Social Media, Echo Chambers and Content Provision

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November 8, 2017

Abstract

We analyze the effects of social media and "echo chambers" on content provision in the news market. We develop a model where media firms compete on content provision and on advertising revenues. In turn, consumers have an ideal variety of content and experience a disutility from consuming content that differs from their ideal variety. In addition, consumers can be single-homing (they consume from just one outlet) or multi-homing (they consume from competing outlets). We model social media as the existence of network effects, i.e., consumers like content that other consumers like. We model echo chambers as the presence of information effects, i.e., consumers obtain additional utility from consuming from different sources. We show that media firms only provide more content under multi-homing than under single-homing, when consumers derive extra utility from consuming from different sources (information effects). The opposite occurs when consumers like to consume what others do (network effects). In other words, when echo chambers and social media are not important in the media market, content provision is larger, and vice-versa.

Keywords: Social Media; Echo Chambers; Content Provision; Two-Sided Markets; Multi-Homing.

JEL Classification: D43, L13, L82, L86.

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1 Introduction

In the last decade, the news media sector has been facing three main trends. First, the migration from print to digital. Second, the rise in importance of social media for the provision of media content. Third, the escalation of divisive politics as shown by "echo chambers"[1].

Regarding the first trend, it is well known that in recent years there has been a large reduction in subscriptions to print newspapers. One of the main reasons is that it is now possible to consume news online (mostly free) and, as a result, news consumption has migrated from print to digital. The main consequence has been a reduction in advertising revenues for media firms, because the increase in online advertising has not yet compensated for the reduction in print advertising. As a result, employment in the media sector has also been in retreat in the last decade, and this has led to a reduction in investigative journalism. For example, according to the Pew Research Center (2016), in the US, the average weekday newspaper circulation, print and digital, fell by 7% in 2015. This is the biggest decline since 2010. Digital circulation has increased by 2%, but the problem is that it accounts for only 22% of total circulation. Furthermore, total advertising revenues declined by 8% in 2015, including both print and digital. Not surprisingly, in 2015 employment in newspapers decreased by 10%, the biggest decline since 2009. In practical terms, this means that nowadays, newspapers in the US have 20,000 fewer employees than 20 years ago.

With respect to social media, according to the Pew Research Center (2016), today 62% of US adults access news from social media sites. As a result, social media outlets are receiving a larger share of the advertising revenues in the industry. In fact, in spite of 20% growth in total digital advertising spending in 2015 (approximately $60 billion), newspapers have not been the primary beneficiaries. In particular, 65% of the digital advertising revenues belong to just five tech companies, such as Facebook, Google, and Twitter. This has important consequences for content provision, because the consumption of news on social media sites has some important differences compared with traditional media. One of the main differences is that in social media, consumers care a lot about what news others consume, talk

[1] According to Del Vicario et al. (2016), “echo chambers” refer to the phenomena where media consumers focus on specific narratives and join homogeneous groups, which are very polarized in relation to others. In these groups, competitive views are often censored, rejected, or underrepresented.

about, and discuss (Goyal, 2012). For instance, some current politics issues can spread very quickly in social media ("informational cascades"), because the topics that are more popular are the ones that attract more views. This shows the emergence of network effects in the consumption of news.

We turn now to the rise in divisive politics. As the last presidential elections in the US showed (see also Brexit in the UK), politics and political discussion have become more divisive. This, together with social media, has changed the way news is consumed. Many media and Internet analysts talk about "echo chambers", in the sense that people in the digital realm consume only news that fits their ideological preferences and biases (Sunstein, 2007, 2016). The empirical evidence seems to confirm the filtering of news on the Internet according to political views (see Wallsten, 2005; Jamieson and Cappella, 2008; Del Vicario et al., 2016; Quattrociocchi et al., 2016). Importantly, it is not only consumers who filter the news: the filtering is also promoted by the algorithms developed by social media websites. The consequence of this has been the creation of "informational cascades" within identified groups of consumers (again network effects), focus of consumers on preferred narratives ("confirmation bias"), and the resulting polarization in society, because consumers ignore (or wrongly refute and manipulate) relevant information that goes against their preferred views.

In order to analyze the effects of social media and echo chambers on content provision, we develop a model where media firms compete on content and advertising. Consumers incur a disutility from consuming content that differs from their ideal type. As such, following Hotelling (1929), we assume that consumers pay a transport cost when they do not find their ideal variety in the media market. In addition, consumers can be single-homing (i.e., they consume from just one media outlet) or multi-homing (i.e., they consume from competing media outlets). We model social media as the presence of network effects, where users like to interact with other users, and the gains from interaction are larger when a platform has many subscribers. In other words, consumers like to consume what other consumers also consume. We follow the formalization of network effects of Doganoglu and Wright (2006, 2010)[2]. In turn, we model echo chambers as the existence of information effects, where consumers derive extra utility from consuming from competing

[2]Doganoglu and Wright (2006, 2010) analyze the effects of multi-homing on compatibility and exclusive dealing, respectively. Choi (2010) considers the case of multi-homing from the perspective of content providers on the Internet. Carrillo and Tan (2006) analyze multi-homing from the perspective of consumers and content providers.

media outlets. For example, we can consider consumers who enjoy being informed about different point of views, and this is facilitated by consuming from different media outlets. We model this extra utility as in Kim and Serfes (2006)[3].

In addition to information and network effects, our model has two more pillars. The first pillar considers a two-sided market, in the sense that media firms derive revenues from advertising (see for instance Rochet and Tirole, 2003; Anderson and Coate, 2005; Esteban et al., 2006; Kind et al., 2007; Peitz and Valletti, 2008; von Ehrlich and Greiner, 2013; and Esteban and Hernández, 2016). Advertisers prefer media firms that have more demand, because their message reaches a larger audience, and therefore media firms would like to attract more consumers in order to increase advertising revenues.

The second pillar takes into account the fact that media firms can choose to follow a single-content or a multi-content strategy, as in Garcia Pires (2013, 2014). With a single-content strategy, media firms only provide one type of content (a point on the Hotelling line). With a multi-content strategy, media firms provide different types of content (a segment on the Hotelling line), and therefore have to decide on the diversity of content offered. To illustrate, consider a right-wing newspaper. A single-content strategy would occur if the right-wing newspaper were to cover all political news (from taxation, to migration, to environment) only from a given right-wing politics perspective; for example, center-right on all issues from migration to economics. A multi-content strategy, would in turn mean that the right-wing newspaper could give different nuances to different political issues, for example more to the right on taxation and more to the center on the environment, or even on a single topic, such as migration, could cover many opinions from more to the right to more to the center.

In this setup, we show that it is not possible to know *à priori* which type of consumers promote more content provision, single-homing consumers or multi-homing consumers. This comes as a surprise, because we would expect that multi-homing consumers would promote more content provision, because they increase the demand for media firms. We demonstrate, however, that the relation between content provision under single-homing and multi-homing depends on what types of benefits/utility consumers derive from

[3]Anderson et al. (2016) introduce vertical differentiation (quality differences) in the multi-homing choice of consumers. Accordingly, consumers place more value on the functionalities of a product that are closer to those of their ideal variety.

multi-homing. If consumers are multi-homing because of network benefits (i.e., they derive extra utility from consuming what other consumers also consume), media firms provide less content with multi-homing consumers than with single-homing consumers.

The reason is that multi-homing consumers in the presence of network effects reduce competition between media firms. Accordingly, with network effects, multi-homing consumers may care more about what other consumers consume than about how much content media firms provide. Therefore, in this case, media firms may have lower incentives to provide content to attract demand, because reducing content does not necessarily reduce demand, as long as the network effects are large.

If instead, consumers are multi-homing because of information benefits (i.e., they derive utility from being informed from different perspectives), media firms provide more content with multi-homing consumers than with single-homing consumers. The reason is that now, media firms have to compete for the consumer who is indifferent between single-homing and multi-homing. Accordingly, this is only possible by providing more content, because more content reduces transport costs that consumers have to incur in order to consume a different variety from their ideal one.

The plan for the rest of the paper is the following. In the next section, we discuss content provision and multi-homing. In Section 3, we present the base model. In Section 4, we analyze the network effects case for the single-homing and the multi-homing scenarios. In Section 5, we analyze the information effects case for the single-homing and the multi-homing scenarios. In Section 6, we discuss our main findings.

2 Content Provision and Multi-Homing

In media markets, as noted by Caillaud and Jullien (2003) and Rochet and Tirole (2003), multi-homing consumers (i.e., consumers who consume from competing media firms) are the norm rather than the exception (for empirical evidence see for instance Berry and Waldfogel, 2001; Gentzkow et al., 2014). However, the literature in media economics has mostly considered single-homing consumers (i.e., consumers who only consume from one media firm). The main reason for this is mainly technical, because the preferred workhorse model in media economics, the Hotelling model (Hotelling, 1929), was initially developed with only single-homing consumers. Recent contributions, such as Doganoglu and Wright (2006, 2010) and Kim and Serfes (2006), have however allowed the possibility of incorporating multi-homing in the Hotelling model. Building on these new contributions, we analyze the impact that multi-homing consumers can have on media firms' incentives to provide content.

The diversity of content provided by media firms is a central concern for media research, media policy, and media regulators. The argument suggests that a media market with a diverse provision of content contributes positively to consumer welfare. On the one hand, a diverse media market satisfies consumers' diverse preferences, and on the other hand it supports a well-functioning market economy and democracy, because consumers can become better informed (see Coase, 1974; Hayek, 1945; and Mill, 1859)[4].

The diversity of content that is available in a media market is then a central question in media economics, and this is in particular the case for media competition on the Internet (see Peitz and Reisinger, 2014). However, to the best of our knowledge, the media economics literature has only looked at this issue in the context of single-content media firms. When media firms are single-content, the question that arises is if the media market will offer minimum differentiation (just one type of content by two competing media firms) or maximum differentiation (two types of content, one for each media duopolist). For this approach, see for instance Gabszewicz et al. (2001, 2002).

Garcia Pires (2013, 2014) departs from the limitations of single-content media firms and considers the case of multi-content media firms. Garcia Pires (2013, 2014) shows that the interaction of multi-content media firms with two-sided markets carries some new implications for content provision not present when only single-content media firms are modeled. In particular, offering more content increases demand because more consumers can consume their ideal variety of content without incurring transport costs. As a result, media firms can also attract more advertising revenues. The drawback of providing more content is that this increases costs, because producing

[4]The media content literature is in this sense related to the literature on media bias. Media bias refers to the bias of the press in the selection of which events are reported and how they are covered (see for instance Mullainathan and Shleifer, 2005; Anand et al., 2007). Therefore, more media content can in principle reduce media bias, but this is not always the case. For empirical evidence on these issues, see for instance Eisensee and Strömberg (2007), Prat and Strömberg (2005, 2011), Rothbauer and Sieg (2013), Snyder and Strömberg (2010), Strömberg (2001, 2004a, 2004b, 2007, 2008).

content is costly. As such, in a two-sided market, the question is not only about minimum *versus* maximum differentiation, but also about the level of content offered by media firms. Garcia Pires (2013, 2014), however, analyzes only content provision in the context of single-homing consumers.

The empirical evidence from journalistic studies supports the view that news firms follow a multi-content strategy, rather than a single-content strategy (see for example, Gans, 1999; Gitlin, 1999; O'Neill and Harcup, 2009; and Coleman et al., 2009). Note, however, that this is done within the limits of the political area that the news outlets defend (Gans, 1999). In other words, left-leaning newspapers often adapt political news to the center, but rarely cross to the right-wing political side.

Newspapers provide multi-content for several reasons. First, by adapting news to readers' political preferences, newspapers can satisfy a larger share of the audience (Gans, 1999). Second, readers' political opinions can change and therefore newspapers need to adapt to them (Gitlin, 1999). Third, newspapers have incomplete information about readers' political preferences, which means that covering different political leanings, rather than just a limited one, is a smart business strategy (O'Neill and Harcup, 2009). Fourth, newspapers try to set a political agenda in the public arena, and in order to achieve this, they publish different articles about a topic to arouse discussion, usually giving different (but close) political leanings to the different articles (Coleman et al., 2009). The multi-content strategy is particularly evident in the online editions of newspapers. For instance, for important topics it is very common to find folders that contain many articles, usually with different views, perspectives, and political leanings on the given topic. Many media firms, from left to right, follow this strategy. See, for example, the recent coverages of the US presidential election, the EU membership referendum in the UK, the environmental summit in Paris, or the Panama papers case.

3 The Model

The model has four pillars: Hotelling (1929) preferences, advertising competition (as in Anderson and Coate, 2005, and Peitz and Valletti, 2008), multi-content media firms (as in Garcia Pires, 2013, 2014) and multi-homing consumers (Doganoglu and Wright, 2006, 2010 and Kim and Serfes, 2006).

The media sector consists of two media firms, media firm 1 and media firm 2. Media firms compete on advertising revenues and the diversity of content provided. Consumers can subscribe to media firm 1, to media firm 2 (single-homing), or to both (multi-homing). Consumers are uniformly distributed on a line of length one, $[0, 1]$, and they have heterogeneous preferences in the Hotelling manner. In other words, each consumer has an ideal content variety and they incur a disutility (transport costs) in consuming content that differs from their ideal one. The line represents consumers' preferences, and we normalize the mass of consumers to one. Media firm 1 is located at point 0 and media firm 2 is located at point 1 on the Hotelling line[5].

In terms of multi-homing, we consider two cases. In the first case, as in Doganoglu and Wright (2006, 2010), multi-homing can arise because consumers derive utility from accessing content that other consumers also access, similar to what occurs in social media. We call this case network effects. In the second case, as in Kim and Serfes (2006), multi-homing may emerge because consumers derive utility from accessing different sources of information with different point of views: the opposite to what occurs with echo chambers. The network information case then tries to capture some characteristics of social media, i.e., the benefits of interacting with many consumers, which is only possible when having access to content from different sources. In turn, the information effects case (together with transport costs), tries to capture some characteristics of echo chambers, because it indicates how open consumers are to content that differs from their ideal content.

Content Provision Regarding content, we allow media firms to provide more than just one type of content. In other words, contrary to standard Hotelling models, media firms are not limited to being located on just a point on the line (single-content strategy). Instead, as in Garcia Pires (2013, 2014), media firms can choose to cover a line segment (multi-content strategy), where the size of the line segment is indicated by $0 \leq d_i \leq 1$.

When deciding between the single-content strategy (a point on the line) and the multi-content strategy (a line segment), a media firm weighs the benefits and the costs of these two strategies. The benefits of a multi-content strategy ensue from an increase in demand, given that transport costs that consumers face are reduced, i.e., consumers inside the content provision seg-

[5]We fix locations because the aim of the paper is not the choice of location in the product space, but rather the choice of the diversity of content. In addition, endogenizing location would force us to introduce price competition, which is not central in media online markets.

ment of the media firm do not incur transport costs in order to consume their ideal content, while consumers outside the content provision segment of a given media firm face lower transport costs. In turn, the costs of a multi-content strategy accrue from the fact that it is more costly to supply more than just one type of content. These costs, as in Alexandrov (2008) and Dewan et al. (2003), equal:

$$C_i = \frac{\gamma d_i^2}{2}, i = 1, 2, \tag{1}$$

where γ is a parameter that captures the technological costs to follow a multi-content strategy. In this way, to model multi-content media firms, we follow the approach of Alexandrov (2008) to "fat products." With fat products, a firm offers just one product that contains a set of characteristics among which consumers can select at no extra cost. An example of a fat product is a software program where consumers can choose between different applications. In other words, fat products are access products: when consumers access a given product, they can choose among what is on offer "inside" the product. In the context of the media market, "fat content" refers to the case where a media outlet caters to different preferences by providing different content, for instance on its website, and consumers can decide what to consume from this set of content offerings, from just some content to all content.[6]

Next, we present some examples of a multi-content strategy using the case of political content. A right-oriented media outlet is said to follow a multi-content strategy when for instance it is inclined more to the right with respect to taxation and more to the center with respect to competition policy. Another possibility is that a media firm can give voice to different (although close) political opinions about taxation policy (or any other policy, such as the

[6] Dewan et al. (2003) have a similar setup to Alexandrov (2008). The difference is that Dewan et al. (2003) model product customization. Customization and fat products are related but not identical concepts. With customization, a firm adapts a standard product and transforms it into several customized products. To acquire a customized product, consumers have to pay an additional price to that of the standard product. An example of a customized product is a personal computer, where consumers can choose between different components at different prices. Then, under customization, and contrary to fat products, price discrimination is central. In the case of the internet media market, it seems more appropriate to think in terms of fat products than in terms of customization, because price discrimination, in spite of some attempts, is not the standard business practice in the industry.

environment). This occurs frequently in newspapers, in particular for opinion columnists, editorials, and important news issues such as elections, political reforms, and political scandals. As argued in the previous section, journalistic studies confirm that media firms usually follow a multi-content strategy (see Gans, 1999; Gitlin, 1999; O'Neill and Harcup, 2009; and Coleman et al., 2009).

In addition, the journalistic studies literature also shows that media firms tend to adapt news only in the vicinity of their core political area, i.e. right-wing newspapers may cover issues closer to the center, but usually not to the left. Consequently, we assume that a media firm can only follow a multi-content strategy that is contiguous to its location on the line, i.e. for media firm 1, the multi-content choice has to be contiguous to point 0; and for media firm 2, the multi-content choice has to be contiguous to point 1. One economic reason for this to occur can be diseconomies of scope. In terms of the model, this could mean that a media firm, when providing content continuously along the line, only needs to incur the costs expressed in equation 1. However, if a media firm provides content discontinuously along the line, it will incur extra sunk costs for each new location and for each associated multi-content segment. The sunk costs might be seen as prohibitive[7]. Note also that choosing a discontinuous line segment would not occur in equilibrium because this would increase advertising competition (relative to the continuous case) and therefore reduce revenues.

Advertising Market We now look at advertising. We assume that media firms derive all their revenues from advertising[8]. As in Anderson and Coate (2005), and Peitz and Valletti (2008), the demand for advertisements for media firm i is:

$$r_i = \alpha - \beta a_i,\ i = 1, 2, \tag{2}$$

where r_i is the price of advertising per consumer, a_i is the advertising

[7] For example, for a media firm to provide content away from its location, it might need to hire new staff and a respective administrative structure that specializes in this different content area. Conversely, when a media firm provides content contiguous to its location on the line, it might be able to continue to use the same staff and structure.

[8] As already mentioned, we focus on advertising competition and ignore price competition, because price competition has not been, at least until now, central to the Internet media market. In contrast, advertising competition has so far been the main battle in the media market.

volume, and the parameters α and β represent the size of the advertising market. Accordingly, a large α and a small β represent a large advertising market, and *vice-versa*.

Gross advertising income is then:

$$A_i = ((\alpha - \beta a_i)\, a_i)\, N_i,\ i = 1, 2, \tag{3}$$

where N_i is the number of consumers of media firm i. We can then see that advertising introduces a two-sided market nature to the model. This is so because advertisers prefer to consume advertisements in media firms that attract a bigger audience (N_i); and media firms would like to increase their audience in order to generate more advertising revenues (A_i).

In this way, the profits of media firm i equal:

$$\Pi_i = A_i - C_i,\ i = 1, 2. \tag{4}$$

Multi-Homing We now turn to multi-homing. As mentioned above, we consider two cases of multi-homing. In the first case, multi-homing occurs because of network effects. In the second case, multi-homing occurs because of information effects[9].

Network Effects (Social Media) The case of network effects follows Doganoglu and Wright (2006, 2010). As in Doganoglu and Wright (2006, 2010), when consuming content from a media firm, consumers, besides the utility derived from consuming the content that the media firm offers, also derive an extra benefit that depends on the size of the firm's audience[10]. In terms of network effects, we assume that a consumer can extract additional benefits from interacting with other consumers who also consume the same type of content, as is the case in social media. We assume that the media market has N consumers. Following Doganoglu and Wright (2006, 2010), consumers are divided into two types according to their marginal valuation

[9] We could have merged the two cases of multi-homing. This would, however, not only make the model more complicated, but it would also make it more difficult to distinguish the effects at work in the case of social media (network effects) and echo chambers (information effects).

[10] For ways of modeling multi-homing similar to that of Doganoglu and Wright (2006, 2010), see de Palma, et al. (1999); Crémer et al. (2000); Gabszewicz et al. (2001); Gabszewicz and Wauthy (2003); Guo (2006).

of the extra network benefits, which we denote by b. A share $0 < \lambda < 1$ of consumers give a high valuation to these extra network benefits, and we have $b = b_H$. A share $1 - \lambda$ of consumers give a low valuation to these extra network benefits, and have $b = b_L$, with $b_H > b_L > 0$.

The utility of a consumer of type b, when he only consumes from media firm 1 (single-homing), and is located outside the multi-content segment of media firm 1, is:

$$U = V - t(x - d_1) + bN_1, \tag{5}$$

where V is the intrinsic value of consuming content from media firm i, t represents the intensity of consumers' preferences (transport costs in Hotelling terminology), and d_i stands for the amount of content supplied by media firm i. We assume that V is sufficiently high so that the media market is covered, i.e., all consumers consume content from at least one media firm. Similarly, when a consumer only consumes from media firm 2 (and is located outside the multi-content segment of media firm 2), $U = V - t(1 - x - d_2) + bN_2$. Furthermore, if a consumer is located inside the multi-content segment of a media firm, his utility simplifies to $U = V + bN_i$ (with $i = 1, 2$), because he does not need to incur transport costs to consume his preferred variety of content[11].

In turn, the utility of a consumer of type b located outside the multi-content segments of the two media firms, when he consumes from both media firms (multi-homing) is:

$$U = V - t(x - d_1) - t(1 - x - d_2) + bN. \tag{6}$$

As $N = 1$, we then have that $U = V - t((1 - d_1 - d_2)) + b$. Again, if a consumer is located inside the multi-content segment of a media firm, his utility simplifies to $U = V + bN$, given that he does not need to incur transport costs to consume his preferred variety of content.

[11]We are therefore assuming that a consumer inside the multi-content segment of a media firm does not pay transport costs even if he consumes news that differs from his ideal variety. Note that this is just a simplification. We could build a more complex version of the model where the disutility of a consumer would equal the sum of the distance to all the different points in the multi-content segment. In this case, it can be easily seen that a consumer inside the multi-content segment would still incur lower transport costs than a consumer outside the multi-content segment of a media firm. The idea that we want to capture is that consumers inside the multi-content segment face lower transport costs than consumers outside it.

Regarding the indifferent consumer, note that, differently from standard Hotelling models, in the model with network effects there are two indifferent consumers, one for each type of consumer, high and low types. Therefore, we have to consider this when finding the indifferent consumers. In addition, in the single-homing scenario, a consumer consumes either from media firm 1 or from media firm 2. As there are λ high types and $(1-\lambda)$ low types, the total number of consumers for media firm 1 equals $N_1 = \lambda s_1 + (1-\lambda) n_1$, while for media firm 2, the total number of consumers is $N_2 = \lambda s_2 + (1-\lambda) n_2$, where s_i $(i = 1, 2)$ is the share of high types and n_i $(i = 1, 2)$ is the share of low types that subscribe to media firm i. As such, the indifferent consumers in each segment, high and low types, are those that make $U_1(s_1, b_H, N_1) = U_2(s_1, b_H, N_2)$ and $U_1(s_1, b_L, N_1) = U_2(s_1, b_L, N_2)$, respectively. Note also that $s_2 = (1-s_1)$ and $n_2 = (1-n_1)$. For the high types, the indifferent consumer is as follows:

$$\begin{aligned} & V - t(s_1 - d_1) + b_H(\lambda s_1 + (1-\lambda) n_1) \\ = {} & V - t(1 - s_1 - d_2) + b_H(\lambda(1-s_1) + (1-\lambda)(1-n_1)). \end{aligned} \tag{7}$$

While for the low types, the indifferent consumer is as follows:

$$\begin{aligned} & V - t(n_1 - d_1) + b_L(\lambda s_1 + (1-\lambda) n_1) \\ = {} & V - t(1 - n_1 - d_2) + b_L(\lambda(1-s_1) + (1-\lambda)(1-n_1)). \end{aligned} \tag{8}$$

We now turn to the multi-homing scenario. We follow Doganoglu and Wright (2006) in assuming that all high types multi-home and all low types single-home. The case where only some high types multi-home and the case where some low types also multi-home are not qualitatively different from the case analyzed in this section. We can think of the case considered here as a benchmark, in the sense that increasing the number of consumers who multi-home strengthens the results regarding the comparisons with the single-homing scenario, and *vice-versa*. In any case, the assumption that all high types multi-home implies that in the network effects formalization, multi-homing consumers are exogenous. In the information effects case, as we will see below, we endogenize the consumers who multi-home.

As all high types multi-home, $s_i = 1$, with $i = 1, 2$. Therefore, $N_1 = \lambda + (1-\lambda) n_1$ and $N_2 = \lambda + (1-\lambda) n_2$. In turn, the share of (low-type) single-homing consumers who join media firm 1 equals $U_1(n_1, b_L, N_1) = U_2(n_1, b_L, N_2)$. The (low- type) indifferent consumer is the one for which:

$$\begin{aligned} &V - t(n_1 - d_1) + b_L(\lambda + (1-\lambda)n_1) \\ &= V - t(1 - n_1 - d_2) + b_L(\lambda + (1-\lambda)(1-n_1)). \end{aligned} \tag{9}$$

In this way, consumer surplus under both the single-homing and multi-homing scenarios equals:

$$\begin{aligned} &CS = \\ &(V + bN_1)N_1 - t\int_{d_1}^{N_1}(x - d_1)\,dx + (V + bN_2)N_2 - t\int_{N_1}^{1-d_2}((1-x) - d_2)\,dx. \end{aligned} \tag{10}$$

Information Effects (Echo Chambers) We now introduce the information effects case that follows from Kim and Serfes (2006). In the information effects case, we assume that consuming from a second media outlet gives some extra utility to a consumer, as it contains additional information to that of the first outlet. We can argue that this is true even when taking into consideration that the second outlet has a different ideological position from the "more" ideal first one. The idea is that when the additional content is at a "less" ideal location, consumers may still consume it because they value additional content. However, it is reasonable to suppose that consumers would only consume from a second outlet if this is not too far from their ideal location (as captured by the transport costs parameter).

To model these ideas, we then assume that consumers have the following valuation when they consume news. If a consumer consumes from just one media firm, he obtains a valuation of V_S. If a consumer consumes from two media firms, he obtains a valuation of V_M, with $V_M > V_S$. As in the previous case (network effects), each consumer has an ideal variety and as a result, consumers suffer a disutility when they have to consume other types of variety. In particular, as before, when a consumer consumes a variety different from his ideal one, he has to pay a transport cost t. If consumer x consumes from media firm 1, his disutility equals $t(x - d_1)$. If consumer x consumes from media firm 2, his disutility equals: $t(1 - (x + d_2))$. If consumer x consumes from both media firm 1 and media firm 2, his disutility equals: $t(x - d_1) + t(1 - (x + d_2))$.

Utility then depends on whether a consumer consumes just one product (single-homing) or whether he consumes two products (multi-homing). If a consumer is outside the content segment of media firm 1 and only consumes from media firm 1, his utility equals:

$$U = V_S - t\,(x - d_1)\,. \tag{11}$$

In the same vein, if a consumer is outside the content segment of media firm 2 and just consumes from media firm 2, his utility equals: $U = V_S - t\,(1 - (x + d_2))$. If a consumer is inside the content segment of media firm 1 (or media firm 2) and just consumes from media firm 1 (or from media firm 2), his utility equals V_S.

For multi-homing, if a consumer is outside the content segment of media firm 1 or media firm 2, his utility equals:

$$U = V_M - t\,((x - d_1) + (1 - (x + d_2)))\,. \tag{12}$$

In turn, for multi-homing, if a consumer is inside the content segment of media firm 1 or media firm 2, his utility equals $V_M - t\,((1 - (x + d_2)))$ and $V_M - t\,((x - d_1))$, respectively.

Then, for single-homing of the indifferent consumer, $\hat{x}$ equals:

$$V_S - t\,(\hat{x} - d_1) = V_S - t\,(1 - (\hat{x} + d_2))\,. \tag{13}$$

With multi-homing, in turn, there are two indifferent consumers. The first indifferent consumer, x_L, is indifferent between consuming from media firm 1 only or consuming from both media firms (media firm 1 and media firm 2). The second indifferent consumer, x_R, is indifferent between consuming from media firm 2 only or consuming from both media firms. The first indifferent consumer, x_L, equals:

$$V_S - t\,(x_L - d_1) = V_M - (t\,(x_L - d_1) + t\,(1 - (x_L + d_2)))\,.$$

Then for the second indifferent consumer, x_R equals:

$$V_S - t\,(1 - (x_R + d_2)) = V_M - (t\,(x_R - d_1) + t\,(1 - (x_R + d_2)))\,. \tag{14}$$

From the equations for the indifferent consumers in the multi-homing scenario, we can already see an important difference to the network effects case. In the network effects case, some consumers have a high valuation of network effects and for that reason, they are assumed to multi-home. In the information case effects, however, multi-homing consumers emerge endogenously when $x_R > x_L$ (we investigate this condition in Section 5). In other words, in the information effects case, multi-homing is endogenous, while in the network effects case, multi-homing is exogenous.

Consumer surplus under single-homing then equals:

$$CS = V_S - t\int_{d_1}^{\hat{x}} (x - d_1)\, dx - t\int_{\hat{x}}^{1-d_2} (1 - (x + d_2))\, dx, \tag{15}$$

and consumer surplus under multi-homing equals:

$$\begin{aligned} CS = &\int_0^{x_L} V_S dx + \int_{x_L}^{x_R} (V_S + V_M)\, dx + \int_{x_R}^{1} V_S dx \\ &-t\int_{d_1}^{x_L} (x - d_1)\, dx - t\int_{x_R}^{1-d_2} (1 - (x + d_2))\, dx \\ &-t\int_{x_L}^{x_R} ((x - d_1) + (1 - (x + d_2)))\, dx. \end{aligned} \tag{16}$$

Social Welfare It can now be seen that social welfare in both the single-homing and multi-homing scenarios is then:

$$W = \Pi_1 + \Pi_2 + CS. \tag{17}$$

Timing of the Game The timing of the game is the following. In the first stage, the media firms choose the diversity of content to offer to consumers, d_i ($i = 1, 2$). In the second stage, media firms decide on advertising prices, a_i. In the next sections, we derive the equilibrium of the model for the two multi-homing cases. We first look at the network effects case and then turn to the information effects case.

4 Social Media and Network Effects

In this section, we analyze the network effects case. We start with the single-homing scenario, and thereafter turn to the multi-homing scenario. We then compare the two scenarios in terms of profits, consumer surplus, and social welfare.

4.1 Single-Homing

We solve the model in the usual fashion. We first find the indifferent consumer, and afterwards solve the model by backward induction (starting with advertising rates, and then the choice of content provision).

Indifferent Consumer To find the indifferent consumer, we solve for s_1 and n_1, from equations 7 and 8, to obtain:

$$\begin{aligned} s_1 &= \frac{(b_H(1-2(1-\lambda)n_1)-t(1-d_2+d_1))}{2(\lambda b_H - t)} \\ n_1 &= \frac{(b_L(1-2\lambda s_1)-t(1-d_2+d_1))}{2(b_L(1-\lambda)-t)}. \end{aligned} \tag{18}$$

We then have two equations in two unknowns, s_1 and n_1. Solving simultaneously for s_1 and n_1, we have:

$$\begin{aligned} s_1 &= \frac{\left(t(1+d_1-d_2)+(d_1-d_2)(b_H-b_L)(1-\lambda)-\Delta^{SH}\right)}{2(t-\Delta^{SH})} \\ n_1 &= \frac{(1+d_1-d_2)(t-\lambda(b_H-b_L))-b_L}{2(t-\Delta^{SH})}, \end{aligned} \tag{19}$$

where $\Delta^{SH} = (\lambda b_H + (1-\lambda)\, b_L)$ is the average value of the network benefits parameter, b, under the single-homing scenario[12]. The higher Δ^{SH} is, the higher the network effects become. To avoid corner solutions, such as in Doganoglu and Wright (2006, 2010), we assume that the intensity of consumers' preferences (transport costs) is higher than the average value of the network benefits, i.e., $t > (\lambda b_H + (1-\lambda)\, b_L)$.

Advertising We now turn to advertising. To find the advertising rates, we need to solve the first order conditions (FOCs) for advertising, $a_i = 1, 2$. We can show that the FOCs for advertising equal[13]:

$$\begin{aligned} \frac{d\pi_1}{da_1} &= \frac{\left(t(1-d_2+d_1)-\Delta^{SH}\right)(\alpha-2\beta a_1)}{2(t-\Delta^{SH})} \\ \frac{d\pi_2}{da_2} &= \frac{\left(t(1-d_1+d_2)-\Delta^{SH}\right)(\alpha-2\beta a_2)}{2(t-\Delta^{SH})}. \end{aligned} \tag{20}$$

[12]Note that although advertising does not enter directly into s_1 and n_1, it enters indirectly via demands d_1 and d_2.

[13]The second order conditions (SOCs) are in the appendix. All SOCs, for both the network effects and information effects cases, are always satisfied.

Solving simultaneously for a_1 and a_2, we obtain:

$$a_1 = a_2 = \frac{\alpha}{2\beta}. \tag{21}$$

Next, we turn to the choice of content by media firms.

Content Regarding the choice of content, we have to solve the FOCs for content provision, $d_i = 1, 2$. We can show that the FOCs for content provision equal:

$$\begin{aligned} \frac{d\pi_1}{dd_1} &= \frac{\left(t\alpha^2 - 8d_1\gamma\beta\left(t - \Delta^{SH}\right)\right)}{8(t - \Delta^{SH})\beta} \\ \frac{d\pi_2}{dd_2} &= \frac{\left(t\alpha^2 - 8d_2\gamma\beta\left(t - \Delta^{SH}\right)\right)}{8(t - \Delta^{SH})\beta}. \end{aligned} \tag{22}$$

Solving simultaneously for d_1 and d_2, we obtain:

$$d_1 = d_2 = \frac{\alpha^2 t}{8(t - \Delta^{SH})\beta\gamma}. \tag{23}$$

As we assume that $t > (\lambda b_H + (1 - \lambda) b_L)$, then, media firms provide positive levels of media content, i.e., $d_1 = d_2 > 0$.

Furthermore, the level of content provided by media firms has the following relations with the parameters in the model:

$$\begin{aligned} \frac{d(d_i)}{d\alpha} &= \frac{\alpha t}{4(t - \Delta^{SH})\beta\gamma} > 0 \\ \frac{d(d_i)}{d\beta} &= -\frac{\alpha^2 t}{8(t - \Delta^{SH})\beta^2\gamma} < 0 \\ \frac{d(d_i)}{dt} &= -\frac{\Delta^{SH}\alpha^2}{8(t - \Delta^{SH})^2\beta\gamma} < 0 \\ \frac{d(d_i)}{db_H} &= \frac{\lambda\alpha^2 t}{8((t - \Delta^{SH}))^2\beta\gamma} > 0 \\ \frac{d(d_i)}{db_L} &= \frac{(1 - \lambda)t\alpha^2}{8((t - \Delta^{SH}))^2\beta\gamma} > 0 \\ \frac{d(d_i)}{d\lambda} &= \frac{(b_H - b_L)t\alpha^2}{8((t - \Delta^{SH}))^2\beta\gamma} > 0, \text{ with } i = 1, 2. \end{aligned} \tag{24}$$

We can see that the provision of content increases with the size of the advertising market (high α and low β), with the valuation that consumers give to the network effects (high b_H and high b_L), and the number of high-type consumers (high λ). In turn, the provision of content decreases with the intensity of consumers' preferences (high transport costs, t).

4.2 Multi-Homing

As in the previous subsection, we start by finding the indifferent consumer, thereafter advertising rates, and then the choice of content.

Indifferent Consumer In the network effects case, all high-type consumers (consumers who place high values on network effects) multi-home, while all low-type consumers (consumers who place low values on network effects) single-home. In other words, the indifferent consumer is a low-type consumer. Solving equation 9 for n_1, we obtain:

$$n_1 = \frac{\left(t(1-d_2+d_1)-\Delta^{MH}\right)}{2(t-\Delta^{MH})}. \tag{25}$$

Note that $\Delta^{MH} = (1-\lambda)\, b_L$ is the average value of the network benefits parameter b under the multi-homing scenario.

For media firm 2, $n_2 = 1 - n_1$. From n_1, it is straightforward to derive total demand for media firm 1, because $N_1 = \lambda + (1-\lambda)\, n_1$:

$$N_1 = \frac{(t(\lambda(1+d_2-d_1)+(1+d_1-d_2)))+b_L(\lambda-1)(\lambda+1)}{2(t-\Delta^{MH})}. \tag{26}$$

Advertising We now find the advertising rates. As in the previous section, in order to do this, we need to solve the model for the FOCs for advertising. The FOCs for a_1 and a_2 are as follows:

$$\begin{aligned} \frac{d\pi_1}{da_1} &= \frac{((t(\lambda(1+d_2-d_1)+(1+d_1-d_2))-b_L(1-\lambda)(\lambda+1)))(\alpha-2\beta a_1)}{2(t-\Delta^{MH})} \\ \frac{d\pi_2}{da_2} &= \frac{(t(1+d_2-d_1)-b_L(1-\lambda))(\alpha-2\beta a_2)(1-\lambda)}{2(t-\Delta^{MH})}. \end{aligned} \tag{27}$$

Solving simultaneously for a_1 and a_2, we obtain the same advertising levels as in the single-homing scenario: $a_1 = a_2 = \frac{1}{2}\frac{\alpha}{\beta}$.

Content We now analyze the choice of content of the two media firms. As in the previous section, in order to do this, we examine the FOCs for content. The FOCs for d_1 and d_2 are as follows:

$$\begin{aligned} \frac{d\pi_1}{dd_1} &= \frac{\alpha^2 t(1-\lambda)-8d_1\gamma\beta(t-b_L(1-\lambda))}{8\beta(t-\Delta^{MH})} \\ \frac{d\pi_2}{dd_2} &= \frac{\alpha^2 t(1-\lambda)-8d_2\gamma\beta(t-b_L(1-\lambda))}{8\beta(t-\Delta^{MH})}. \end{aligned} \tag{28}$$

Solving simultaneously for d_1 and d_2, we obtain:

$$d_1 = d_2 = \frac{(1-\lambda)t\alpha^2}{8((t-\Delta^{MH})\beta\gamma)}. \quad (29)$$

We can see that $d_1 = d_2 > 0$ if $t > (1-\lambda)\, b_L$. This is always the case because we assume that $t > (\lambda b_H + (1-\lambda)\, b_L)$. Then also in the multi-homing scenario, media firms always provide positive levels of content.

As in the previous section, we also analyze how the different parameters in the model affect the level of content provided. It follows that:

$$\begin{aligned}
\frac{d(d_i)}{d\alpha} &= \frac{(1-\lambda)t\alpha}{4(t-\Delta^{MH})\beta\gamma} > 0 \\
\frac{d(d_i)}{d\beta} &= -\frac{(1-\lambda)t\alpha^2}{8(t-\Delta^{MH})\beta^2\gamma} < 0 \\
\frac{d(d_i)}{dt} &= -\frac{(1-\lambda)^2\alpha^2 b_L}{8(t-\Delta^{MH})^2\beta\gamma} < 0 \\
\frac{d(d_i)}{db_L} &= \frac{(1-\lambda)^2 t\alpha^2}{8(t-\Delta^{MH})^2\beta\gamma} > 0 \\
\frac{d(d_i)}{d\lambda} &= -\frac{\alpha^2 t^2}{8(t-\Delta^{MH})^2\beta\gamma} < 0, \text{ with } i = 1, 2. \quad (30)
\end{aligned}$$

We can see that, apart from one important exception, content provision in the multi-homing scenario behaves in a similar way to content provision in the single-homing scenario. As in the single-homing scenario, under the multi-homing scenario, content provision increases with the size of the advertising market (high α and low β), and with the valuation that low-type consumers give to the network effects (high b_L), and decreases with the intensity of consumers' preferences (high t). In addition, the valuation that high-type consumers place on the network effects (b_H) does not influence content provision, because all high-type consumers multi-home.

In contrast to the single-homing scenario, under the multi-homing scenario, content provision decreases with the number of consumers who are of the high type (high λ). The reason for this is that multi-homing consumers reduce the competition between media firms, given that they only consume from media firms. Therefore, media firms do not have to compete to capture multi-homing consumers. As a result, media firms can offer less content, given that less content will not reduce demand, and therefore it will also not decrease advertising revenues (and profits).

Multi-Homing versus Single-Homing We can now compare the levels of content provision under the single-homing scenario and the multi-homing scenario:

$$D^{SH} - D^{MH} = \frac{(t+(b_H-b_L)(1-\lambda))t\alpha^2\lambda}{4(t-\Delta^{SH})(t-\Delta^{MH})\beta\gamma} > 0, \tag{31}$$

where the superscript SH stands for single-homing and the superscript MH stands for multi-homing, with $D^{SH} = d_1^{SH} + d_2^{SH}$ and $D^{MH} = d_1^{MH} + d_2^{MH}$. We can see that the level of content provision is higher under the single-homing scenario than under the multi-homing scenario. The reason is that, as we have stated above, multi-homing consumers, by reducing competition between media firms, reduce the need for media firms to provide content.

4.3 Profits, Consumer Surplus, and Social Welfare

In this subsection, we examine profits, consumer surplus, and social welfare under the network effects case. We start with the single-homing scenario, then consider the multi-homing scenario, and then compare the two.

Single-Homing We can show that profits under the single-homing case equal:

$$\Pi_1^{SH} = \Pi_2^{SH} = \frac{\alpha^2}{8\beta} - \frac{t^2\alpha^4}{128(t-\Delta^{SH})^2\beta^2\gamma}, \tag{32}$$

where SH stands for single-homing.

For consumer surplus, we have:

$$CS^{SH} = \frac{\left(4v-t+2\Delta^{SH}\right)}{4} + \frac{t^2\alpha^2}{8(t-\Delta^{SH})\beta\gamma}\left(1 - \frac{t\alpha^2}{8(t-\Delta^{SH})\beta\gamma}\right). \tag{33}$$

As such, social welfare under single-homing is:

$$W^{SH} = \frac{\alpha^2}{4\beta} + \frac{\left(4v-t+2\Delta^{SH}\right)}{4} + \frac{t^2\alpha^2}{8(t-\Delta^{SH})\beta\gamma}\left(1 - \frac{\alpha^2}{8(t-\Delta^{SH})\beta}\left(\frac{t}{\gamma}+1\right)\right). \tag{34}$$

Multi-Homing For the multi-homing scenario, profits are:

$$\Pi_1^{MH} = \Pi_2^{MH} = \frac{(\lambda+1)\alpha^2}{8\beta} - \frac{\alpha^4t^2(1-\lambda)^2}{128(t-\Delta^{MH})^2\beta^2\gamma}, \tag{35}$$

where MH stands for multi-homing.

Consumer surplus is:

$$CS^{MH} = \frac{\alpha^2 t^2(1-\lambda)}{8(t-\Delta^{MH})\beta\gamma}\left(1 - \frac{\alpha^2 t(1-\lambda)}{8(t-\Delta^{MH})\beta\gamma}\right) + \frac{\left(\left(4v-\left(\lambda^2+1\right)(t-2\lambda)+2b_L(1-\lambda)\left(\lambda^2+1\right)\right)\right)}{4}. \tag{36}$$

As a result, social welfare equals:

$$W^{MH} = \frac{(\lambda+1)\alpha^2}{4\beta} + \frac{\left(\left(4v-\left(\lambda^2+1\right)(t-2\lambda)+2b_L(1-\lambda)\left(\lambda^2+1\right)\right)\right)}{4} + \frac{\alpha^2 t^2(1-\lambda)}{8(t-\Delta^{MH})\beta\gamma}\left(1 - \frac{\alpha^2(1-\lambda)}{8(t-\Delta^{MH})\beta}\left(\frac{t}{\gamma}+1\right)\right). \tag{37}$$

Single-Homing versus Multi-Homing In terms of profits, consumer surplus, and social welfare, we are interested in comparing the two cases, single-homing and multi-homing. For profits, we have:

$$\Pi^{SH} - \Pi^{MH} = -\frac{\alpha^2\lambda}{8\beta} + \frac{((1-\lambda)(\lambda b_H+(2-\lambda)b_L)-t(2-\lambda))(t+(1-\lambda)(b_H-b_L))t^2\alpha^4\lambda}{128(t-\Delta^{SH})^2((t-\Delta^{MH}))^2\beta^2\gamma} < 0. \tag{38}$$

It can be shown that $\Pi^{SH} - \Pi^{MH} < 0$. To see this, note that the first term in equation 38 is always negative. This term captures the effect of the size of the advertising market on profits and it becomes more important when α is much larger than β (large advertising market). Regarding the second term, all elements in this term are positive with the exception of $(\lambda b_H + b_L(2-\lambda)) - t(2-\lambda)$, which is negative for $t > \frac{(1-\lambda)(\lambda b_H+b_L(2-\lambda))}{(2-\lambda)}$. Since $\Delta^{SH} - \frac{(1-\lambda)(\lambda b_H+b_L(2-\lambda))}{(2-\lambda)} = \frac{b_H\lambda}{(2-\lambda)} > 0$, the result above follows.

This suggests that profits are always lower under single-homing than under multi-homing. This is because multi-homing competition is softer and media firms have higher demand, because some consumers consume from both media firms. This fact contributes positively to profits in two ways under the multi-homing scenario relative to the single-homing scenario. First, because of lower competition in the multi-homing scenario, media firms need to invest less in content, leading to lower costs. Second, because of higher demand in the multi-homing scenario, media firms have higher advertising revenues.

With respect to consumer surplus, we have:

$$CS^{SH} - CS^{MH} = \frac{\lambda(\lambda(t-2\lambda(1-b_L))+2(b_H-\lambda b_L-1))}{4} + \frac{t^2\alpha^2\lambda(t+(1-\lambda)(b_H-b_L))}{8(t-\Delta^{SH})((t-\Delta^{MH}))\beta\gamma}\left(1 - \frac{\alpha^2 t(t(2-\lambda)-(1-\lambda)(\lambda b_H+(2-\lambda)b_L))}{8(t-\Delta^{SH})((t-\Delta^{MH}))\beta\gamma}\right). \tag{39}$$

Two effects are present when comparing consumer surplus in the single-homing scenario and in the multi-homing scenario. First, as we have seen above, media firms provide more content under single-homing than under multi-homing. Second, under multi-homing, network effects are larger, because multi-homing consumers benefit from network effects from all consumers in the market. The first effect contributes to higher consumer surplus in the single-homing scenario relative to the multi-homing scenario. The second effect contributes to higher consumer surplus under the multi-homing scenario relative to the single-homing scenario. The first effect tends to be stronger than the second effect when the intensity of consumers' preferences (t) is low in relation to the network effects (b_H and b_L).

From equations 38 and 39, we can also calculate the difference in social welfare between the single-homing and multi-homing scenarios:

$$W^{SH} - W^{MH} = -\frac{\alpha^2\lambda}{4\beta} + \frac{\lambda(\lambda(t-2\lambda)+2(b_H-\lambda(1-\lambda)b_L)-2)}{4}$$
$$+\left(1 - \frac{\alpha^2(t+\gamma)(t(2-\lambda)+(\lambda-1)(\lambda b_H+(2-\lambda)b_L))}{8(t-\Delta^{SH})(t-\Delta^{MH})\beta\gamma}\right)\frac{(t+(1-\lambda)(b_H-b_L))t^2\alpha^2\lambda}{8(t-\Delta^{SH})(t-\Delta^{MH})\beta\gamma}. \quad (40)$$

The same forces as demonstrated above for profits and consumer surplus also affect social welfare under the multi-homing and the single-homing scenarios. Social welfare tends to be higher in the multi-homing scenario than in the single-homing scenario, when the advertising market is large (i.e., larger α in relation to β), and when the intensity of consumers' preferences (t) is high relative to the network effects (b_H and b_L).

Figure 1 and Figure 2 summarize the results above. Figure 1 compares the single-homing scenario and the multi-homing scenario when the average value of network benefits is low. Figure 2 compares the single-homing scenario and the multi-homing scenario when the average value of network benefits is high. First, as mentioned above, profits are always higher in the multi-homing scenario relative to the single-homing scenario. Second, as the advertising market becomes smaller (high β), the single-homing scenario becomes more attractive in respect of consumer surplus and social welfare. In turn, for a large advertising market (low β), consumer surplus and social welfare tend to be higher with the multi-homing scenario. Third, when the average value of network benefits is small, the single-homing scenario tends to dominate the multi-homing scenario in terms of consumer surplus and social welfare, especially when the advertising market is small. On the contrary, when the

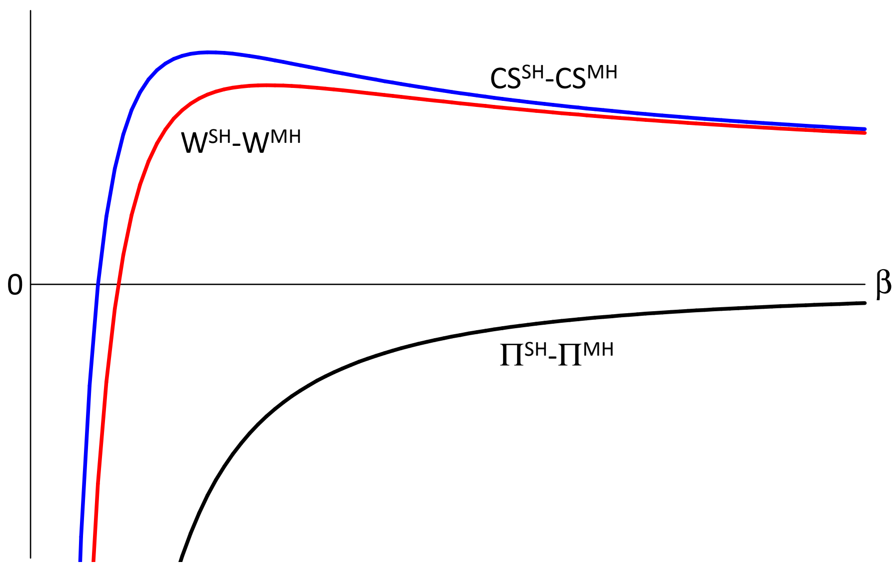

Figure 1: Low average value of the network benefits

average value of network benefits is high, the multi-homing scenario tends to dominate the single-homing scenario.

5 Echo Chambers and Information Effects

In this section, we analyze the case with information effects. We start by looking at the single-homing scenario, then the multi-homing scenario, and conclude by comparing the two scenarios in terms of profits, consumer surplus, and social welfare.

5.1 Single-Homing

As for the network effects case, we solve the model by backward induction. We start with the indifferent consumer, then find advertising levels and finally, content provision.

Indifferent Consumer It is straightforward to check that for the indifferent consumer in the single-homing scenario we have:

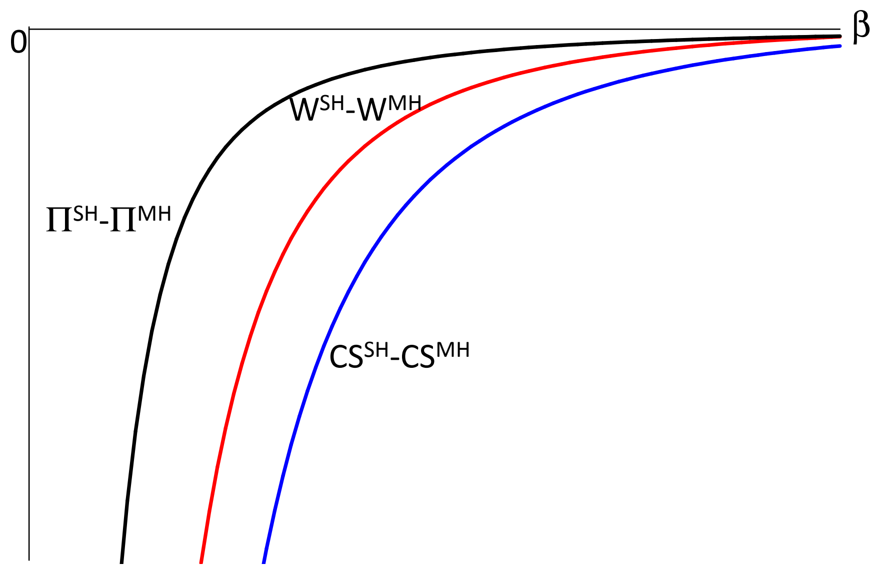

Figure 2: High average value of the network benefits

$$\hat{x} = \frac{(1+d_1-d_2)}{2}. \quad (41)$$

Advertising It can be shown that the FOCs in relation to advertising (a_i, with $i = 1, 2$) are:

$$\begin{aligned} \frac{d\Pi_1}{da_1} &= \frac{1}{2}\left(\alpha - 2\beta a_1\right)\left(d_1 - d_2 + 1\right) \\ \frac{d\Pi_2}{da_2} &= \frac{1}{2}\left(\alpha - 2\beta a_2\right)\left(d_2 - d_1 + 1\right). \end{aligned} \quad (42)$$

Solving equation 42 for a_i, with $i = 1, 2$, we obtain:

$$a_1 = a_2 = \frac{\alpha}{2\beta}. \quad (43)$$

Advertising levels are then the same under the network effects case and the information effects case.

Content We next find the content provision levels of the two media firms under single-homing. We can show that the FOCs for content provision are:

$$\begin{aligned} \frac{d\Pi_1}{dd_1} &= \frac{\alpha^2 - 8\beta\gamma d_1}{8\beta} \\ \frac{d\Pi_2}{dd_2} &= \frac{\alpha^2 - 8\beta\gamma d_2}{8\beta}. \end{aligned} \tag{44}$$

Solving equation 44 for d_i, with $i = 1, 2$, we obtain:

$$d_1 = d_2 = \frac{\alpha^2}{8\beta\gamma}. \tag{45}$$

We can see that:

$$\begin{aligned} \frac{\delta d_1}{\delta \alpha} &= \frac{\alpha}{4\beta\gamma} > 0 \\ \frac{\delta d_1}{\delta \beta} &= -\frac{\alpha^2}{8\beta^2\gamma} < 0 \\ \frac{\delta d_1}{\delta \gamma} &= -\frac{\alpha^2}{8\beta\gamma^2} < 0. \end{aligned} \tag{46}$$

Content provision then increases with the size of the advertising market (high α and low β) and decreases with the costs of providing content (high γ).

5.2 Multi-Homing

We now analyze the multi-homing scenario. Again, we solve the model by backward induction.

Indifferent Consumer We have seen in Section 3 that what differentiates the single-homing scenario from the multi-homing scenario is the indifferent consumer. While in the single-homing scenario there is just one indifferent consumer, in the multi-homing scenario, there are two. We can show that in the multi-homing scenario, for the first indifferent consumer, x_L, we have:

$$x_L = \frac{t(1-d_2) - (V_M - V_S)}{t}. \tag{47}$$

For the second indifferent consumer, x_R, we have:

$$x_R = \frac{td_1 + (V_M - V_S)}{t}. \tag{48}$$

In order for multi-homing to arise in equilibrium, we need that $x_L \neq x_R$. If $x_L = x_R$, we fall back to the single-homing scenario. In particular, for multi-homing to emerge, we need that $x_R - x_L > 0$. This is so if:

$$x_R - x_L > 0 \Leftrightarrow t < \frac{2(V_M - V_S)}{1 - d_1 - d_2}. \tag{49}$$

In other words, multi-homing occurs when transport costs are not too high in relation to consumers' valuation of multi-homing, $V_M - V_S$, and to the diversity of content provided in the market $(1 - d_1 - d_2)$. Accordingly, the higher V_M is in relation to V_S, and the higher the diversity of content, higher d_1 and d_2, the more likely it is that multi-homing occurs.

Advertising We now turn to advertising. The FOCs in relation to advertising are:

$$\begin{aligned} \frac{d\Pi_1}{da_1} &= (\alpha - 2\beta a_1)\frac{V_M - V_S + td_1}{t} \\ \frac{d\Pi_2}{da_2} &= (\alpha - 2\beta a_2)\frac{V_M - V_S + td_2}{t}. \end{aligned} \tag{50}$$

Solving equation 42 for a_i, with $i = 1, 2$, we obtain the same advertising levels as for the single-homing scenario (equation 43), i.e., $a_1 = a_2 = \frac{\alpha}{2\beta}$.

Content We now turn to content provision. The FOCs for content provision are:

$$\begin{aligned} \frac{d\Pi_1}{dd_1} &= \frac{\alpha^2 - 4\beta\gamma d_1}{4\beta} \\ \frac{d\Pi_2}{dd_2} &= \frac{\alpha^2 - 4\beta\gamma d_2}{4\beta}. \end{aligned} \tag{51}$$

Solving equation 44 for d_i, with $i = 1, 2$, we obtain:

$$d_1 = d_2 = \frac{\alpha^2}{4\beta\gamma}. \tag{52}$$

Similar to the single-homing scenario, content provision increases with the size of the advertising market (high α in relation to β) and is reduced with the costs of providing content (high γ).

Multi-Homing versus Single-Homing Regarding the relation between the single-homing scenario and the multi-homing scenario, we are interested in two issues. First, in the network effects case, we would like to know in which scenario, multi-homing or single-homing, the market provides more content. Second, we would like to know under what conditions the single-homing scenario and the multi-homing scenario emerge in equilibrium. It is not possible to answer this question in the network effects case, because it assumes that multi-homing is exogenous.

Start with the amount of content provided by the market in each scenario, single-homing versus multi-homing:

$$D^{SH} - D^{MH} = -\tfrac{\alpha^2}{4\beta\gamma} < 0, \tag{53}$$

where the superscript SH stands for single-homing and the superscript MH for multi-homing, with $D^{SH} = d_1^{SH} + d_2^{SH}$ and $D^{MH} = d_1^{MH} + d_2^{MH}$. We can then conclude that the multi-homing scenario provides more content than the single-homing scenario. The reason for this result is that under multi-homing, demand is larger. Therefore, there is higher competition for advertising, which in turn promotes media firms to provide more content in order to attract more demand and, as such, advertising revenues. Furthermore, under multi-homing, media firms have greater incentives to provide more diversified content (to reduce transport costs faced by consumers) in order to attract more demand.

In the network effects case, more content is offered under single-homing than under multi-homing, and the opposite occurs in the information effects case. The reason for this difference is that in the network effects case, multi-homing consumers reduce competition between media firms. Accordingly, when consumers multi-home because they like to consume the same as others consume (network effects), this means that even if media firms reduce content provision, consumers will not necessarily lose much in terms of utility, because they continue to receive the benefits of consuming what others consume. As a result, in the network effects case in the presence of multi-homing consumers, media firms can reduce content provision without reducing demand or consumer surplus. On the contrary, in the information effects case, consumers care about how much utility they receive from consuming from more than just one media outlet, in addition to how much content they consume. As a result, in the presence of multi-homing consumers, media firms have incentives to increase content in order to attract more consumers to multi-homing.

We now analyze when the single-homing and the multi-homing scenarios arise in equilibrium. This question relates to equation 49, i.e., if $x_R - x_L \lesseqgtr 0$. For $x_R - x_L > 0$, multi-homing occurs, while for $x_R - x_L \leq 0$, we have single-homing instead. It can be shown that:

$$\begin{aligned} \text{For } \frac{\alpha^2}{4\gamma} &< \beta < \frac{\alpha^2}{2\gamma} \Rightarrow x_R > x_L \text{ if } t > -4\beta\gamma\frac{(V_M - V_S)}{\alpha^2 - 2\beta\gamma} \\ \text{For } \beta &> \frac{\alpha^2}{2\gamma} \Rightarrow x_R > x_L \text{ if } t < -4\beta\gamma\frac{(V_M - V_S)}{\alpha^2 - 2\beta\gamma}. \end{aligned} \tag{54}$$

The first relation is valid when the advertising market is large ($\frac{\alpha^2}{4\gamma} < \beta < \frac{\alpha^2}{2\gamma}$), while the second relation is valid when the advertising market is small ($\beta > \frac{\alpha^2}{2\gamma}$). It can be shown that the first relation is always satisfied, because $t > 0$. The second relation, in turn, is only satisfied when t is small. In other words, when the advertising market is large, multi-homing always arises. The rationale for this is that when the advertising market is large, media firms can finance content diversification, which reduces transportation costs for consumers (especially for consumers located outside the content provision segments of the two media firms). As a result, more consumers are willing to consume from the two media firms. In turn, when the advertising market is small, media firms cannot finance content diversification via advertising revenues, and as a consequence, content provision in the market is smaller. In this way, consumers are only willing to consume from both media firms (multi-homing) when transport costs are not too high.

5.3 Profits, Consumer Surplus, and Social Welfare

In this subsection, we examine profits, consumer surplus, and social welfare under the information effects case. We start with the single-homing scenario, thereafter the multi-homing scenario, and then compare the two.

Single-Homing In the single-homing scenario, profits equal:

$$\Pi_1^{SH} = \Pi_2^{SH} = \frac{\alpha^2}{8\beta}\left(1 - \frac{\alpha^2}{16\beta\gamma}\right), \tag{55}$$

where SH stands for multi-homing.

With respect to consumer surplus, we have:

$$CS^{SH} = V_S - \frac{t\left(\alpha^2 - 4\beta\gamma\right)^2}{64\beta^2\gamma^2}. \tag{56}$$

In terms of social welfare, we have:

$$W^{SH} = V_S - \frac{\left(t\left(\alpha^2-4\beta\gamma\right)^2+\alpha^2\gamma\left(\alpha^2-16\beta\gamma\right)\right)}{64\beta^2\gamma^2}. \tag{57}$$

Multi-Homing In the multi-homing scenario, profits equal:

$$\Pi_1^{MH} = \Pi_2^{MH} = \frac{\alpha^2}{32\beta}\left(\frac{\alpha^2}{\beta\gamma} + \frac{8(V_M-V_S)}{t}\right), \tag{58}$$

where MH stands for multi-homing.

Consumer surplus, in turn equals:

$$CS^{MH} = \frac{(V_M-V_S)(V_S+V_M)}{t} + \frac{\left(V_M\left(\alpha^2-2\beta\gamma\right)+2\beta\gamma V_S\right)}{2\beta\gamma}. \tag{59}$$

Social welfare in the multi-homing scenario is then:

$$W^{MH} = \frac{(V_M-V_S)\left(\alpha^2+2\beta(V_S+V_M)\right)}{2t\beta} + \frac{\alpha^4+16\beta^2\gamma V_S+8\beta V_M\left(\alpha^2-2\beta\gamma\right)}{16\beta^2\gamma}. \tag{60}$$

Single-Homing versus Multi-Homing We now compare the single-homing and the multi-homing scenarios in terms of profits, consumer surplus, and social welfare. We start with profits. It is straightforward to check that the difference between profits in the single-homing and the multi-homing scenario equal:

$$\Pi^{SH} - \Pi^{MH} = -\alpha^2\frac{t\left(5\alpha^2-16\beta\gamma\right)+32\beta\gamma(V_M-V_S)}{128t\beta^2\gamma}. \tag{61}$$

The sign of $\Pi^{SH} - \Pi^{MH}$ depends on the two terms in the numerator. The first term captures the effect of the size of the advertising market and transport costs, while the second term captures the effect of consumers' preferences for multi-homing. We can see that the second term, the effect of consumers' preferences for multi-homing, is unambiguously positive, because $V_M > V_S$. Then, the higher the value of V_M in relation to V_S is, the smaller the profits under single-homing relative to multi-homing become. The first term is only positive for $\beta < \frac{5\alpha^2}{16\gamma}$, and negative for $\beta > \frac{5\alpha^2}{16\gamma}$. As such, a small advertising market leads to larger profits under single-homing than under multi-homing, and more so with higher transportation costs, t. The reason for this is that under single-homing, competition for advertising is not as fierce as under multi-homing, given that media firms do not share consumers. Furthermore, larger transport costs make multi-homing less attractive for consumers, which makes them consume less and therefore reduces profits for media firms.

We turn now to consumer surplus. The difference in consumer surplus between the single-homing and the multi-homing scenario is:

$$CS^{SH} - CS^{MH} = -\frac{t^2\left(\alpha^2-4\beta\gamma\right)^2+32t\beta\gamma V_M\left(\alpha^2-2\beta\gamma\right)+64\beta^2\gamma^2(V_M-V_S)(V_S+V_M)}{64t\beta^2\gamma^2}. \quad (62)$$

The difference in consumer surplus between the single-homing and the multi-homing scenario is also affected by the size of the advertising market, transport costs (first and second terms), and by consumers' preferences for multi-homing (third term). We can see that larger transport costs and a larger advertising market make consumers worse off in the single-homing regime. This is so because under the single-homing scenario, media firms provide less content than in the multi-homing scenario (and less so the larger the advertising market is), which means that consumers pay higher transport costs. In addition, the more consumers value multi-homing, the worse off they are under the single-homing case relative to the multi-homing scenario.

With respect to social welfare, we have:

$$W^{SH} - W^{MH} =$$
$$-\frac{t\alpha^2\left(t\alpha^2+\gamma\left(5\alpha^2-16\beta\gamma\right)\right)+8t\beta\gamma\left(\alpha^2-2\beta\gamma\right)(4V_M-t)+32\beta\gamma\left(\gamma(V_M-V_S)\left(\alpha^2+2\beta(V_M+V_S)\right)\right)}{64t\beta^2\gamma^2}. \quad (63)$$

As for profits and consumer surplus, the difference in social welfare between the single-homing and multi-homing scenarios is affected by the size of the advertising market, transport costs (first and second terms), and by consumers' preferences for multi-homing (second and third terms). In particular, social welfare tends to be lower in the single-homing case when transport costs are high, the advertising market is large, and consumers have a high valuation of multi-homing. Opposite results are obtained for the multi-homing scenario.

The above results are summarized in Figure 3 and Figure 4. Figure 3 shows either high transport costs (high t) or low valuation of multi-homing (low V_M in relation to V_S). Figure 4 shows either low transport costs (low t) or high valuation of multi-homing (high V_M in relation to V_S). In both cases, multi-homing is more attractive with low β, i.e., when the advertising market

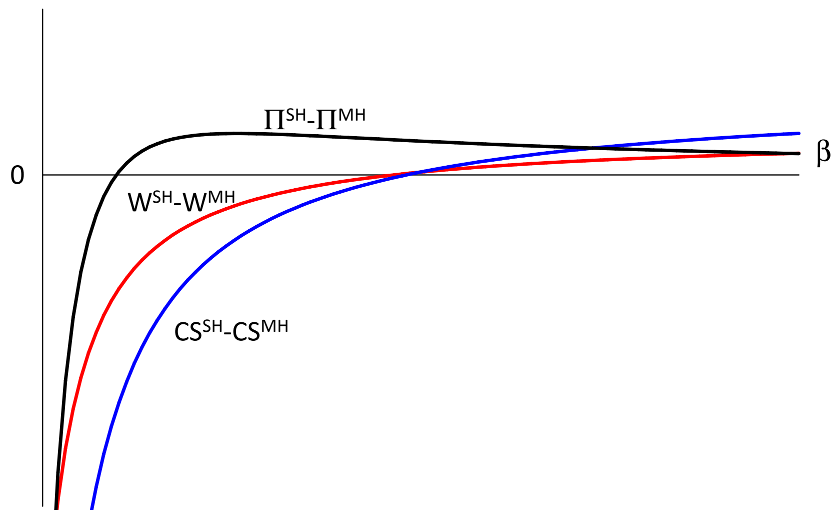

Figure 3: High transport costs (high t) or low valuation of multi-homing (low V_M and high V_S)

is large. The opposite occurs for high β, i.e. small advertising market. In addition, when transport costs are low or consumers do not value multi-homing highly (Figure 3), single-homing can be more attractive than multi-homing (in terms of profits, consumer surplus, and social welfare), especially when the advertising market is small. It is more difficult for this to occur when transport costs are low or consumers value multi-homing highly (Figure 4). In this last case, multi-homing tends to offer higher profits, higher consumer surplus, and higher social welfare.

6 Discussion

In this paper, we have analyzed the effects of social media and echo chambers on the diversity of content provided in the media market. We have considered two cases that try to capture social media and echo chambers: network effects and information effects, respectively. With the network effects case, consumers derive utility from consuming the same that others consume. This case tries to capture some of the characteristics present in social media, in particular network effects with other consumers. With the information effects

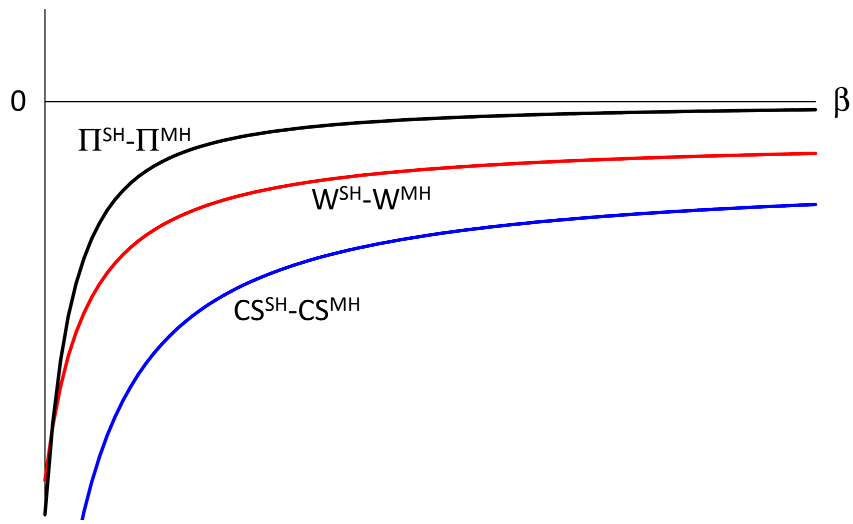

Figure 4: Low transport costs (low t) or high valuation of multi-homing (high V_M and low V_S)

case, consumers derive utility from consuming from more than just one outlet. This case tries to capture the opposite of echo chambers, where consumers are averse to views that are opposite to their own.

In addition to network effects and information effects, our model has also introduced two additional characteristics present in media markets on the demand side. First, consumers have an ideal variety of content and they suffer a disutility from consuming content that differs from their ideal content. Second, consumers can be single-homing consumers (they consume from just one media outlet, such as in echo chambers) or multi-homing consumers (they consume from more than just one media outlet). Multi-homing consumers are ubiquitous, for instance on the Internet, but a large part of the literature on media economics focuses on single-homing consumers.

From the supply side, we have introduced two central characteristics of media markets on the Internet. First, competition for advertising revenues. Second, competition for content. The first characteristic captures the two-sided nature of media markets. Advertisers prefer to advertise in media firms with a larger audience, because this allows them to expose their message to more consumers. As such, media firms have strong incentives to increase demand (via an increase in content provision) in order to attract advertising revenues.

The second characteristic tries to tackle a limitation of many models of media markets, where it is usually assumed that media firms only provide one type of content. In reality, however, and especially regarding the Internet, most media firms are multi-content. The incentives for media firms to be multi-content are that this strategy might allow them to capture more demand (and therefore advertising revenues), because then consumers incur lower transportation costs (than under single-content strategy) to consume their ideal variety (which means lower disutility from consumption). A multi-content strategy is in this sense a way for media firms to cater to diverse consumer preferences.

We show that the comparison of the level of content provision in the media market between the single-homing and the multi-homing scenario depends on what type of motivation for multi-homing we are considering. In this sense, our paper also provides a methodological contribution, because we show that different models of multi-homing can provide different results. In fact, in the case of network effects, content provision is larger with single-homing than with multi-homing. The reason for this is that multi-homing consumers, by consuming from different media firms, reduce competition in the media market, because media firms face lower competition to attract these consumers. Accordingly, with network effects, multi-homing consumers might give more weight to what other consumers consume than to how much content media firms provide. As a result, there is less need for media firms to provide a more diversified content to attract demand (and therefore generate more advertising revenues). The outcome is that social welfare only tends to be higher under the multi-homing scenario relative to the single-homing scenario when the advertising market is large, and when the network effects are large relative to the intensity of consumers' preferences (transportation costs), and *vice-versa*.

In the case of information effects, we show that the opposite occurs, i.e., content provision is higher under the multi-homing scenario than under the single-homing scenario. The reason is that, in the information effects case, consumers only multi-home if media firms provide enough content. In this sense, and compared with the network effects case, in the information effects case media firms have stronger incentives to provide content in order to attract demand (and therefore generate more advertising revenues). In terms of social welfare, in the network effects case social welfare is higher with multi-homing than with single-homing when the advertising market is large; consumers value multi-homing more than single-homing (large information benefits) and the intensity of consumers' preferences is low (transport costs are small), and vice-versa. The effect of transport costs is particularly interesting, because it shows that when the intensity of consumers' preferences is high (they strongly dislike different opinions from their own), the more likely it is that single-homing consumers will emerge (i.e., "echo chambers"). This can provide a rationale for the phenomenon of divisive politics that we are currently witnessing. We believe that our results raise a series of challenges for media authorities and regulators, because a main objective is that media firms provide diversified content. The media authorities and regulators, however, only have instruments to deal with the supply side of the market (such as competition law), and they can therefore do little to tackle the demand side. The question that arises is whether supply side instruments can counteract demand side forces that reduce media content. If not, regulation of media markets may need to be considered. This is in our view an interesting avenue to explore further. All of these issues are especially relevant in a world where social media make network effects a central feature of media markets and where politics are more divisive because people are less tolerant of opinions that do not agree with their own, making information effects weaker, and echo chambers more pervasive.

A Appendix

Network Effects. Single-Homing: SOCs. SOCs for advertising:

$$\begin{aligned} \frac{d^2\Pi_1}{da_1^2} &= -\frac{(t(1-d_2+d_1)-(\lambda b_H+b_L(1-\lambda)))\beta}{(t-\Delta^{SH})} \\ \frac{d^2\Pi_2}{da_2^2} &= -\frac{(t(1+d_2-d_1)-(\lambda b_H+b_L(1-\lambda)))\beta}{(t-\Delta^{SH})}. \end{aligned} \tag{64}$$

At the symmetric equilibrium $d_1 = d_2$, the SOCs for advertising are always satisfied.

SOCs for content:

$$\frac{d^2\Pi_1}{dd_1^2} = \frac{d^2\Pi_2}{dd_2^2} = -\gamma. \tag{65}$$

The SOCs for content are then always satisfied.

Network Effects. Multi-Homing: SOCs. SOCs for advertising:

$$\begin{aligned}\frac{d^2\Pi_1}{da_1^2} &= -\frac{(t((1+d_1-d_2)+\lambda(1+d_2-d_1))-b_L(1-\lambda)(1+\lambda))\beta}{(t-\Delta^{MH})} \\ \frac{d^2\Pi_2}{da_2^2} &= -\frac{(t(1+d_2-d_1)-b_L(1-\lambda))(1-\lambda)\beta}{(t-\Delta^{MH})}.\end{aligned} \tag{66}$$

At the symmetric equilibrium $d_1 = d_2$, the SOCs for advertising are always satisfied.

SOCs for content:

$$\frac{d^2\Pi_1}{dd_1^2} = \frac{d^2\Pi_2}{dd_2^2} = -\gamma. \tag{67}$$

The SOCs for content are then always satisfied.

Information Effects. Single-Homing: SOCs. SOCs for advertising:

$$\begin{aligned}\frac{d^2\Pi_1}{da_1^2} &= -\beta\left(d_1 - d_2 + 1\right) \\ \frac{d^2\Pi_2}{da_2^2} &= -\beta\left(d_2 - d_1 + 1\right).\end{aligned} \tag{68}$$

The SOCs for advertising are always satisfied.

SOCs for content:

$$\frac{d^2\Pi_1}{dd_1^2} = \frac{d^2\Pi_2}{dd_2^2} = -\gamma. \tag{69}$$

The SOCs for content are then always satisfied.

Information Effects. Multi-Homing: SOCs. SOCs for advertising:

$$\begin{aligned}\frac{d^2\Pi_1}{da_1^2} &= -2\beta\frac{(V_M-V_S)+td_1}{t} \\ \frac{d^2\Pi_2}{da_2^2} &= -2\beta\frac{(V_M-V_S)+td_2}{t}.\end{aligned} \tag{70}$$

The SOCs for advertising are always satisfied.

SOCs for content:

$$\frac{d^2\Pi_1}{dd_1^2} = \frac{d^2\Pi_2}{dd_2^2} = -\gamma. \tag{71}$$

The SOCs for content are then always satisfied.

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