v(\theta)$ as there are at least two advertisers willing to bid as much. Now, given $\delta^1_{1,k} = 0$, these advertisers also have WTP $w^2_{2,k} = zv(\theta)\frac{D_2}{D_2+D_{12}} + zv(\theta)\frac{D_{12}}{D_2+D_{12}} < v(\theta)$ for impressions auctioned by I_2, so $\bar{b}^2_2 = zv(\theta)\frac{D_2}{D_2+D_{12}} + zv(\theta)\frac{D_{12}}{D_2+D_{12}} < v(\theta)$. It follows that I_2 cannot in fact distribute any of the impressions on P_2, as it is not willing to pay for any such impression is smaller than that of I_1. This contradicts our initial assumption. Suppose now that $\tilde{n} = 1$. Given $n - \tilde{n} \geq 5$ advertisers only acquire impressions via I_1 by assumption, this intermediary must receive $\bar{b}^1_p = v(\theta)$ for any impression. Again, this is because there are at least two advertisers willing to bid as much for any impression auctioned by I_1. This value exceeds $zv(\theta)\frac{D_2}{D_2+D_{12}} + zv(\theta)\frac{D_{12}}{D_2+D_{12}}$, so by the same reasoning as above we conclude that I_2 cannot distribute any impression.

We can thus conclude that any equilibrium must be such that all advertisers acquire impressions only via I_1. Given $\delta^2_{2,k} = 0$ for any of these advertisers, they have $w^1_2 = w^1_1 = v(\theta)$ for any non-repeated impression auctioned by I_1. Therefore, $\bar{b}^1_p = v(\theta)$, $\forall p$.

A.3 Proof of Proposition 3

Under the VS scenario, the quality levels $q_p(VS)$ chosen by platform p solve the following first-order conditions:

$$\frac{\partial \pi_p(VS)}{\partial q_p} = v\left(\frac{\partial D_p}{\partial q_p} + \frac{\partial D_{12}}{\partial q_p}\right) - \frac{\partial k_p(q_p)}{\partial q_p} = 0, \quad p \in \{1, 2\}. \tag{19}$$

Consider now the VI scenario. The first-order condition that characterizes q_1 in the VI scenario is

$$\frac{\partial \pi_1(VI)}{\partial q_1} = v\left(\frac{\partial D_1}{\partial q_1} + \frac{\partial D_{12}}{\partial q_1}\right) + vz\frac{1}{n}\frac{\partial D_{12}}{\partial q_1} - \frac{\partial k_1(q_1)}{\partial q_1} = 0. \tag{20}$$

Then, the first-order conditions that characterize q_2 are

$$\frac{\partial \pi_2(VI)}{\partial q_2} = zv\left(\frac{\partial D_2}{\partial q_2} + \frac{\partial D_{12}}{\partial q_2}\right) - zv\frac{1}{n}\frac{\partial D_{12}}{\partial q_2} - \frac{\partial k_2(q_2)}{\partial q_2} = 0. \tag{21}$$

The equilibrium qualities $q_p(VI)$ solve the system of (20) and (21).

Observe that, given $\frac{\partial (D_p + D_{12})}{\partial q_{-p}} = 0$, the terms in (19) do not depend on the quality set by the other publisher, q_{-p}.

The first-order condition (20) contains an extra positive term compared to (19) in the VS scenario. Hence, we conclude that $q_1(VS) < q_1(VI)$. Then, the first-order condition (21) contains an extra negative term compared to (19) in the VS scenario. Moreover, the first term is multiplied by z. Hence, we conclude that $q_2(VS) > q_2(VI)$.

A.4 Characterizing the equilibrium without exclusive access to P_1's ad inventory in Section 6

We determine the equilibrium allocation and prices of impressions for a given advertising market. Because the equilibrium is isomorphic in all markets, we can just focus on a single one.

STEP 1: We denote advertiser k's willingness-to-pay for an impression on publisher p delivered by intermediary i as $w^i_{p,k}$. Suppose the impression is auctioned by I_1 and falls on a single-homer. Then $w^1_{p,k} = v(\theta)$ for any k and so $\overline{b}^1_p = v(\theta)$. As a result, I_2 can never bid more than this amount for such impressions. This implies that I_1 must distribute all impressions on single-homers in equilibrium, at a price of $v(\theta)$.

STEP 2: Focus now on impressions on multihomers auctioned by I_1 and impressions auctioned by I_2 (that are not distinguished by single- and multi-homers). Advertiser k has $w^1_{p,k} = v(\theta)(1 - \delta^2_{-p,k})$, for any non-repeated impression auctioned by I_1 on p, where $\delta^2_{-p,k}$ is the share of impressions k acquires through I_2 on $-p$. As for impressions auctioned by I_2, k has $w^2_{2,k} = v(\theta)z\frac{D_p}{D_p+D_{12}} + v(\theta)z\frac{D_{12}}{D_p+D_{12}}(1 - \delta^1_{1,k})$ for any impression auctioned by I_2 on publisher p. We can have $\delta^1_{-p,k} > 0$ only if $w^1_{-p,k} \geq w^1_{-p,-k}$ for all $-k \neq k$. That is, k has the highest WTP (possibly tied with other advertisers). Suppose this holds and let $n^m \in [1, n]$ be the number of advertisers for which $w^1_{-p,k} = w^1_{-p,-k}$, including k, and suppose $n > n^m$. The other $n - n^m$ advertisers get $\delta^1_{-p} = 0$ and so must have $w^2_p = zv(\theta)$ for any impression by 2 on p. Given $\delta^1_{-p,k} > 0$, this WTP exceeds that of k, $w^i_{p,k} = v(\theta)z\frac{D_p}{D_-p+D_{12}} + v(\theta)z\frac{D_{12}}{D_-p+D_{12}}(1 - \delta^1_{p,k})$. It is thus impossible to have $\delta^1_{p,k} > 0$ and $\delta^2_{-p,k} > 0$. Suppose now that $n^m = n$. This can only hold if $\delta^2_{p,k} = \delta^1_{-p,k} = \frac{1}{n}$, and $w^1_{p,k} = w^1_{-p,k} = v(\theta)\left(1 - \frac{1}{n}\right)$ while $w^2_{p,k} = w^2_{-p,k} = v(\theta)z\frac{D_p}{D_-p+D_{12}} + v(\theta)z\frac{D_{12}}{D_-p+D_{12}}(1 - \frac{1}{n})$ for any k. Any advertiser could profitably deviate by bidding $v(\theta)\left(1 - \frac{1}{n}\right) + \epsilon$ for impressions on p and zero on $-p$. We conclude that there cannot be equilibria where any advertiser acquires ads on both publishers via different intermediaries.

STEP 3: We now show that, whenever $z < 1$, there cannot be an equilibrium where any advertiser acquires impressions auctioned by I_2. Suppose $\tilde{n}$ advertisers acquire impressions via I_2. We know from Step 2 that these advertisers cannot acquire impressions on multi-homers on I_1, i.e., $\delta^1_{p,k} = 0$ for any advertiser k in this group. This implies that $w^1_{2,k} = v(\theta)$ for any impression on P_2 auctioned by I_1, as these cannot be repeated. It follows that, provided $\tilde{n} \geq 2$, we have $\overline{b}^1_2 = v(\theta)$. Now, given $\delta^1_{1,k} = 0$, these advertisers also have WTP $w^2_{2,k} = zv(\theta)\frac{D_2}{D_2+D_{12}} + zv(\theta)\frac{D_{12}}{D_2+D_{12}} < v(\theta)$ for impressions auctioned by

I_2, so $\overline{b}_2^2 = w_{2,k}^2$. It follows that I_2 cannot in fact distribute any of the impressions on P_2, which contradicts our initial assumption. If $\tilde{n} = 1$, given $n - \tilde{n} \geq 5$ advertisers only acquire impressions via I_1, this intermediary must receive $\overline{b}_p^1 = v$ for any impression, which again exceeds $w_{2,k}^2$.

We can thus conclude that any equilibrium must be such that all advertisers acquire impressions via I_1. Given $\delta_{p,k}^2 = 0$ for any of these advertisers, they have $w_2^1 = w_1^1 = v(\theta)$ for any non-repeated impression auctioned by I_1. Therefore, $\overline{b}_p^1 = v(\theta)$, $\forall p$. Moreover, given $\delta_{p,k}^1 = \frac{1}{n}$ for any advertiser, they all have equal willingness to pay of $v(\theta) z \frac{D_p}{D_{-p}+D_{12}} + v(\theta) z \frac{D_{12}}{D_{-p}+D_{12}}(1 - \frac{1}{n})$ for any impression on publisher p auctioned by I_2. This also equals the equilibrium price at which I_2 could sell any impression, and thus equals $\overline{B}^2$ for any p. We thus still find an adtech tax that increases with the share of multi-homers.

A.5 Reserve Price by the publishers

Consider a given ad market, θ. Given $v(\theta)$ and the equilibrium price of impressions on P_2 without the reservation price, r, which is $\overline{B}_2(VI) = zv(\theta)\left(1 - \frac{D_{12}}{D_2+D_{12}}\frac{1}{n}\right)$, the price conditional on $r \geq 0$ will be $zv(\theta)(1-m)$ if $r \leq zv(\theta)(1-m)$, and it will be r if $zv(\theta) \geq r > zv(\theta)(1-m)$, where we denote $m \equiv \frac{D_{12}}{D_2+D_{12}}\frac{1}{n})$ for convenience. No impression will be sold if $r > zv(\theta)$. Proposition 2 shows that, without the reservation price, P_2 expects to pay an adtech tax of $v(\theta)(1 - z(1-m))$ for every impression. Given $r_2 \geq 0$, the tax equals $v(\theta) - r$ for any impression whenever $r \leq v(\theta) < r/z(1-m)$ and $v(\theta)(1 - z(1-m))$ whenever $v^H \geq v(\theta) \geq r/z(1-m)$. Therefore, the Proposition still holds qualitatively.

In the following, let $G(v(\theta))$ be the cumulative distribution of advertising returns in each market. Given the reserve price, P_2's expected revenue, considering impressions in all markets, is as follows:

$$R_2 = \left(\int_r^{\frac{r}{z(1-m)}} r dG(v(\theta)) + z(1-m)\int_{\frac{r}{z(1-m)}}^{v^H} v dG(v(\theta))\right)(D_2 + D_{12}), \quad if \quad \frac{r}{z(1-m)} < v^H,$$

$$R_2 = \int_r^{v^H} r dG(v(\theta))(D_2 + D_{12}), \quad if \quad \frac{r}{z(1-m)} \geq v^H.$$

The profit-maximizing value of r for P_2 depends on the distribution $F(v)$. We do not establish this price but we are going to establish under which conditions, given r, Proposition 3 still holds.

Suppose first that $\frac{r}{z(1-m)} < v^H$. The profit of P_2 is

$$\pi_2 = \left(\int_r^{\frac{r}{z(1-m)}} r dG(v(\theta)) + z(1-m)\int_{\frac{r}{z(1-m)}}^{v^H} v dG(v(\theta))\right)(D_2 + D_{12}) - k_2 q_2.$$

Taking the derivative of this expression with respect to q_2 we find

$$\frac{\partial \pi_2}{\partial q_2} = \frac{\partial A}{\partial m}\frac{\partial m}{\partial q_2}(D_2 + D_{12}) + A\frac{\partial(D_2 + D_{12})}{\partial q_2} - k_2',$$

where $A \equiv \left(\int_r^{\frac{r}{z(1-m)}} rdF(v) + z(1-m)\int_{\frac{r}{z(1-m)}}^{v^H} vdG(v(\theta))\right)$ and

$$\frac{\partial A}{\partial m} = \frac{r}{z(1-m)^2}rg\left(\frac{r}{z(1-m)}\right) - \int_{\frac{r}{z(1-m)}}^{v^H} vdG(v(\theta)) +$$
$$-z(1-m)\frac{r}{z(1-m)^2}\frac{r}{z(1-m)}g\left(\frac{r}{z(1-m)}\right) = -\int_{\frac{r}{z(1-m)}}^{v^H} vdG(v(\theta)).$$

Compare this derivative to (6) and observe that $A < v$ and that and that $D_p + D_{12}$ does not depend on q_{-p}. Hence, $\frac{\partial m}{\partial q_2} > 0$ is sufficient for $q_2^{VS} > q_2^{VI}$. This condition holds, for example, if D_0 is small. As for the integrated firm, we have

$$\pi_1^1 = v(D_1 + D_{12}) + B(D_2 + D_{12}) - k_1 q_1,$$

where $B \equiv \int_r^{\frac{r}{z(1-m)}}(v - r)dG(v(\theta)) + zm\int_{\frac{r}{z(1-m)}}^{v^H} vdG(v(\theta))$ and

$$\frac{\partial B}{\partial m} = \frac{r}{z(1-m)^2}\frac{zrm}{z(1-m)}g\left(\frac{r}{z(1-m)}\right) + \int_{\frac{r}{z(1-m)}}^{v^H} vdG(v(\theta)) +$$
$$-\frac{zrm}{z(1-m)}\frac{r}{z(1-m)^2}g\left(\frac{r}{z(1-m)}\right) = \int_{\frac{r}{z(1-m)}}^{v^H} vdG(v(\theta)).$$

Taking the derivative of π_1^1 with respect to q_1 we get

$$\frac{\partial \pi_1}{\partial q_1} = v\frac{\partial(D_1 + D_{12})}{\partial q_1} + \frac{\partial B}{\partial m}\frac{\partial m}{\partial q_1}(D_2 + D_{12}) - k_1',$$

Comparing this expression to (6) and observing that $\frac{\partial m}{\partial q_1} > 0$ and that $\frac{\partial(D_p + D_{12})}{\partial q_{-p}} = 0$, we conclude that $q_1^{VS} < q_1^{VI}$.

Suppose now that $\frac{r}{z(1-m)} \geq v^H$, so that $\pi_2 = \int_r^{v^H} rdF(v)(D_2 + D_{12}) - k_2 q_2$. Differentiating this expression with respect to q_2, we get

$$\frac{\partial \pi_2}{\partial q_2} = \int_r^{v^H} rdG(v(\theta))\frac{\partial(D_2 + D_{12})}{\partial q_2} - k_2'.$$

Given $\int_r^{v^H} rdG(v(\theta)) < v$, when comparing this expression to (6), we obtain that $q_2^{VS} <$

q_2^{VI}. As for the integrated firm, we have

$$\pi_1^1 = v(D_1 + D_{12}) + \int_r^{v^H} (v - r) dG(v(\theta))(D_2 + D_{12}) - k_1 q_1.$$

Taking the derivative of this expression with respect to q_1 and comparing it to (6), we find that $q_1^{VS} < q_1^{VI}$.

A.6 Merger between P_2 and I_2

We determine the equilibrium allocation and prices of impressions for a given advertising market. Because the equilibrium is identical in all markets, to ease notation in the following we drop the argument θ from the advertising return.

STEP 1: We denote advertiser k's willingness-to-pay for an impression on publisher p delivered by the intermediary i, with $p = i$ in this scenario, as $w_{p,k}^i$. If the impression falls on a single-homer, then $w_{p,k}^i = zv$. If the impression falls on a multi-homer, then $w_{p,k}^i = vz(1 - \delta_{-p,k}^{-i})$. Given that both firms cannot distinguish between single-and multi-homers, the willingness to pay is described in expression (16), for any advertiser.

STEP 2: Given advertiser k has $w_{p,k}^i = vz\left(1 - \frac{D_{12}}{D_2+D_{12}}\delta_{-p}^{-i}\right)$, we can show that there cannot be an equilibrium where this advertiser places ads on both publishers. We can have $\delta_{-p,k}^{-i} > 0$ only if $w_{-p,k}^{-i} \geq w_{-p,-k}^{-i}$ for all $-k \neq k$. That is, k has the highest willingness-to-pay (possibly tied with other advertisers). Suppose this holds and let $n^m \in [1, n]$ be the number of advertisers for which $w_{-p,k}^{-i} = w_{-p,-k}^{-i}$, including k, and suppose $n > n^m$. The other $n - n^m$ advertisers get $\delta_{-p}^{-i} = 0$ and so must have $w_p^i = zv$ for any impression by i on p. Given $\delta_{-p,k}^{-i} > 0$, this WTP exceeds that of k, $w_{p,k}^i = zv\left(1 - \frac{D_{12}}{D_2+D_{12}}\delta_{-p}^{-i}\right)$. It is thus impossible to have $\delta_{p,k}^i > 0$ and $\delta_{-p,k}^{-i} > 0$. Suppose now that $n^m = n$. This can only hold if $\delta_{p,k}^i = \delta_{-p,k}^{-i} = \frac{1}{n}$, and $w_{p,k}^i = zv\left(1 - \frac{D_{12}}{D_2+D_{12}}\frac{1}{n}\right)$, for any k. Any advertiser could profitably deviate by bidding $zv\left(1 - \frac{D_{12}}{D_2+D_{12}}\frac{1}{n}\right) + \epsilon$ for impressions on p and zero on $-p$. We conclude that there cannot be equilibria where any advertiser acquires ads on via different intermediaries and publishers in this setting.

STEP 3: Given the above, the equilibrium must be such that bids submitted by any advertiser must be as in expression (17). Given $n > 5$ advertisers, we can also establish that these are also equal to the equilibrium prices of each impression on each firm. The revenues characterized in (18) follow.

STEP 4: Consider now Stage 1. Starting from (18), we can write the profit of each firm net of quality investment costs:

$$\pi_1^1 = zv(D_1 + D_{12}) - k_1(q_1), \quad \pi_2^2 = zv(D_2 + D_{12}) - k_2(q_2), \tag{22}$$

The equilibrium quality levels, that we denote by $\mathbf{q}(\mathbf{M}) \equiv (q_1(M), q_2(M))$ maximise the above expressions. When compared to compared to (5), (7) and (8), we can establish that $q_1(M) < q_1(VS) < q_1(VI)$ and $q_2(VI) < q_2(M) < q_2(VS)$.

B Analysis of the Examples

B.1 Independent consumer preferences

We assume that the consumers are distributed uniformly with respect to their value for the content offered by the publishers. We employ a uniform distribution with the unit support — i.e., $u_1 \sim \mathcal{U}[0,1]$ and $u_2 \sim \mathcal{U}[0,1]$. Under these assumptions, we are able to make informed and clear cut presentation of the impact of vertical integration on consumer surplus and total welfare.

The associated single-homing consumer demand at each publisher p and the multi-homing demand is

$$D_p(q_p, q_{-p}) = (1-c+\gamma q_p)(c-\gamma q_{-p}), \quad D_{12}(q_1, q_2) = (1-c+\gamma q_1)(1-c+\gamma q_2) \text{ for } p \in \{1,\ 2\}.$$

Vertical Separation. The equilibrium quality levels at the publisher p is given as $q_p(VS) = v\gamma$, for $p \in \{1,\ 2\}$. The ensuing single-homing and multi-homing demands are respectively given as follows.

$$D_p(VS) = \left(1 - c + v\gamma^2\right)\left(c - v\gamma^2\right),\ D_{12}(VS) = \prod_{i\in\{1,2\}} \left(1 - c + v\gamma^2\right) \text{ for } p \in \{1,\ 2\}.$$

The equilibrium profit of publisher p and the advertisers is given as

$$\pi_p(VS) = \frac{v(2(1-c) + v\gamma^2)}{2}, \qquad \pi_{Ad}(VS) = 0, \text{ for } p \in \{1,\ 2\}.$$

The profit of the intermediaries is $\pi_i(VS) = 0$ for $i \in \{1,\ 2\}$. Consumer surplus is given as $CS(VS) = (1 + v\gamma^2 - c)^2$. Total welfare is then $W(VS) = CS(VS) + \pi_1(VS) + \pi_2(VS) = (1-c)^2 + v(1+\gamma^2)(2(1-c) + v\gamma^2)$.

Vertical Integration. The equilibrium quality levels at the integrated publisher P_1 and the independent publisher P_2 is respectively given as

$$q_1(VI) = \frac{\gamma v\left(n(n+1-c) + \gamma^2 v(n+c-1)+\right)}{n^2 + v^2\gamma^4}, q_2(VI) = \frac{\gamma v\left(n(n+c-1) - \gamma^2 v(n+1-c)\right)}{n^2 + v^2\gamma^4}.$$

The associated single-homing and multi-homing demands are

$$D_1(VI) = (1 + \gamma q_1(VI) - c)(c - \gamma q_2(VI)), D_2(VI) = (1 + \gamma q_2(VI) - c)(c - \gamma q_1(VI)),$$

and

$$D_{12}(VI) = (1 + \gamma q_1(VI) - c)(1 + \gamma q_2(VI) - c).$$

The profit of the integrated firm P_1, *the independent publisher* P_2 and the advertisers is respectively given as

$$\pi_1(VI) = v(D_1(VI) + D_{12}(VI)) + \frac{vD_{12}(VI)}{n} - \frac{k_1(q_1(VI))^2}{2},$$

$$\pi_2(VI) = v(D_2(VI) + D_{12}(VI)) - \frac{vD_{12}(VI)}{n} - \frac{k_2(q_2(VI))^2}{2} \text{ and, } \pi_{AD}(VI) = 0.$$

Consumers surplus under vertical integration is given as

$$CS(VI) = \frac{n^2 \left(1 + v\gamma^2 - c\right)^2}{n^2 + v^2\gamma^4}.$$

Total welfare is then $W(VI) = CS(VI) + \pi_1(VI) + \pi_2(VI)$.

Welfare implications of vertical integration. The profit of the vertically integrated firm is higher than the profit of the independent publisher. This is straightforward as the vertically integrated firm is able to skim off a portion of the revenues to the independent publisher via "Bid-Shading".

Taking the difference of the consumer surplus in the two cases yields

$$CS(VS) - CS(VI) = \frac{\gamma^4 v^2 \left(1 + \gamma^2 v - c\right)^2}{n^2 + \gamma^4 v^2} > 0.$$

The above difference is always positive implying that vertical integration hurts consumers vis-á-vis vertical separation. Thus, we show that in this example consumers are better off under vertical separation.

Taking the difference of the total surplus in the two cases yields

$$W(VS) - W(VI) = \frac{v^2\gamma^2 \left(1 + \gamma^2\right)\left(1 + v\gamma^2 - c\right)^2}{n^2 + v^2\gamma^4} > 0.$$

The above expression is always positive. Thus, we show that total welfare falls after a vertical integration.

B.2 Negatively correlated preferences.

We assume that the consumers are distributed uniformly with respect to their value for the content offered by the publishers. We employ a uniform distribution with the unit support for the preference parameter $u_1 \sim \mathcal{U}[0,1]$. Further, we assume negative correlation between u_2 and u_1 and employ a simple transformation with $u_2 = 1 - u_1$. The consumer segmentation in this case can then be represented as in the following figure.

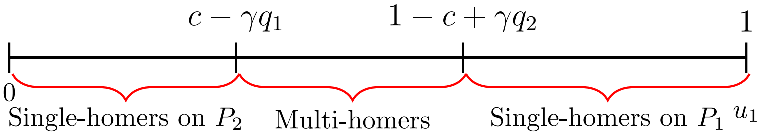

Figure 2: Single and multi-homing consumers.

Thus, the associated single-homing consumer demand at each publisher p and the multi-homing demand is

$$D_1 = c - \gamma q_2,\ D_2 = c - \gamma q_1,\ D_{12}(q_1, q_2) = 1 - c + \gamma q_2 - (c - \gamma q_1).$$

Vertical Separation. The equilibrium quality levels at the publisher p and the ensuing single-homing and multi-homing demands are respectively given as follows.

$$q_p(VS) = v\gamma,\ D_p(VS) = c - v\gamma^2,\ D_{12}(VS) = 1 + 2(v\gamma^2 - c).$$

The equilibrium profit of publisher p, advertisers and the advertising network p is given as

$$\pi_p(VS) = \frac{v(2(1-c) + v\gamma^2)}{2}, \qquad \pi_{Ad}(VS) = 0, \qquad \pi_{AN}(VS) = 0 \text{ for } p \in \{1,\ 2\}.$$

Consumer surplus in our setting is given as $CS(VS) = (1 - c + v\gamma^2)^2$. Total welfare is then $W(VS) = CS(VS) + \pi_1(VS) + \pi_2(VS) = (1-c)^2 + v(1+\gamma^2)(2(1-c) + v\gamma^2)$.
Vertical Integration. The equilibrium outcome under vertical integration is as follows. The equilibrium quality levels at the integrated publisher 1 and the independent publisher P_2 is respectively given as $q_1(VI) = \frac{(n+1)v\gamma}{n}$ and $q_2(VI) = \frac{(n-1)v\gamma}{n}$. The associated single-homing and multi-homing demands are

$$D_1(VI) = c - \gamma q_2(VI), D_2(VI) = c - \gamma q_1(VI), D_{YC}(VI) = 1 + 2(v\gamma^2 - c).$$

The profit of the integrated publisher 1 is

$$\pi_1(VI) = \frac{v\left((1-c)(n+1) - c + v\gamma^2(n+3)\right)}{n} - \frac{\left(\frac{(n+1)v\gamma}{n}\right)^2}{2}.$$

The profit of *the independent publisher* P_2 and the advertisers is respectively given as

$$\pi_2(VI) = \frac{v\left((1-c)(n-1)+c+v\gamma^2(n-3)\right)}{n} - \frac{\left(\frac{(n-1)v\gamma}{n}\right)^2}{2}, \ \pi_{AD}(VI) = 0.$$

Consumers surplus under vertical integration is given as

$$CS(VI) = \frac{n^2\left(1+\gamma^2 v - c\right)^2 + \gamma^4 v^2}{n^2}.$$

Total welfare is then $W(VI) = CS(VI) + \pi_1(VI) + \pi_2(VI)$.

Welfare implications of vertical integration. The profit of the vertically integrated firm is higher than the profit of the independent publisher.

Taking the difference of the consumer surplus in the two cases yields

$$CS(VS) - CS(VI) = -\frac{v^2\gamma^4}{n^2} < 0.$$

The above expression is always negative in the relevant parameter range implying that vertical integration benefits consumers. Thus, we show that in this example consumers are better off under vertical integration.
Taking the difference of the total surplus in the two cases yields

$$W(VS) - W(VI) = \frac{v^2\gamma^2(1-\gamma^2)}{n^2} > 0.$$

The above expression is positive when $\gamma < 1$ and negative otherwise.

The result on welfare is a bit nuanced. Recall, that welfare is the sum of consumer surplus and advertising surplus. Firstly, we find that the advertising surplus is higher under vertical separation (vis-á-vis). To be more concrete,

$$\Delta AS = \sum_{p\in\{1,2\}} \left(D_p(VS) + D_{12}(VS) - D_p(VI) - D_{12}(VI) - \left(\frac{q_p(VS)^2}{2} - \frac{q_p(VI)^2}{2}\right)\right)$$

$$\Delta AS = \sum_{p\in\{1,2\}} \left(- \left(\frac{q_p(VS)^2}{2} - \frac{q_p(VI)^2}{2}\right)\right) > 0. \quad (23)$$

Vertical integration does not increase the total number of impressions available but increases cost. This is because only the investment of each individual publisher changes while the total investment level across them remains unchanged. As the investment costs are convex, an increase in investment by the integrated publisher results in increased investment cost. This increased investment cost due to reallocation of investment efforts negatively affects advertising surplus under vertical integration. However, the negative impact of advertising surplus on total welfare under vertical integration can be countervailed by its impact on consumer surplus. Specifically, when consumers' sensitivity to quality is high (when $\gamma > 1$), we find that total welfare can be higher under vertical integration than under vertical separation as the consumer surplus gains are greater than welfare losses due to increased investment costs. Else when $\gamma \leq 1$, total welfare is lower under vertical integration.

B.3 Positive correlation of preferences.

We assume that the consumers are distributed uniformly with respect to their value for the content offered by the publishers. Further, these values are positively correlated such that $u_2 = \alpha u_1$ with $u_1 \sim [0,1]$ and $u_2 \sim [0,\alpha]$ with $\alpha \in [0,1]$. Thus, utility of consumers when visiting P_2 can be appropriately modified.

For a complete analysis of this extension, two cases must be considered — i.e., (i) $\bar{u}_1 \leq \bar{u}_2$ and (ii) $\bar{u}_1 > \bar{u}_2$ where the definition of $\bar{u}_1$ and $\bar{u}_2$ is explained below. This is because the demand structure is different in the two cases.

(i) Case $\bar{u}_1 \leq \bar{u}_2$. Consumers visit content providers when they receive positive utility. Thus, consumers participate on P_1 and P_2 respectively when

$$V_1 \geq 0 \implies u_1 \geq \bar{u}_1 := c - \gamma q_1 \text{ and } V_2 \geq 0 \implies u_1 \geq \bar{u}_2 := \frac{c - \gamma q_2}{\alpha}.$$

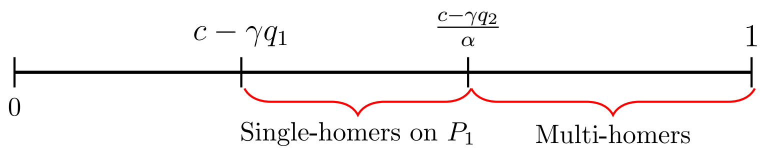

Figure 3: Single and multi-homing consumers.

The associated demands are $D_1 = \frac{c-\gamma q_2}{\alpha} - (c - \gamma q_1)$ and $D_2 = 0$ and $D_{12} = 1 - \frac{c-\gamma q_2}{\alpha}$.
Vertical Separation. The equilibrium quality levels at the publisher P_1 and P_2 are respectively given as follows. $q_1(VS) = v\gamma$ and $q_2(VS) = \frac{v\gamma}{\alpha}$ The equilibrium profit of publishers P_1 and P_2 is $\pi_1(VS) = \frac{2v(1-c)+v\gamma^2}{2}$ and $\pi_2(VS) = \frac{v(v\gamma^2+2\alpha(\alpha-c))}{2\alpha^2}$. The profit of advertisers and the intermediary p is zero. Consumer surplus in this setting is

$$CS(VS) = \frac{\alpha^2\left(\alpha^2+\alpha+c^2+\alpha(c-4)c\right)+2\alpha\gamma^2 v\left(\alpha(\alpha+1)-\left(\alpha^2+1\right)c\right)+\left(\alpha^3+1\right)\gamma^4 v^2}{2\alpha^3}.$$

Welfare is given as $W(VS) = CS(VS) + \sum_{p\in\{1,2\}} \pi_p(VS)$.
Vertical Integration. The equilibrium quality levels at the integrated publisher P_1 and the independent publisher P_2 is respectively given as $q_1(VI) = v\gamma$, $q_2(VI) = \frac{(n-1)v\gamma}{\alpha n}$.

The profit of the integrated publisher 1, the independent publisher P_2 and is respectively given as $\pi_1(VI) = \frac{v\left(2\alpha n(\alpha(n+1)-c(\alpha n+1))+\gamma^2 v\left(n\left(\alpha^2 n+2\right)-2\right)\right)}{2\alpha^2 n^2}$, $\pi_2(VI) = \frac{(n-1)v\left(2\alpha n(\alpha-c)+\gamma^2(n-1)v\right)}{2\alpha^2 n^2}$. Consumers surplus under vertical integration is given as

$$CS(VI) = \frac{\left(\begin{array}{l}\alpha^2 n^2\left(\alpha^2+\alpha+c^2-\alpha(4-c)c\right)\\ \quad +2\alpha\gamma^2 nv\left(\alpha(\alpha n+n-1)-c\left(\alpha^2 n+n-1\right)\right)+\gamma^4 v^2\left(n\left(\alpha^3 n+n-2\right)+1\right)\end{array}\right)}{2\alpha^3 n^2}.$$

Total surplus is then $W(VI) = CS(VI) + \pi_1(VI) + \pi_2(VI)$.
Welfare implications of vertical integration. The profit of the vertically integrated firm is higher than the profit of the independent publisher. Taking the difference of the consumer surplus in the two cases yields

$$CS(VS) - CS(VI) = \frac{\gamma^2 v\left(v\gamma^2(2n-1)-2\alpha n(c-\alpha)\right)}{2\alpha^3 n^2} > 0.$$

The above is always positive in the relevant parameter range implying that vertical integration hurts consumer surplus. Thus, we show that in this example consumer's are always worse-off under vertical integration.
Taking the difference of the total surplus in the two cases yields

$$W(VS) - W(VI) = \frac{\gamma^2 v\left(v\gamma^2(2n-1)+v\alpha-2n\alpha(c-\alpha)\right)}{2\alpha^3 n^2} > 0.$$

The above is always positive in the relevant parameter range. Thus, we show that total welfare falls after vertical integration.

(ii) Case $\bar{u}_1 > \bar{u}_2$. Consumers visit content providers when they receive positive utility. Thus, consumers participate on P_1 and P_2 respectively when

$$V_1 \geq 0 \implies u_1 \geq \bar{u}_1 := c-\gamma q_1 \text{ and } V_2 \geq 0 \implies u_1 \geq \bar{u}_2 := \frac{c-\gamma q_2}{\alpha}.$$

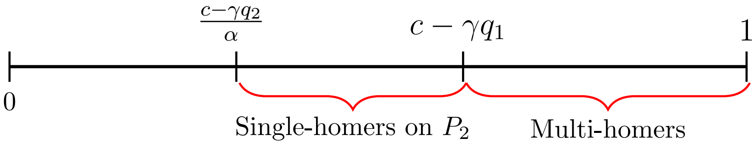

Figure 4: Single and multi-homing consumers.

The associated demands are $D_1 = 0$ and $D_2 = (c-\gamma q_1) - \frac{c-\gamma q_2}{\alpha}$ and $D_{12} = 1-(c-\gamma q_1)$.
Vertical Separation. The equilibrium quality levels at the publisher P_1 and P_2 are respectively given as follows. $q_1(VS) = v\gamma$ and $q_2(VS) = \frac{v\gamma}{\alpha}$ The equilibrium profit of publisher P_1 and P_2 is $\pi_1(VS) = \frac{2v(1-c)+v^2\gamma^2}{2}$ and $\pi_2(VS) = \frac{v(v\gamma^2+2\alpha(\alpha-c))}{2\alpha^2}$. The profit of advertisers

and the intermediaries is zero. Consumer surplus in this setting is

$$CS(VS) = \frac{\alpha^2 \left(\alpha^2 + \alpha + c^2 - \alpha(4-c)c\right) + 2\alpha\gamma^2 v \left(\alpha(\alpha+1) - \left(\alpha^2+1\right)c\right) + \left(\alpha^3+1\right)\gamma^4 v^2}{2\alpha^3}.$$

Welfare is given as $W(VS) = CS(VS) + \sum_{p\in\{1,2\}} \pi_p(VS)$.

Vertical Integration. The equilibrium quality levels at the integrated publisher P_1 and the independent publisher P_2 is respectively given as $q_1(VI) = \frac{v\gamma(n+1)}{n}$, $q_2(VI) = \frac{v\gamma}{\alpha}$.

The profit of the integrated publisher P_1, the independent publisher P_2 and is respectively given as $\pi_1(VI) = \frac{(n+1)v\left(\gamma^2 v(n+1)v + 2n(1-c)\right)}{2n^2}$, $\pi_2(VI) = \frac{v\left(\gamma^2 v\left(n\left(n-2\alpha^2\right)-2\alpha^2\right)+2\alpha n(\alpha(n-1)-c(n-\alpha))\right)}{2\alpha^2 n^2}$. Consumers surplus under vertical integration is given as

$$CS(VI) = \frac{\left(\begin{array}{r}\alpha^2 n^2 \left(\alpha^2 + \alpha + c^2 - \alpha c(4-c)\right) + 2\alpha\gamma^2 n v \left(\alpha(\alpha + \alpha n + n) - c\left(\alpha^2(n+1)+n\right)\right) \\ + \gamma^4 v^2 \left(n^2 + \alpha^3(n+1)^2\right)\end{array}\right)}{2\alpha^3 n^2}.$$

Total surplus is then $W(VI) = CS(VI) + \pi_1(VI) + \pi_2(VI)$.

Welfare implications of vertical integration. The profit of the vertically integrated firm is higher than the profit of the independent publisher. Taking the difference of the consumer surplus in the two cases yields

$$CS(VS) - CS(VI) = -\frac{\gamma^2 v \left(2(1-c)n + \gamma^2(2n+1)v\right)}{2n^2} < 0.$$

The above expression is always negative in the relevant parameter range implying that vertical integration benefits consumer surplus.

Thus, we show that in this example consumer's are always worse-off under vertical integration.

Taking the difference of the total surplus in the two cases yields

$$W(VS) - W(VI) = \frac{\gamma^2 v \left(v(1-\gamma^2) - 2n(1+\gamma^2 v - c)\right)}{2n^2}.$$

The above is positive if and only if $n > \frac{v(1-\gamma^2)}{2(1+\gamma^2 v - c)}$.