Abstract

Net neutrality is believed to prevent the emergence of exclusive online content which yields Internet fragmentation. We examine the relationship between net neutrality regulation and Internet fragmentation in a game-theoretic model that considers the interplay between termination fees, exclusivity and competition between two Internet Service Providers (ISPs) and between two Content Providers (CPs). An exclusivity arrangement between an ISP and a CP reduces the CP’s exposure to some end users but it also reduces competition over ads among the CPs. Fragmentation arises in equilibrium when competition over ads among the CPs is very strong, the CPs’ revenues from advertisements are very low, the content of the CPs is highly complementary, or the termination fees are high. We find that the absence of fragmentation is always beneficial for consumers, as they can enjoy all available content. Policy interventions that prevent fragmentation are thus good for consumers. However, results for total welfare are more mixed. A zero-price rule on traffic termination is neither a sufficient nor a necessary policy instrument to prevent fragmentation. In fact, regulatory interventions may be ineffective or even detrimental to welfare and are only warranted under special circumstances.

Keywords: Net neutrality; Internet fragmentation; Exclusivity.

JEL Codes: L13; L51; L52; L96.
1 Introduction

In the past few years the debate over net neutrality (NN) has attracted large attention by academia and the public alike. Thereby, the term NN masks several distinct policy issues that are all concerned with how data flows on the Internet should be handled and priced (Krämer et al., 2013). One of the most salient issues of NN regulation is that it seeks to maintain the status quo whereby content and service providers (CPs) pay only once for access to the Internet (usually to some backbone provider), and not again for the delivery of their traffic to end users at each terminating Internet service provider (ISP). This custom of ISPs not to charge termination fees has been coined the zero-price rule (Hemphill, 2008; Lee and Wu, 2009). However, although the zero-price rule is still the status quo today, several ISPs worldwide, among them AT&T (Bloomberg, 2005), Telefonica and Vodafone (Lambert, 2010) as well as Deutsche Telekom (Deutsche Welle, 2010), have publicly announced that they intend to depart from this custom. This has heated, if not started, the public debate on NN.

Following Lee and Wu (2009), proponents of NN justify the zero-price rule based on the arguments that it i) is efficient with respect to the economics of two-sided markets, ii) stimulates innovation and investment in broadband networks as well as content, and iii) prevents a fragmentation of the Internet. The first two of these arguments have been analyzed extensively by the recent academic literature, resulting in a more differentiated view in this regard (see Schuett, 2010; Faulhaber, 2011; and Krämer et al., 2013 for a survey). The conclusion from this research is that the zero-price rule is in fact only efficient under special circumstances (see, e.g., Economides and Tåg, 2012; Guo et al. 2012) and that the effect of NN regulation on innovation and investment is at best ambiguous (see, e.g., van Schewick, 2007; Jamison and Hauge, 2008; Choi and Kim, 2010; Cheng et al., 2011; Economides and Hermalin, 2012; Krämer and Wiewiorra, 2012; Reggiani and Valletti, 2012; Bourreau et al., 2014; Guo and Easley, 2014). Interestingly, the third argument, that the zero-price rule prevents a fragmentation of the Internet, has thus far not been considered in detail. This aspect of the NN debate is important, however, as has recently been highlighted by Neelie Kroes, vice president of the European Commission, who emphasized that Internet fragmentation should be a concern to all Internet stakeholders: “I know there are pressures—regulatory, political and economic—to ‘fragment’ the Internet [...]. But the Internet’s most important characteristic is its universality: in principle, every node can communicate with every other. This has important implications for innovation, plurality, democratic values, cohesion and economic growth” (Worth, 2011). Moreover, a comprehensive analysis of the effect of a zero-price rule with respect to all three of the above mentioned arguments seems necessary in the light of current regulatory developments: several governments throughout the world (e.g., Canada, Japan, France,
Germany, UK (Carter et. al, 2010; Sluijs, 2012)) are considering whether to adopt a zero-price rule. The USA, Netherlands, Chile and Slovenia already enacted such NN regulation, which in the case of the USA, has been challenged in courts.

The link between Internet fragmentation and NN regulation (i.e., a zero-price rule) may not be obvious immediately. It can be traced back to an influential article by Lee and Wu (2009), who conjectured that the presence of termination fees “would almost certainly result in service providers ‘competing’ for content, as seen in other platform industries, by charging different fees and bargaining on exclusive arrangements with content providers. In turn, such bilateral agreements would inevitably lead to fragmentation—where certain content would only be available on certain service providers—and hence multiple ‘Internets’” (p.67). Certainly, this is a daunting hypothesis, which, if it were true, could be able to tilt the debate in favor of NN regulation. However, this conjecture was never investigated formally and there are at least two reasons to scrutinize it. First, the authors build their argument on a comparison of the Internet to other platform industries, such as video consoles and credit cards. Thereby they neglect that, albeit the Internet can be seen as a platform industry that connects end users with CPs, it is also very different from the aforementioned industries with respect to how content is financed. On the Internet content is still predominantly financed through advertisements (Dou, 2004; Evans, 2009; Anderson, 2012) and these advertisement revenues are collected directly by the CPs. This makes the Internet distinct from other platform industries in which content is either paid directly by end users (as, e.g., in the context of video games and credit cards) and not by advertisements, or in which advertisement revenues are collected by the vertically integrated platform providers (e.g., by TV stations and newspapers) and not by independent CPs.

Second, the proposed link between the presence of termination fees and the existence of exclusive content does not seem to be inevitable. For example, in the mid 90s, when the zero-price rule was still undisputed, many ISPs, including AOL, Prodigy and Compuserve, each adopted a so-called walled garden strategy, which relied on exclusive content to attract customers. More recently, especially mobile ISPs seem to compete for customers through exclusive content that is delivered through carrier-specific apps. To be precise, in this context ‘exclusive’ usually refers only to exclusive mobile access (e.g., via a smartphone) to the content, but does not mean that the content is generally not available through other channels (e.g., fixed networks). Nevertheless, the exclusive content deals are clearly aimed to differentiate the (mobile) ISPs’ networks, and they occur in the absence of a termination fee for CPs. For example, Verizon and the NFL recently struck an exclusive content deal where certain games can be streamed only on smartphones of Verizon subscribers (CNNMoney, 2013). In order to attain this exclusive content, Verizon pays an exclusivity fee of $1 billion over the course of four years.
Similarly, in the past Verizon customers received exclusive mobile access to content of Microsoft (Los Angeles Times, 2010) and ESPN (Verizon, 2007). Other mobile ISPs have made similar exclusivity arrangements. These include AT&T with Electronic Arts (AT&T, 2008) and Zynga (Bloomberg, 2011), Vodafone and Eidos (PRNewswire, 2003) as well as Deutsche Telekom and Bild, Germany’s largest tabloid newspaper (Nehl and Parplies, 2002). Hence, although the extent of exclusive content on the Internet is still rather limited (which is in line with the intuition that the current status quo of zero termination fees inhibits Internet fragmentation) it is not obvious that a zero-price rule can prevent Internet fragmentation.

Thus, it is interesting to study the precise interaction between the zero-price rule and Internet fragmentation. In this paper we propose a game-theoretic model to formally address this issue. The model takes into account the specifics of the Internet industry and considers the interplay between termination fees (i.e., a departure of the zero-price rule where fees are paid by the CPs to the terminating ISPs), exclusivity arrangements, and competition between ISPs and CPs, respectively. In this context, we also consider various externalities (such as complementarity and substitutability of content) that were previously not considered in the literature on NN. In this vein, we can offer a more fine grained view on whether and when termination fees in fact raise the danger of Internet fragmentation, and what their impacts are on the ISPs’ and CPs’ profits as well as on welfare. Moreover, we consider the impact of a no-exclusivity rule, which forbids ISPs and CPs to strike a deal on the exclusivity of content, as an alternative to the zero-price rule. The no-exclusivity rule, which is easy to implement and enforce by policy-makers, may address the problem of Internet fragmentation more directly. A similar rule has been proposed to the TV broadcasting market in the UK, for example. However, this was justified on the grounds of antitrust concerns and not by the fear of fragmentation (Weeds, 2013).

In particular, we consider competition between two access ISPs which connect Internet users to CPs. Internet users prefer the ISP that offers more (or more valuable) content. In reverse, CPs make money through online advertisements and therefore prefer to be seen by many users. Hence, there are cross-side network effects which characterize a two-sided market (Armstrong, 2006; Rochet and Tirole, 2006). If exclusivity arrangements are allowed, each ISP can bargain with a CP for the terms under which it is visible exclusively to the ISP’s customers. Generally, the CP must trade-off two effects when considering whether to accept such an exclusivity arrangement. On the one hand, exclusivity may result in a loss of exposure, thereby diminishing the CP’s ad revenues. On the other hand, CPs are in competition for Internet users’ ‘clicks’ and thus, by means of exclusivity agreements, CPs may benefit from reduced competition. In addition, the ISP may choose to compensate the CP for agreeing to be exclusive to the ISP. This is especially true for highly valued content, which will in turn raise
the relative attractiveness of the ISP and induce customers to sign a contract with it.

Our results highlight that Internet fragmentation (i.e., exclusivity of content) can occur also in the presence of a zero-price rule. This holds true, even if ISPs are not allowed to financially compensate the CP for a loss in exposure (i.e., when the exclusivity fees are also restricted to be zero). In a nutshell, a zero-price rule, as suggested by Lee and Wu (2009), is neither a necessary nor a sufficient condition to prevent Internet fragmentation. Hence, our finding is in line with the empirical evidence described above. However, everything else equal, we also confirm that Internet fragmentation does become more likely with the introduction of termination fees. The reason is simply that termination fees accrue at each ISP where the CP is visible and thus they affect the CP’s outside option in favor of accepting exclusivity. However, the conditions under which fragmentation occurs are more subtle and sometimes counterintuitive; and even in the presence of termination fees, fragmentation is not the inevitable outcome.

First, we note that there are various degrees to fragmentation that must be differentiated. Fragmentation, if it occurs, can either be partial, i.e., only a subset of the CPs is available exclusively at some ISP, or full, i.e., each CP is available at exactly one ISP only. Full fragmentation is the likely outcome when either i) competition over ads among the CPs is very strong, or ii) when the CPs’ revenue from advertisements are very low (i.e., there are only weak network effects for consumers on the CP side), or iii) when the online content of the CPs is highly complementary, or iv) when the termination fees are high. When CPs compete fiercely for customers’ clicks (case i), then full fragmentation becomes more likely, because it offers the CP a means to collectively evade this competitive pressure, although, unilaterally, exclusivity can harm a CP. Likewise, if the CPs’ ability to make money through advertisements is limited (case ii), they prefer to strike an exclusivity deal. If, however, Internet users consider the CPs’ content as highly complementary on the consumer side, then it is more likely that there is a Nash equilibrium wherein each ISP seeks to have an exclusive deal with a CP: if a rival ISP has agreed exclusivity with a CP, then the other ISP will want to do the same with the remaining CP, as, otherwise, the complementarity would benefit only the rival (case iii). Finally, when the termination fees paid to each ISP are high enough, it becomes more expensive for the CPs to deliver their content to both ISPs (case iv). On the contrary, if some of the above conditions are not met, either partial or no fragmentation is the likely outcome. In particular, fragmentation does not occur if competition over ads among the CPs is weak and CPs’ revenues from ads are high.

Concerning welfare, we find that consumer surplus is always highest under no fragmentation. Since the joint value of both contents is at least as high as the value of each content solely, this result arises as competition between ISPs does not allow them to raise the subscription fees too much to reflect
the increase in content. However, with respect to total welfare, which also incorporates the ISPs’ and CPs’ revenues, no fragmentation is the efficient outcome only when ad competition among the CPs is rather weak. If ad competition between CPs is strong, then exclusivity provides a means to avoid this competitive pressure and to increase CPs’ profits, which can render full fragmentation the efficient outcome with respect to total welfare. Thus, if policy makers want to ensure no fragmentation (e.g., because they value consumer surplus more, or because they believe that competition over ads among the CPs is rather weak), then a simple no-exclusivity rule is a well-suited instrument. By contrast, as noted above, a zero-price rule cannot prevent Internet fragmentation. In all other cases, (NN) regulation is at best superfluous, because it cannot improve on the equilibrium outcome without NN regulation. In fact, such regulation can be harmful, in the sense that the equilibrium is shifted away from the first-best. Thus, after all, NN regulation in the form of a zero-price rule does not seem to be the appropriate policy instrument to prevent Internet fragmentation.

The remainder of the article is organized as follows. In Section 2, we relate our framework and findings to the extant literature. Section 3 sets up the model. Section 4 derives the equilibrium with termination and exclusivity fees and discusses the properties of the equilibrium outcome. Section 5 examines different approaches with respect to NN regulation, and policy implications are discussed in Section 6. Finally, in Section 7 we present and discuss extensions and limitations of our base model before we conclude in Section 8.

2 Related literature

The present paper relates both to the literature on NN, as well as to the literature on exclusive dealing. The economic research on NN is reviewed by Schuett (2010), Faulhaber (2011), and Krämer et al. (2013). These reviews highlight that deviations from NN can either occur with respect to the zero-price rule (e.g., demanding a termination fee from each CP that is accessible through the ISP’s network), or with respect to the so-called no-discrimination rule (e.g., blocking of content or degrading traffic flows by non-integrated CPs), or both (e.g., pay-for-priority arrangements between ISP and CP). In this paper, we only consider NN as a zero-price rule for two reasons: first, the aim of this paper is to analyze the relationship between termination fees (i.e., the zero-price rule) and Internet fragmentation. To focus on this issue we deliberately abstract from additional issues that may arise due to network congestion management (e.g., Guo et al., 2013) or due to competition of vertically-integrated ISPs with independent CPs (e.g., Guo et al., 2010). In this context, also note that exclusive content, that we consider here, is not comparable to network management practices
such as blocking content, because blocking is the result of unilateral action by the ISP and not, as here, the outcome of a bilateral, voluntary agreement between the ISP and CP. Second, our focus on the zero-price rule is in line with the majority of the economic papers on NN (e.g., Jamison and Hauge, 2008; Choi and Kim, 2010; Cheng et al., 2011; Economides and Hermalin, 2012; Economides and Tåg, 2012; Guo et al., 2012; Krämer and Wiewiorra, 2012; Reggiani and Valletti, 2012; Bourreau et al., 2014; Choi et al., 2014; Guo and Easley, 2014). These papers have addressed important policy questions, ranging from the effect of a zero-price rule on CPs’ surplus (e.g., Jamison and Hauge, 2008; Economides and Tåg, 2012), on broadband investment (e.g., Choi and Kim, 2010; Cheng et al., 2011; Krämer and Wiewiorra, 2012), on content innovation (e.g., Hermalin and Katz, 2007; Guo et al., 2012), end user surplus and coverage of the consumer market (e.g., Krämer and Wiewiorra, 2012; Guo and Easley, 2013), as well as on competition between ISPs (e.g., Economides and Tåg, 2012; Reggiani and Valletti, 2012; Njoroge et al., 2013; Bourreau et al., 2014; Choi et al., 2014). In summary, the previous economic literature suggests that a deviation from the zero-price rule may generally benefit welfare (i.e., consumer surplus or total surplus), although most papers also identify particular scenarios under which NN is welfare superior (see Krämer et al., 2013, for a review). In particular, by the logic of a two-sided market, consumer surplus has a tendency to be higher when deviating from NN because the ISP is likely to lower end users subscription fees when charging termination fees from CPs. Also total surplus tends to be higher without NN, because the ISP can use its increased pricing flexibility to incentivize more efficient utilization of the network. However, none of these papers considers the effect of the zero-price rule on Internet fragmentation, and, as we will show, the zero-price rule has a different effect on welfare here. On the one hand, as consumers prefer a non-fragmented Internet and the zero-price rule hinders Internet fragmentation, it generally benefits consumer surplus. On the other hand, the zero-price rule restricts the contractual flexibility of ISPs and CPs, which can negatively affect total surplus, especially in the presence of strong competition among CPs. Overall we thus find mixed evidence on the effect of the zero-price rule on welfare. At the same time, we can show that NN regulation is neither a necessary nor a sufficient policy instrument to improve welfare in the context of Internet fragmentation.

Our paper also relates to the literature on exclusive dealing, which, however, is primarily concerned with the conditions under which exclusive content emerges in the broadcasting and media industry (e.g., Armstrong, 1999; Dukes and Gal-Or, 2003; Peitz and Valletti, 2008; D’Annunzio and Russo, 2013; Weeds, 2013). The paper from this stream of the literature that is most similar to ours is Hagiu and Lee (2011). The authors also consider competition between platforms that can beforehand offer exclusivity contracts to CPs. However, their model set up differs in some key aspects to ours, as
the authors clearly have other platform industries in mind (such as the video games industry), where consumers pay for content directly. The main differences are thus, that Hagiu and Lee 1) do not consider ad-financed CPs, who cannot control the pricing of their content directly, 2) do not consider termination fees, and 3) do not consider that CPs are in competition with each other (for ads, in our model). These differences in assumptions also drive important differences in the results. For example, Hagiu and Lee find that either no or full fragmentation occurs in equilibrium. In their setting, unlike ours, partial fragmentation is not an equilibrium outcome. Moreover, because the focus of the paper is different, Hagiu and Lee study the conditions under which fragmentation occurs and do not address the policy questions that we are concerned with here. Thus, to the best of our knowledge, our paper is the first that formally considers the relationship between termination fees and exclusive contracting in the context of the NN debate.

3 A model of competing ISPs and CPs

We consider a scenario in which end users have the choice between two ISPs through which they can access content and services on the Internet. For expositional clarity, we assume that there exist exactly two CPs on the Internet to which all end users wish to have access. Of course, while the Internet is made up of a magnitude of CPs in reality, a subset of which creates some positive utility, this simplified structure of two CPs allows us best to study the role of NN regulation on the competition between CPs and ISPs. In order to obtain more general results, we make no particular assumption on the nature of the content, and allow for every feasible economic relationship between the two contents, i.e., they may be perceived as complementary, substitutable or independent by the end users. We assume that CPs provide content free of charge to the end users via the broadband networks of the ISPs and derive revenues from advertising on their websites. This is the prevalent business model on the Internet (Dou, 2004; Evans, 2009; Anderson, 2012) and has therefore also been the dominant modeling assumption in previous literature (e.g., Choi and Kim, 2010; Cheng et al., 2011; Guo et al., 2012; Krämer and Wiewiorra, 2012; Reggiani and Valletti, 2012; Bourreau et al., 2014).

Absent NN regulation, i.e., no zero-price-rule is in effect, an ISP may charge a positive termination fee for sending the CPs’ content to its customers. Moreover, each CP and ISP may strike an exclusivity deal under which the CP’s content is available exclusively at the ISP. Internet fragmentation is said to occur whenever some content is not delivered by all ISPs and, consequently, not to all end users. Partial fragmentation occurs if only one of the two CPs strikes an exclusivity deal, whereas full fragmentation is said to occur when each CP is mutually exclusive at one ISP. The details of the model follow.
End users  There is a unit mass of heterogeneous end users that have a natural preference for one of the two ISPs. Users’ preference for the ISPs is denoted by \( z \), and assumed to be uniformly distributed between zero and one (Hotelling, 1929). The two ISPs (denoted by \( i \in \{ A, B \} \)) are horizontally differentiated and located at either end of the users’ preference spectrum, i.e., ISP A at \( z = 0 \) and ISP B at \( z = 1 \) (see, e.g., Economides and Tåg, 2012; Bourreau et al., 2014; Choi et al., 2014 for a similar set up). Thus, a type \( z \) consumer derives utility of 
\[
U_z = b + u_A - p_A - tz,
\]
when he subscribes to ISP A, whereas he obtains utility of 
\[
U_z = b + u_B - p_B - t(1 - z),
\]
when he subscribes to ISP B. Thereby, \( b \) denotes the base utility from being connected to the Internet, \( u_i \) denotes the utility of the content that is available at ISP \( i \) and \( p_i \) is the subscription fee. Moreover, \( t \) measures the degree of competition between the two ISPs. When \( t \) is large, the users’ preference for the ISPs becomes more important, such that competition on the basis of \( u_i \) and \( p_i \) becomes weaker. End users will choose the ISP that gives them the highest utility. We denote the end user demand for ISP \( i \) by \( D_i \).\(^1\) Furthermore, we assume that \( b \) is large enough, such that the market is fully covered, i.e., \( D_A + D_B = 1 \).

Content providers  There are two competing and differentiated CPs (denoted by \( j \in \{ 1, 2 \} \)) that derive revenues from advertising and may have to pay fixed termination fees to the ISPs via which they deliver their content to the end users. Without loss of generality, let CP 1 offer content that is valued weakly more by the end users (\( u_1 \geq u_2 \)) when consumed on its own. Although the content of CP 1 is weakly more valuable to consumers, this does not imply that CP 1 faces higher marginal costs than CP 2. CPs provide information goods, which are characterized by large fixed costs and zero marginal costs. When both contents are available to the end user, the utility of the joint consumption of both CPs’ content is denoted as \( u_{12} \). It is reasonable to assume that there exists no disutility from the availability of more content, i.e., \( u_{12} \geq u_1 \). Therefore, both contents jointly do not reduce the value of any one content alone. Notice that \( u_{12} \) denotes the level of complementarity/substitutability of the CPs content. As \( u_{12} \) increases, everything else being equal, the contents of CP 1 and CP 2 become more complementary. Also note that \( u_A, u_B \in \{ u_{12}, u_1, u_2 \} \) depending on the content that each ISP offers.

Following the current concerns of the policy debate outlined in the introduction, we introduce two types of lump-sum fees that might be exchanged between the ISPs and CPs. First, the termination fee \( f \), paid by a CP to the ISP for delivering its content to the end users. This fee \( f \) is constant, the same across the ISPs and the CPs, and is exogenously set, for example, by a regulator. Consequently,

\(^1\)For expositional clarity, we suppress the arguments of the demand function \( D_i(\text{u}_A, \text{u}_B, \text{p}_A, \text{p}_B) \) and write \( D_i \) in the following.
\( f = 0 \) corresponds to the zero-price rule. Second, we also study an exclusivity fee \( e_{ij} \) which is paid by CP \( j \) when it delivers its content exclusively to ISP \( i \). As will be described later, \( e_{ij} \) is endogenously determined via a negotiation between the ISPs and the CPs. It may thus be positive or negative. This means that the ISP may either pay the CP to be exclusive to its network, or be paid in order to grant the CP exclusivity. Each CP may choose to be available at a single ISP (and pay the termination fee plus the exclusivity fee) or at both ISPs (and pay only the termination fee, but at each ISP); that is, we allow the CPs to single-home or to multi-home. In particular, this means that when CPs do not have to pay termination fees \( (f = 0) \), which is the current status quo, then the content of both CPs will generally be available at both ISPs, unless a CP deliberately chooses to make its content available exclusively. If a CP agrees to be exclusive with ISP \( i \), then it can only be accessed by the end users connected to that ISP.\(^2\)

CPs receive advertising revenues depending on the exposure to end users and depending on the level of competition over ads among the two CPs.\(^3\) Thus, a CP that is available at both ISPs receives an exposure of \( D_A + D_B = 1 \). Similarly, a CP that is only available at one ISP, say \( i \), will inevitably have a reduced exposure of \( D_i < 1 \).

When the CP competes for customers’ clicks with the other CP, the CPs receive a “standard” advertisement rate of \( r \). However, if a CP is the only CP available to the end users at some ISP, it is assumed that this CP can demand a higher advertising rate \( (ar, \text{with } a > 1) \). In other words, we are particularly interested in how the level of ad competition between CPs affects Internet fragmentation: when only one CP is available at an ISP, it is natural to assume that the CP will be able to command higher revenues from advertising compared to the situation where the CP has to share the end users’ attention with another CP at the same ISP. There are several ways to motivate this assumption. For example, think of end users that consume Internet services for a limited period of time: therefore, when there are multiple contents offered by the platform they connect to, they may not visit all available content. This implies that, in the presence of more CPs at any given ISP \( i \), each CP effectively receives less than \( D_i \) visits, whereas it would have received \( D_i \) visits if it were the only CP at ISP \( i \). Consequently, the advertisement rate it can demand from advertisers is lower. Similarly, CPs may

\(^2\)Exclusivity here is one-way, meaning that if ISP \( i \) has an exclusivity deal with CP \( j \), CP \( j \) delivers its content only to ISP \( i \), but ISP \( i \) may serve CP \( j \) too.

\(^3\)In reality, CPs receive ad revenues either for each click on a given ad ("competition for clicks") or for each page impression on which a given ad is shown ("competition for eyeballs"). Usually, CPs offer both advertising models concurrently (such as Google or Facebook). Knowing that a certain percentage of the page visitors also clicks on an ad (this factor is known as the click-through-rate), both models likewise depend crucially on how many visitors a CP can potentially attract to its website. This is what we denote by ‘exposure’. For the purpose of our analysis it is therefore not relevant whether a CP offers an advertisement model that is based on per-click or per-impression, or both.
be literally substitutable, meaning that end users visit one specific content (e.g., one search engine) and not all available content, something that affects the effectiveness of advertising and the revenues associated to it (see Athey et al., 2012). But also if CPs are complementary and users are not time constrained, such that all end users connected to a given ISP will visit all available CPs, there is likely a differentiation in advertisement rates. For example, assume that the advertisers’ marginal valuation for an ad impression decreases with the number of impressions as in D’Annunzio and Russo (2013). Say the first impression is worth $r_1$, whereas subsequent impressions of the same ad are only worth $r$ with $r_1 = ar > r$. Consequently, if a CP is the only outlet for ads at a given ISP, it can demand an advertisement rate of $r_1$. By contrast, if there are two CPs associated with an ISP, then advertisers have the choice to buy ad space from both CPs or only from one of the CPs. As each CP will be visited equally often by the same end users, the advertiser will buy ad space from only one CP (say randomly) if CPs ask for more than $r$. This will drive the advertisement rate down to $r$, as any higher advertisement rate could be profitably undercut by the rival CP.

Although we fall short of providing a fully-specified game of competition between CPs, our reduced-form approach is an advancement with respect to the extant literature and allows us to study various types of competition scenarios, as exemplified above. A CP can be sure that end users on a platform will watch only its own content when this content is the only content delivered in that platform and thus the advertising rate will be $r_1 = ar$. If instead a CP has to share the end users’ attention with another CP on the same platform, the advertising rate will be reduced. The parameter $a$ reflects this type of competitive pressure: the higher is $a$, the stronger is the competition for clicks. Moreover, notice that $a$ can possibly take on any value between one and infinity. To see this, notice that $a = r_1/r$ goes to infinity when the value of the second impression of an ad goes to zero in the example above.

In summary, depending on the exclusivity of content, the profit of CP $j$ is given by

$$
\Pi_{CP_j} = \begin{cases} 
    r - 2f & \text{if both CPs non-exclusive} \\
    arD_i + rD_{-i} - 2f & \text{if CP $j$ non-exclusive & CP $-j$ exclusive at ISP $-i$} \\
    rD_i - f - e_{ij} & \text{if CP $j$ exclusive at ISP $i$ & CP $-j$ non-exclusive} \\
    arD_i - f - e_{ij} & \text{if CP $j$ exclusive at ISP $i$ & CP $-j$ exclusive at ISP $-i$.}
\end{cases}
$$

Thereby, $-i$ and $-j$ denote the index of the other ISP and CP, respectively. Moreover, note that the exposure $D_i$ differs among the four cases.

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4Thus, competition between CPs is modeled only indirectly via the parameter $a$. It is different from competition between ISPs, who instead compete in a more standard way by setting prices to attract subscribers.
Internet service providers  The profit function of ISP $i$ is

$$
\Pi_{ISP_i} = \begin{cases} 
  p_i D_i + 2f & \text{if both CPs non-exclusive} \\
  p_i D_i + f & \text{if CP } j \text{ non-exclusive & CP } -j \text{ exclusive at ISP } -i \\
  p_i D_i + 2f + e_{ij} & \text{if CP } j \text{ exclusive at ISP } i \text{ & CP } -j \text{ non-exclusive} \\
  p_i D_i + f + e_{ij} & \text{if CP } j \text{ exclusive at ISP } i \text{ & CP } -j \text{ exclusive at ISP } -i.
\end{cases}
$$

(1)

Notice that the cases correspond to no, partial and full Internet fragmentation, respectively.

**Structure and timing**  We consider the following three-stage game:

1. The ISPs make simultaneously a take-it-or-leave-it exclusivity offer to CP 1, $e_{i1}$. CP 1 accepts one of the two offers, or rejects both in which case it delivers its content to both ISPs.⁵

2. (a) If there was no exclusivity reached in the first stage, the ISPs make simultaneously a take-it-or-leave-it exclusivity offer to CP 2, $e_{i2}$, and CP 2 either accepts one of the two offers or rejects both and delivers its content to both ISPs.

   (b) Otherwise, if ISP $-i$ has agreed with CP 1 on an exclusivity contract, it cannot offer an exclusivity contract to CP 2 as well. Thus, only ISP $i$ can make an exclusivity offer to CP 2. CP 2 either accepts this offer, or rejects it and delivers its content to both ISPs.⁶

3. The ISPs simultaneously announce the subscription fees $p_A$, $p_B$ and the end users, who are aware about which CP is available at each ISP, choose which ISP to subscribe to.

Under NN regulation, the game is modified in one of the following three ways. First, NN regulation can impose a zero-price rule, which restricts the termination fee to zero. This is the standard notion of NN regulation that is currently discussed in the policy debate. Second, regulators may also wish to adopt a stricter form of the zero-price rule which restricts all fees that might be exchanged between ISPs and CPs to zero (i.e., the termination fees and the exclusivity fees). Third, and alternatively, NN regulation could impose a straightforward no-exclusivity rule which forbids any exclusivity arrangements between ISPs and CPs. These cases are presented in Section 5.

The base model outlined above establishes the minimal set of interactions necessary to drive our results. Evidently, the actual interaction between ISPs and CPs may be more complex. In the appendix

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⁵ Without reaching an exclusivity arrangement, a CP delivers its content to both ISPs. This corresponds to the status quo where the content is available to all ISPs.

⁶ We do not study the extreme case where a single ISP offers both contents and the rival ISP exits the market; this scenario would almost certainly be blocked by the antitrust authorities.
we therefore study several variants and extensions of the above three-stage game, which show that our main insights derived from this game are robust. In Appendix D we allow ISPs to make exclusivity offers to both CPs simultaneously. In Appendix F we study an extended game where CPs determine the quality of their content endogenously at an initial stage. Similarly, in Appendix G we consider a game where ISPs determine the termination fee endogenously. Finally, in Appendix H we modify the last stage of the game in that we allow consumers to subscribe to both ISPs (multi-homing). We discuss these extensions in more detail in Section 7.

4 Without NN regulation

Without NN regulation, exclusivity contracts and positive termination fees are both feasible. Recall that the ISPs make exclusivity offers first to the more efficient CP, i.e., CP 1, that generates more value in the network and then to the less efficient CP 2. The two ISPs, however, are symmetric such that it is in most cases not necessary to distinguish between them. Thus, there are four potential subgames that should be considered (see Figure 1). These can be denoted by a tuple \((x, y)\), where \(x, y \in \{E, NE\}\) means that CP 1 \((x)\) and CP 2 \((y)\) are exclusive \((E)\) or not exclusive \((NE)\) with any of the two ISPs, respectively. When both CPs sign an exclusivity contract, full fragmentation emerges, \((E, E)\),\(^7\) while when a single CP signs an exclusivity contract, partial fragmentation emerges, either \((E, NE)\) or \((NE, E)\).\(^8\) Finally, when both CPs deliver their content to both ISPs, there is no fragmentation, i.e., \((NE, NE)\).

We proceed backwards to solve for the subgame perfect equilibrium.

[Place Figure 1 about here]

Stage 3: Subscription fees and end users’ decisions At the third stage, each consumer chooses whether to subscribe to ISP A or ISP B. The consumer that is indifferent between the two ISPs, denoted by \(\tilde{z}\), is derived by equating \(b + u_A - p_A - t\tilde{z} = b + u_B - p_B - t(1 - \tilde{z})\), which yields

\[
\tilde{z}(u_A, u_B, p_A, p_B) = \frac{1}{2} + \frac{u_A - u_B}{2t} + \frac{p_B - p_A}{2t}.
\]

\(^7\)The case where CP 1 delivers its content exclusively to ISP A and CP 2 delivers its content exclusively to ISP B is symmetric to the case where CP 1 delivers its content exclusively to ISP B and CP 2 delivers its content exclusively to ISP A.

\(^8\)The case where CP \(j\) delivers its content exclusively to ISP A and CP \(-j\) delivers its content to both ISPs is symmetric to the case where CP \(j\) delivers its content exclusively to ISP B and CP \(-j\) delivers its content to both ISPs.
The end users’ demands for ISP A and ISP B are thus \( D_A = \bar{z} \) and \( D_B = 1 - \bar{z} \), respectively. The two ISPs compete by setting a subscription fee to the end users. ISP \( i \) maximizes (1) with respect to \( p_i \). Since \( f \) and \( e_{ij} \) are fixed fees, the first-order conditions give the equilibrium subscription fees

\[
p_A = t + \frac{u_A - u_B}{3}, \quad p_B = t + \frac{u_B - u_A}{3}.
\]

Replacing for \( p_A \) and \( p_B \) into (2), we obtain for the equilibrium demand of the ISPs

\[
D_A = 1 - D_B = \frac{1}{2} + \frac{u_A - u_B}{6t},
\]

which is exactly 1/2 in case the same content is available at both ISPs. Otherwise the ISP with the more valuable content receives a higher market share than the rival.

In order to focus on the interesting case where each ISP receives positive demand, we need that 

\[-3t < u_i - u_{-i} < 3t.\]

A sufficient condition that satisfies this, and that we assume throughout the paper, is

\[t > (u_{12} - u_2)/3.\]

**Stage 2: Exclusivity offered to CP 2**  In this stage, there are two different types of subgames, depending on whether CP 1 has accepted exclusivity (cases \((E, \cdot)\)) or not (cases \((NE, \cdot)\)).

While we relegate all the details to Appendix A, we now sketch how the game develops. Consider first the case where, in stage 1, CP 1 has agreed on exclusivity with ISP \(-i\). In this case, at stage 2, it is ISP \( i \) that can respond by offering exclusivity to CP 2 (this corresponds to the left branch of Figure 1). Since exclusivity fees are lump sums, exclusivity will arise if and only if the joint profits of CP 2 and ISP \( i \) are higher under exclusivity than without it. There are two conflicting effects at play here. On the one hand, when exclusivity is chosen, ISP \( i \) gets a larger market share and can compensate CP 2 for agreeing to exclusivity. On the other hand, the CP that delivers its content to a single ISP exclusively, inevitably loses some exposure. The value to CP 2 from exposure, however, depends on the intensity of competition over ads between the CPs. We find that, when ad competition is high (i.e., \( a > \tilde{a} \)), the first effect dominates the second effect and, thus, full fragmentation arises in equilibrium. Exclusivity prevails as CPs’ competition is intense and thus the benefit from exposure is low, which also means that CP 2 may end up paying a rather substantial exclusivity fee.

Fragmentation can also arise for weak competition over ads among the CPs (\( a \leq \tilde{a} \)), as long as the advertisement rate is generally low (\( r < \tilde{r} \)). The reason for exclusivity is now different, however. Take for example, the extreme case where \( r \) approaches zero. It is then cheap for ISP \( i \) to attract exclusively
CP 2, since the latter has not much advertising revenues to lose anyway, while the ISP can increase its own market share. Instead, when competition over ads among the CPs is weak \((a \leq \hat{a})\) and the advertisement rate is high \((r \geq \hat{r})\), it would be very costly to convince CP 2 to agree on exclusivity. Therefore, in this parameter range, ISP \(i\) does not offer exclusivity to CP 2.

The remaining cases are those in which no exclusivity has been reached at stage 1 between CP 1 and any ISP (right branch of Figure 1). Now, there is competition between the two ISPs for CP 2; either one ISP achieves an exclusive arrangement with CP 2, or the content of CP 2 is delivered to both platforms. This bidding game obviously goes to the advantage of CP 2, and stops when each ISP is just indifferent between winning and losing to the rival the content delivered by CP 2. In particular, exclusivity arises as long as \(r < \bar{r}\). Again, in the presence of a high advertisement rate \((r \geq \bar{r})\), exclusivity is not offered to CP 2 by any of the two ISPs, because it would be too costly to compensate CP 2 for its loss in exposure.

**Stage 1: Exclusivity offered to CP 1**  At the first stage of the game, the reasoning is similar, with the additional feature that CP 1 and the ISPs anticipate the decisions in the second stage. Exclusivity with CP 1 will arise if and only if the joint profits of CP 1 and ISP \(i\) are higher under exclusivity than without it. CP 1 will be offered an exclusivity contract which it accepts either when the ad competition between CPs is very strong \((a \geq \hat{a})\) or when ad competition between CPs is weak \((a < \hat{a})\) and the advertisement rate is rather low. Whereas for \(a \geq \hat{a}\), full fragmentation is the inevitable equilibrium outcome (i.e., \((E, E)\)), for \(a < \hat{a}\) either full (\((E, E)\)), partial (\((E, NE)\), or (\(NE, E)\)) or no fragmentation (\((NE, NE)\)) may arise in equilibrium, depending on the level of \(r\). The equilibrium outcome is summarized by the following proposition. The details of the proof are in Appendix A.

**Proposition 1**  Full Internet fragmentation emerges in equilibrium either when ad competition between CPs is relatively high \((a \geq \hat{a})\), or when ad competition between CPs is relatively low \((a < \hat{a})\) and the advertisement rate on the Internet is low \((r < \hat{r}(a))\). When ad competition between CPs is relatively low \((a < \hat{a})\) and the advertisement rate takes intermediate values \((\hat{r}(a) < r < \bar{r})\), partial Internet fragmentation occurs. On the contrary, no Internet fragmentation occurs when ad competition between CPs is relatively low \((a < \hat{a})\) and the advertisement rate is high \((r \geq \max \{\bar{r}, \hat{r}(a)\})\).

The relevant thresholds are as follows:

\[
\hat{a} = \frac{(u_{12} - u_2 + 3t)}{(u_{12} - u_1)}
\]

\[
\hat{r}(a) = \left( f + \frac{u_{12} - u_1}{3} + \frac{(u_1 - u_2)^2}{18t} - \frac{(u_{12} - u_2)^2}{18t} \right) / \left( \frac{3t + u_{12} - u_2 - a(u_{12} - u_1)}{6t} \right)
\]
\[
\bar{r} = \left( \frac{(3t + u_{12} - u_2)^2 - \frac{3t}{2} + f}{18t} \right) / \left( \frac{3t - (u_{12} - u_2)}{6t} \right).
\] (8)

Before providing the intuition for this result, we first present a numerical example to illustrate the equilibrium outcome. Figure 2 shows the thresholds for the various fragmentation cases and the resulting equilibrium regions in the \((a, r)\) space.\(^9\) When \(a\) is high enough full fragmentation always occurs. Full fragmentation also emerges for low values of \(a\) and \(r\): in the area to the left of the dashed vertical line, both exclusivity fees become negative, i.e., ISPs pay the CPs to obtain exclusivity. The exclusivity fee paid by the less efficient CP becomes positive faster with the increase in \(a\) than the exclusivity fee paid by the more efficient CP.

For relative low values of \(a\) and intermediate values of \(r\), partial fragmentation is the equilibrium outcome. Finally, when \(r\) is high enough but \(a\) is not too high, CPs deliver their content to both ISPs and serve all end users.

[Place Figure 2 about here]

We now provide further intuition for the three types of equilibria that emerge from Proposition 1.

**Full fragmentation.** In our three-stage game, full Internet fragmentation emerges in equilibrium either when \(a\) is relatively high, or when both \(a\) and \(r\) are relatively low. For relatively high \(a\), competition for ads between the CPs is strong enough; thus, a way to relax this competition is to collectively opt for exclusivity at each platform. Note, however, that a CP cannot unilaterally evade competition by choosing exclusivity: say CP 1 and ISP A strike an exclusive deal, but CP 2 multi-homes. Then CP 2 (and not CP 1) is going to benefit from reduced competition, because it is the only CP available at ISP B, whereas CP 1 continues to face competition by CP 2 at ISP A. Hence, the CPs can only evade competition if they both strike an exclusive deal with a different ISP, i.e., under full fragmentation. Also note that competition between CPs can be so intense and thus the CPs’ benefits under full fragmentation so large, that for relatively high values of \(a\) and \(r\), both exclusivity fees are positive (i.e., CPs should pay these fees to the ISPs). But as \(a\) and \(r\) become smaller, competition between ISPs becomes the driver for full Internet fragmentation. Advertising revenues are not too important, and each ISP is fighting with its rival for an exclusivity contract, in order to boost the demand they obtain and, therefore, their revenues via the subscription fees. The exclusivity fee paid by the more efficient CP 1 is lower than the exclusivity fee paid by CP 2 \((e_{11} < e_{12})\), since CP 1 can leverage its content which is more valuable to the end users. In this context, it is important to mention

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\(^9\)In the figure, it is assumed that the two contents are purely additive \((u_{12} = u_1 + u_2)\). As will be seen later, the results are qualitatively unchanged if content is complementary or substitutable or if \(u_{12}\) and \(a\) are correlated.

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that the absolute size of the exclusivity fee generally depends on the relative bargaining power between ISPs and CPs which we do not study in detail. However, also note that whether exclusivity emerges in equilibrium depends only on the comparison of the joint profits of the ISP and CP in each scenario. Hence, the fragmentation equilibrium is independent of the relative bargaining power, i.e., how the additional surplus from exclusivity is divided among the ISP and CP.

Partial fragmentation. For intermediate values of the advertising rate $r$ and $a < \tilde{a}$, partial fragmentation is obtained in equilibrium. Depending on the parameter values, both types of partial fragmentation may emerge in equilibrium, i.e., with exclusivity obtained by the more efficient CP 1, (E, NE) or with the less efficient CP 2, (NE, E). In both cases the CP that delivers its content exclusively to a single ISP obtains a slotting fee, while the rival CP delivers its content to both ISPs. The reason for this richness of partial fragmentation equilibria stems from the possible different best replies by CP 2 in the continuation game. When $r$ is high enough, it is a dominant strategy for CP 2 always not to be exclusive in the continuation game. Hence, in the first stage, CP 1 goes for exclusivity with ISP $i$ only when it can be compensated enough for the loss of exposure at the other ISP $-i$. This indeed happens as long as $r < \tilde{r}$, yielding (E, NE). When instead $r$ is low, in the ensuing game there is no dominant strategy for CP 2: if CP 1 achieves exclusivity, then CP 2 will not, while if CP 1 does not, then CP 2 will. In this region, therefore, CP 1 has to take into account also the additional possibility that, by not accepting exclusivity, it will induce CP 2 to achieve exclusivity at some ISP $i$, which actually can benefit CP 1 since it will achieve higher revenues at ISP $-i$: this opens the room for a (NE, E) equilibrium when $a$ is sufficiently high.

No fragmentation. For relatively high values of the advertising rate $r$ and $a < \tilde{a}$, no fragmentation occurs. All content is available to both platforms and, thus, to all end users. In this area, it is a dominant strategy for CP 2 to never accept exclusivity at the second stage. Anticipating this, CP 1 also has no incentive to get exclusivity in the first stage since the advertising rate $r$ is high enough. CPs prefer to obtain revenues via advertising at both platforms than via exclusivity fees.

From (4), we also obtain that the number of the end users subscribed to the ISP with more content (i.e., with $u_{12}$) or with the more valuable content ($u_1$), is higher than the number of end users subscribed to the ISP with less content (either $u_1$ or $u_2$) or the less valuable content ($u_2$). In addition, from (3), we obtain that the ISP with more content or the more valuable content can extract higher subscription fees by the end users. Nevertheless, in all cases, the profits of ISP $A$ are equal to the profits of ISP $B$. While this is trivial without fragmentation, as both ISPs carry the same content,

\footnote{We provide all the details of this equilibrium scenario in Appendix A.}
identical profits arise also with full or partial fragmentation due to the bargaining power that CPs have to pay low exclusivity fees or even extract a part of the ISPs’ profits. The bidding war among the ISPs for an exclusive CP makes them - finally - indifferent between winning and losing.

**Comparative statics** We now discuss how Internet fragmentation is affected through changes in the exogenous parameters of our setting. In particular, we study \( u_{12} \), which is a measure of content substitutability, and \( t \), which is a measure of ISPs’ intensity of competition.

*Complementarity of content.* First, we examine how the level of complementarity (or substitutability) of the two contents affects the equilibrium outcome. We obtain these results by directly differentiating expressions (7) and (8) with respect to \( u_{12} \). As the level of complementarity between the two contents \( u_{12} \) increases, the two thresholds \( \widehat{r}(a) \) and \( \widehat{r} \) increase as well (\( d\widehat{r}/du_{12} > 0, \, d\widehat{r}/du_{12} > 0 \)). This means that the threshold \( \widehat{r}(a) \) that characterizes the full fragmentation area increases with \( u_{12} \), leading to more full fragmentation, and that the threshold \( \widehat{r} \) that characterizes the no fragmentation area increases with \( u_{12} \) as well, leading to less no fragmentation in the market.

**Proposition 2** *As the two contents become more complementary, that is, as \( u_{12} \) increases, full fragmentation is more likely to arise in equilibrium, while no fragmentation is less likely to arise in equilibrium.*

The intuition behind this result is as follows: full fragmentation is more likely when the content becomes *more* complementary because it is then particularly valuable for an ISP to try to break an equilibrium without full fragmentation. To see this, imagine that ISP \( i \) has an exclusive deal with CP 1 at stage 1. At stage 2, ISP \(-i\) can either offer an exclusivity deal to CP 2, or let this content be available on both platforms: since \( u_{12} \) is large, the latter scenario is what ISP \(-i\) wants to *avoid*, since it would be only the rival to benefit from the complementarity. This shifts to the left the threshold \( \widehat{r}(a) \) that we identified at stage 2, making full fragmentation more likely to arise. As an outcome, no consumer enjoys any complementarity, precisely when this could be valuable to them. This apparent paradox arises because, taking as given the exclusivity reached by the rival ISP, the remaining ISP does not want to confer a positive externality to its rival.

As CPs are instead more substitutable for the end users, it becomes less and less likely that a full fragmentation scenario could emerge in equilibrium. In the limiting case, if the content of CP 2 does not add any more value when consumed jointly (\( u_{12} = u_1 \)) and the termination fee \( f \) is zero, there is no possibility of full fragmentation.\(^{11}\)

\(^{11}\)From (6), we have \( \widehat{a} \to \infty \) when \( u_{12} \to u_1 \) and from (7), we have \( \widehat{r} \to 0 \) when \( u_{12} \to u_1 \) and \( f \to 0 \).
Moreover, an increase in $u_{12}$ shifts $\tilde{r}$ up, which means that the no fragmentation area reduces as content becomes more complementary. To see this, imagine CP 2 delivers its content to both ISPs. As $u_{12}$ goes up, it becomes more likely that CP 1 prefers to be available exclusively at one ISP, which will be willing to pay a slotting allowance to CP 1, so as to take advantage solely of the content complementarity. This leads to a decrease in the area of no fragmentation.

The above result is presented in a numerical example in Figure 3. Three alternative cases are plotted. First, the CPs offer complementary contents ($u_{12} > u_1 + u_2$). Second, the CPs offer purely additive content ($u_{12} = u_1 + u_2$) and, third, they offer substitutable contents ($u_{12} < u_1 + u_2$).

Competition between ISPs. As $t$ increases, the ISPs become more differentiated such that competition between them is reduced. By directly differentiating expressions (8) and (7) with respect to $t$, we obtain that the threshold $\tilde{r}$ always decreases with $t$ ($d\tilde{r}/dt < 0$), whereas the threshold $\tilde{r}(a)$ increases for low $a$ ($d\tilde{r}/dt \geq 0$) for $a \leq \frac{6f(u_{12}-u_2)+(u_{12}-u_1)(u_1-u_2)+3(u_{12}-u_2))}{2(u_{12}-u_1)(3f+u_{12}-u_1)}$ and decreases with high $a$.

**Proposition 3** As competition between ISPs increases, Internet fragmentation is more likely to arise in equilibrium. Full fragmentation may be either more or less likely to arise, depending on the level of ad competition between CPs.

The threshold $\tilde{r}$ shifts down with $t$, which means that no fragmentation is more likely to arise in equilibrium. Competition among the ISPs is relaxed and, thus, they are less keen on obtaining exclusivity of content to boost their own demand, since the end users are less willing to switch to the rival ISP. Concerning the threshold $\tilde{r}(a)$ that defines the full fragmentation area, we find that $\tilde{r}(a)$ shifts to the right with $t$ when $a$ is relatively high leading to less full fragmentation, but $\tilde{r}(a)$ shifts up for relatively low values of $a$. In Figure 4, we present a numerical example.

5 NN regulation: Zero-price rule, strict zero-price rule and the no-exclusivity rule

We now discuss the impact of the different approaches to NN regulation on Internet fragmentation. First, NN regulation can impose a zero-price rule, which sets the termination fee to zero. Second, a stricter form of the zero-price rule restricts all fees that might be exchanged between ISPs and CPs
to zero (i.e., the termination and the exclusivity fees). Third, and alternatively, NN regulation could impose a straightforward no-exclusivity rule which forbids any exclusivity arrangements between ISPs and CPs, but does not impose restrictions on the termination fees (this would preclude the first two stages of the basic game described in the previous section). We now analyze each case in turn.

5.1 Zero-price rule

The effect of a zero-price rule can be readily addressed by studying how a change in $f$ affects the equilibrium outcome of the (otherwise) unregulated scenario. In particular, differentiating the relevant thresholds (7) and (8) with respect to $f$, yields $\partial r / \partial f > 0$ and $\partial e / \partial f > 0$. Consequently, as the termination fee $f$ increases, full fragmentation is more likely to arise in equilibrium, while no fragmentation is less likely to arise in equilibrium. However, it is important to note that (full and partial) Internet fragmentation may still occur under a zero-price rule where $f$ is restricted to zero. The equilibrium properties described by Proposition 1 remain valid.

**Proposition 4** A zero-price rule cannot prevent full or partial Internet fragmentation. However, Internet fragmentation is less likely to occur under a zero-price rule.

[Place Figure 5 about here]

In Figure 5, we change the values of the termination fee $f$, and find that, as $f$ increases, the area of full fragmentation increases and the area of no fragmentation decreases, since it becomes more expensive for the CPs to deliver their contents to both ISPs.$^{12}$

5.2 Strict zero-price rule

Under the strict notion of the zero-price rule, both termination fees and exclusivity fees are restricted to zero, i.e., $f = e_{ij} = 0, i = A, B, j = 1, 2$. Otherwise, the structure and timing of the game remains the same as before. In particular, a CP can still choose to offer its content (without any direct financial compensation) exclusively at one of the two ISPs.

Again, we provide some intuition for the derivation of the equilibrium, while we relegate all the technical details to Appendix B. The lump-sum fees have no impact on the optimal subscription price of the ISPs in the third stage of the game. In the second stage, CP 2 decides whether to accept exclusivity or not, provided CP 1’s decision. If CP 1 has an exclusivity contract with an ISP, then

$^{12}$All profits must be non-negative. A sufficient condition is $r \geq 2f$, which is always satisfied in Figure 5.
CP 2 wishes to be exclusive with the other ISP if and only if ad competition between the two CPs is strong \((a > \tilde{a})\). Otherwise, if CP 1 does not have an exclusivity contract with any ISP, then CP 2 always prefers not be exclusive to any ISP. Anticipating this, CP 1 decides whether to be exclusive to any ISP in the first stage. In the absence of exclusivity fees, the ISPs cannot engage in a bidding war for CP 1. Nevertheless, we find that if ad competition between the CPs is strong \((a > \tilde{a})\), CP 1 opts for exclusivity exactly to mitigate this effect, anticipating that CP 2 will also opt for exclusivity. Otherwise, if competition is weak, CP 1 decides to deliver its content to all ISPs and thus, CP 2 also refrains from exclusivity which yields no fragmentation in equilibrium. Thus, partial fragmentation cannot occur in equilibrium under the strict zero-price rule.

**Proposition 5**  
**Full Internet fragmentation may arise in equilibrium even under the strict zero-price rule, where all termination and exclusivity fees are zero. In particular, full Internet fragmentation emerges in equilibrium when competition between CPs is intense \((a > \tilde{a})\). Otherwise, the Internet remains unfragmented. Partial fragmentation does not emerge in equilibrium.**

In addition, by comparing the two full fragmentation cases (one arises when ISP \(A\) delivers exclusively the content of CP 1 and ISP \(B\) delivers exclusively the content of CP 2, the other is when ISP \(A\) delivers exclusively the content of CP 2 and ISP \(B\) delivers exclusively the content of CP 1), we observe that ISP \(i\) obtains higher profits than its rival ISP, when ISP \(i\) carries the content of the more efficient CP. In contrast, without NN regulation or under the standard zero-price rule, the two ISPs always obtained the same profits for the same parameter values due to the power of CPs to extract a part of the ISPs’ profits. In the absence of exclusivity fees, the bidding war between the ISPs cannot be triggered, which preserves the ISPs’ profits.

### 5.3 No-exclusivity rule

The regulator could also enact a blunt no-exclusivity rule. That is, all content must be delivered to all ISPs. This rule is similar to a mandated interconnection of networks, which is well-known to the telecommunications industry. Obviously, under the no-exclusivity rule Internet fragmentation can, by definition, not occur. This means that the profits of the two ISPs are the same, since they split the market equally. Likewise, the advertisement revenues of the two CPs are the same, although CP 1 is more efficient, since they reach an identical exposure.
6 Welfare analysis and policy implications

6.1 Welfare analysis

To discuss the policy implications for the case without NN regulation and the various NN cases, we make reference to the concepts of consumer surplus and total welfare. These are natural choices, given the attention put by regulators on users and efficiency, respectively, though of course one could also conduct an additional analysis based on the profits of the remaining stakeholders.

We start with consumer surplus. By summing up the net surplus of all end users, we obtain the consumers’ surplus for all potential values of $u_A$ and $u_B$,

$$
CS = \int_0^{D_A} (u_A - p_A - tz) \, dz + \int_{D_A}^1 (u_B - p_B - t(1-z)) \, dz.
$$

By substituting the demand and subscription fees (from expressions (4) and (3)), we have

$$
CS = \frac{u_A + u_B}{2} + \frac{(u_A - u_B)^2}{36t} - \frac{5}{4}t.
$$

(9)

The analysis of $CS$ is immediate. Note that $\frac{\partial CS}{\partial u_i} = \frac{1}{2} + \frac{u_i - u_{i-1}}{18t} > 0$, where the positive sign is always ensured by (5). Hence, it is always better for consumers at ISP $i$ to obtain more content, whatever the content offered at ISP $-i$. Intuitively, higher content will be reflected in a higher price, as described by (3), but competition ensures that the direct increase in utility always more than compensates for the higher subscription fee. Hence the ranking of possible equilibria, from the consumers’ perspective, is unambiguous: no fragmentation is strictly better than any partial fragmentation equilibria, which, in turn, do strictly better than full fragmentation.

In particular, by substituting the relevant expressions from the equilibrium outcome presented in Appendix A into expression (9), we find that, in the unregulated case, it is

$$
CS^* = \begin{cases} 
\frac{u_1 + u_2}{2} + \frac{(u_1 - u_2)^2}{36t} - \frac{5}{4}t & \text{if Full fragmentation} \\
\frac{u_{12} + u_2}{2} + \frac{(u_{12} - u_2)^2}{36t} - \frac{5}{4}t & \text{if Partial fragmentation (E, NE)} \\
\frac{u_{12} + u_1}{2} + \frac{(u_{12} - u_1)^2}{36t} - \frac{5}{4}t & \text{if Partial fragmentation (NE, E)} \\
u_{12} - \frac{5}{4}t & \text{if No fragmentation.}
\end{cases}
$$

By direct comparison of consumer surplus in the case without NN regulation among the different fragmentation scenarios, we confirm the $CS$ ranking described above. Also, $CS$ under the partial fragmentation $(NE, E)$ scenario is higher compared to the partial fragmentation $(E, NE)$ scenario,
which is expected since under \((NE, E)\) the more valuable content is delivered to both ISPs and hence enjoyed by all end users.

We now turn to the analysis of total welfare. Total welfare \(W\) is defined as the sum of ISPs’ profits, CPs’ profits and consumers’ surplus,

\[
W = \Pi_{ISP_A} + \Pi_{ISP_B} + \Pi_{CP_1} + \Pi_{CP_2} + CS. \tag{10}
\]

The analysis is more involved, as there are now several trade-offs. On the one hand, symmetric distribution of content between both ISPs is more efficient than asymmetric distributions, since the resulting symmetric ISPs’ market shares at equilibrium minimize transportation costs. In addition, it is more efficient that users see both types of content, instead of excluding any possible viewer. Hence, from this perspective, one would expect no fragmentation to dominate both partial and full fragmentation. On the other hand, however, fragmented equilibria always increase the advertising revenues that enter directly the profits of the CP that faces no competition, and may increase the total ad revenues available at a given ISP. Hence, this effect can potentially go in the opposite direction.

To resolve this possible tension, we substitute the relevant expressions from the equilibrium outcome presented in Appendix A into (10). Total welfare in the unregulated case is then

\[
W^* = \begin{cases} 
\frac{u_1 + u_2}{2} + \frac{5(u_1 - u_2)^2}{36t} - \frac{1}{4}t + ar & \text{if Full fragmentation} \\
\frac{u_{12} + u_2}{2} + \frac{5(u_{12} - u_2)^2}{36t} - \frac{1}{4}t + r\left(\frac{3t + u_{12} - u_2}{6t} + \frac{a(3t - (u_1 - u_2))}{6t}\right) & \text{if Partial fragmentation } (E, NE) \\
\frac{u_{12} + u_1}{2} + \frac{5(u_{12} - u_1)^2}{36t} - \frac{1}{4}t + r\left(\frac{3t + u_{12} - u_1}{6t} + \frac{a(3t - (u_{12} - u_1))}{6t}\right) & \text{if Partial fragmentation } (NE, E) \\
u_{12} - \frac{1}{4}t + 2r & \text{if No fragmentation.} 
\end{cases} \tag{11}
\]

We find that, whenever \(a\) is relatively low (i.e., competition for ad revenues among the CPs is relatively low and, thus, the advertising profits obtained via exclusivity are not too high), total welfare under no fragmentation exceeds the total welfare under partial fragmentation, and the latter exceeds, in turn, the total welfare under full fragmentation.\(^{13}\) In particular, when \(a \leq 2\) this result always holds. Hence, in this case, all the welfare effects described above go in the same direction and there is no trade-off. Therefore, for weak ad competition among the CPs (low \(a\)), it would be socially more desirable to obtain no fragmentation, since advertising revenues are not important, while content variety is. Nevertheless, this may not be an equilibrium outcome without any policy intervention.

In addition, when we compare the relative welfare between the two types of partial fragmentation,

\(^{13}\)See Appendix C for a welfare comparison of all feasible outcome scenarios.
we observe a further trade-off. When exclusivity is achieved by the more valuable CP, \((E, NE)\), on the one hand, \(CS\) is lower compared to the \((NE, E)\) scenario since less end users enjoy the more valuable content, but, on the other hand, the more valuable CP obtains a higher market share and higher profits.

**Proposition 6** No fragmentation is always the efficient outcome with respect to consumer surplus. With respect to total welfare, no fragmentation is efficient when ad competition between content providers is rather low \((a \leq 2)\). When ad competition between content providers is rather high \((a > 2)\), any one of the feasible fragmentation outcomes \((NE, NE), (E, NE), (NE, E), (E, E)\) may be efficient with respect to total welfare, depending crucially on the interplay of the parameter values.

Using the same numerical example as before, the total welfare ranking is illustrated in Figure 6, which shows the region of validity of each equilibrium outcome (focus on the solid lines), and the corresponding welfare ranking (focus on the downward sloping dashed and dotted lines). Below the downward sloping dashed line, the efficient outcome is no fragmentation \((NE, NE)\). Above the downward sloping dotted line, the efficient outcome is full fragmentation \((E, E)\), while in between the dashed and the dotted line, the efficient outcome is partial fragmentation \((NE, E)\).\(^{14}\) It is clear that, for the same set of parameters, the corresponding equilibrium outcome does not always coincide with the efficient outcome. In fact, only in the shaded areas the privately chosen equilibrium regimes are also socially optimal. In all other areas, a welfare-maximizing regulator would want to achieve a different regime. Note the richness of possibilities that arise: there may be both excessive content (e.g., point A), as well as excessive exclusivity (e.g., point B). At point A, the equilibrium outcome is no fragmentation \((NE, NE)\), while the social optimum regime is full fragmentation \((E, E)\). But at point B, firms choose full fragmentation \((E, E)\), while the social optimum regime is no fragmentation \((NE, NE)\). Note that for \(a < 2\) only excessive exclusivity may arise.

[Place Figure 6 about here]

### 6.2 Policy implications

Having shown that there is potentially room for intervention, the next step is to ask whether the specific policy tools at the regulator’s disposal are apt to improve welfare.\(^{15}\) We first discuss the

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\(^{14}\)Note that this precise welfare ranking is due to the choice of parameters. For a different set of parameters, partial fragmentation with \((E, NE)\) may emerge as the efficient outcome in between no and full fragmentation, or partial fragmentation may never be efficient.

\(^{15}\)In this analysis, a social planner (or a regulator) can impose a specific type of Internet fragmentation via the NN tools he may use, but he does not set the subscription fees paid by the end users.
role played by termination fees in an otherwise unregulated scenario (zero-price rule). Note that the presence of the termination fees does not affect the level of total welfare since these fees are pure transfers from the CPs to the ISPs. Nevertheless, the termination fees affect the critical thresholds of \( r \) which define the type of Internet fragmentation. When the termination fee \( f \) increases, both critical thresholds \( \tilde{r}(a) \) and \( \tilde{r} \) increase, thus, full fragmentation becomes more likely, while no fragmentation becomes less likely (Proposition 4). Through exclusivity, the CPs avoid paying the termination fees twice. Therefore, the zero-price rule where the termination fee is restricted to zero, ensures that no fragmentation emerges more often in equilibrium. However, as pointed out by Proposition 4 and Figure 5, partial and full fragmentation remain to emerge in equilibrium. In addition, a strict zero-price rule, where both termination and exclusivity fees are restricted to zero, ensures that no fragmentation emerges more often in equilibrium, compared to the unregulated case; but it does not always ensure no fragmentation. Consequently, a (strict) zero-price rule is not a perfect policy instrument to fully prevent Internet fragmentation. Clearly, when consumer surplus is the ultimate policy goal, then no fragmentation is always the preferred outcome, and a no-exclusivity rule is consequently a perfect policy instrument.

**Proposition 7** With respect to consumer surplus, the no-exclusivity rule is a perfect policy instrument.

With respect to total welfare, the analysis is more involved. According to Proposition 6, no Internet fragmentation is the unique efficient outcome when the intensity of competition over ads among the CPs is rather low (i.e., \( a \leq 2 \)). Thus, for the subsequent discussion it is useful to consider this case first, and then the case where \( a > 2 \).

**When no Internet fragmentation is the unique efficient outcome \( (a < 2) \)** As mentioned above the zero-price rule can help to achieve the efficient outcome in equilibrium more often (see Figure 7). However, even when \( a \leq 2 \), partial and full fragmentation continue to arise in equilibrium for low values of \( r \).

[Place Figure 7 about here]

By contrast, recall that the strict zero-price rule prevents partial fragmentation in equilibrium and achieves no fragmentation whenever \( a \leq \hat{a} \) (see Proposition 5). Since \( \hat{a} > 2 \), the strict zero-price rule effectively prevents Internet fragmentation for \( a \leq 2 \) (see Figure 8). However, the strict zero-price rule is a heavy-handed regulation that is hard to administer, because the regulator would have to monitor
the possible side-payments \((e_{ij})\) between CPs and ISPs. Evidently, for \(a \leq 2\) the same outcome of no fragmentation could also be achieved by the simple no-exclusivity rule, which is much easier to administer and should therefore be the preferred regulatory instrument in this parameter range.

[Place Figure 8 about here]

**Proposition 8** When no Internet fragmentation is the unique efficient outcome (i.e., when \(a \leq 2\)), all policy interventions (zero-price rule, strict zero-price rule and no-exclusivity rule) will improve total welfare. In particular, the strict zero-price rule and the no-exclusivity rule are perfect policy instruments in this case.

**When Internet fragmentation may be the efficient outcome** \((a > 2)\) When the regulator deems that \(a > 2\), or if it is unsure about the level of \(a\), and it puts considerable weight on total welfare (as opposed to consumer surplus alone), then the choice of the appropriate policy instruments is much more complicated. In fact, none of the policy instruments surveyed here will be able to perfectly align private and social incentives for all parameter ranges.

Consider the case when ad competition between CPs is intense \((a > \bar{a})\), such that full fragmentation is most likely the efficient outcome, unless \(r\) is close to zero. In this parameter range full fragmentation is already achieved in equilibrium without any policy intervention. Thus, the use of additional policy instruments cannot do better than if the market were left without NN regulation. At least the zero-price rule and the strict-zero-price rule will not affect this privately efficient equilibrium outcome and they are thus not harmful here (see also Figures 7 and 8). On the contrary, the application of the no-exclusivity rule could yield to excessive content in this parameter range and is thus potentially harmful to total welfare.

For the case where ad competition between CPs is at an intermediate level \((a \in (2, \bar{a}))\), a meaningful application of any one of the available policy instruments seems almost impossible. Depending on the parameter range and on the policy instrument, welfare can be improved or deteriorated (see Figures 7 and 8) in comparison to the case without NN regulation. Consider point D in Figure 7 and 8, for example. Here the efficient outcome is full fragmentation, which is achieved in the private equilibrium for \(f = 0.4\). Any type of intervention ((strict) zero-price rule or no-exclusivity rule) would be counterproductive there, as this would alter the full fragmentation result and would in turn decrease welfare (the strict zero-price rule and the no-exclusivity rule would lead to no fragmentation, while the zero-price rule would lead to partial fragmentation). In other cases instead, when \(r\) is low, the strict zero-price rule and also the no-exclusivity rule are able to do much better than the private equilibrium,
because they can achieve the first-best regime (e.g., point B in Figure 6).

**Proposition 9** When ad competition between content providers is intense \( (a > \hat{a}) \), policy interventions are at best superfluous with respect to total welfare, but can also be harmful as in the case of the no-exclusivity rule. For intermediate levels of content providers’ ad competition \( (2 < a < \hat{a}) \), any one of the available policy instruments can be harmful to total welfare.

In conclusion, it seems that, for \( a > 2 \), any policy intervention is either unnecessary or risks to be harmful to total welfare. Thus, in the absence of a clear benefit from regulation, it seems safe to say that policy intervention should be avoided.

## 7 Model extensions and limitations

The base model presented above already provides a rich set of equilibria and nuanced policy advice. In an effort to demonstrate the robustness as well as the potential limitations of the base model and its implications, we will now scrutinize some of the assumptions made.

First, the base model assumes that ISPs negotiate initially with the more valuable CP and then subsequently with the less valuable CP. In Appendix D we explore an alternative timing of the game, where both ISPs offer exclusivity contracts simultaneously to the CPs. The analysis shows that our results are very robust in this regard. More precisely, the only difference to the results of the base model is this that, for large \( r \) and large \( a \), no fragmentation and full fragmentation are equilibria. However, this does not affect our policy conclusions since full fragmentation remains an equilibrium for large \( a \) and is the unique equilibrium for small \( r \) and large \( a \).

Second, we posited that the measure of complementarity of the two contents \( (u_{12}) \) and the measure of ad competition among the CPs \( (a) \) are independent. However, it could reasonably be argued that strong CP competition over ads is likely to be driven by high substitutability of content. Thus \( u_{12} \) and \( a \) might be negatively correlated. In Appendix E, we analyze the fragmentation equilibria under such correlation and show that our results are robust to this modification.

Third, in the base model we assume that the CPs’ investment in quality is sunk already at the time when CPs decide about accepting exclusivity contracts. We then characterize the equilibrium for every feasible constellation of CPs’ content qualities. In Appendix F we allow instead the CPs to strategically invest in quality prior to negotiating exclusivity. We then determine for zero and non-zero termination fees which quality levels will be chosen by the CPs, and which fragmentation outcome will prevail in equilibrium. We can show that termination fees do not just affect the fragmentation
regime, but also the CPs’ incentives to invest in content quality. As in the base model, fragmentation becomes more likely when termination fees increase. However, under fragmentation, CPs’ incentives to invest into quality also increase. Thus, over and beyond the welfare effects discussed previously, a departure from the zero-price rule has an additional positive welfare effect due to the fact that CPs’ content quality is likely to increase.

Fourth, the base model assumes that termination fees are exogenous and the same for both ISPs. We then characterize the equilibrium for every value of such a termination fee. Although this assumption is certainly a simplification, which keeps the analysis tractable, it is worth mentioning that it is not an insensible assumption. Firstly, as termination fees are currently set at zero, it is unlikely that a regulator would allow for large variations compared to the status quo, as changes might be disruptive. Secondly, if changes are allowed, they would be implemented either by the regulator itself, who would treat ISPs identically, or by industry-wide agreements that, again, are very likely to be non-discriminatory. In either case, both ISPs would charge the same level of f. Yet, it is of interest to analyze the case where, alternatively, each ISP could set unilaterally its own termination fee, that is, ISP A could set a termination fee f_A unilaterally and independently from f_B, the fee set by ISP B. We study this extension in Appendix G. We find that each ISP would have unilateral incentives to set high termination fees, as it is typical of competitive bottlenecks. We can show that the results of Proposition 4 are extended to its natural consequence: with endogenous termination fees, the only equilibria that can arise are those that involve full fragmentation. Moreover, as termination fees, in our model, do not affect the amount of content delivered, they are simply an additional rent extraction device that ISPs use to appropriate CPs’ profits, but they do not directly affect total surplus.

Fifth, in the base model we assume that end users subscribe to exactly one of the two ISPs, i.e., they single-home. This is sensible when end users have a limited budget or when they incur significant transaction costs for establishing and maintaining a second network subscription. However, it can also be reasonable to assume that end users are indeed able to subscribe to both ISPs, i.e., they multi-home. This can be desirable when users are confronted with a full fragmentation scenario. By multi-homing users can then ‘undo’ fragmentation. We study multi-homing in Appendix H. We derive that multi-homing can possibly occur, and thus affect our results, only in a fairly limited parameter region. This is the case when \( t \in \left( \frac{u_{12}-u_2}{2}, \frac{2u_{12}-(u_1+u_2)}{2} \right) \), i.e., when the degree of content complementarity (\( u_{12} \)) is neither too large, nor too small compared to the degree of differentiation between ISPs (\( t \)). Even in this parameter region, we can show that the different fragmentation scenarios that we characterize under single-homing (full/partial/no fragmentation) still arise. In this sense, our main results are robust. However, in line with the intuition, if we allow for multi-homing, fragmentation becomes less
likely as users themselves can undo full fragmentation by subscribing to both ISPs. Moreover, multi-homing yields new trade-offs with respect to welfare. On the one hand, with multi-homing some (but generally not all) end users see all content under full fragmentation. This tends to increase consumer surplus compared to single-homing. On the other hand, prices are monopoly-like under multi-homing and those end users that multi-home also bear additional transportation costs. This tends to lower consumer surplus compared to single-homing. Likewise, there exists also an additional welfare trade-off from the perspective of the CPs. On the one hand, CPs earn less exclusivity ad revenues under multi-homing. On the other hand, there is also additional demand (viewers) due to multi-homing. In other words, we cannot expect that multi-homing generally delivers better welfare results compared to single-homing and the assessment depends crucially on the specific parameter setting.

Sixth, in the base model we assume that CPs receive revenues predominantly from advertising. In fact, this was highlighted as one of the distinct features that differentiates Internet CPs from other, traditional CPs. Notice that even though a CP’s revenue model may not be entirely financed through advertisement, it may still heavily rely on advertisement. This includes the so-called “freemium” model, where a basic version of the content is offered for free (and financed through advertisements) whereas consumers have to pay extra to access the premium version. Popular services that use the freemium model are, for example, Skype, LinkedIn, Spotify and Flickr. However, even for the most successful services, the freemium model still relies on advertising. Usually users that are willing to pay for the service are greatly outnumbered and comprise only around five percent of all users (see, e.g., Doerr et al., 2010; Wagner et al., 2013). Accordingly, advertisement expenditures on the Internet continue to grow (Nielsen, 2013). Nevertheless, we acknowledge as a limitation of our model that we do not consider direct payments between end users and CPs. This would fundamentally change our model and parallel more closely the model analyzed in Hagiu and Lee (2011).

Seventh, in the base model we assume that ISPs make take-it-or-leave-it offers to the CPs. This does not necessarily mean that all the surplus of CPs is extracted. The ISPs’ bargaining power is in fact limited as they compete for attaining exclusivity with CPs. In any case, it is important to highlight that the relative bargaining power of ISPs and CPs in each stage will only affect the size and sign of the exclusivity fee, but not the fragmentation equilibrium outcome or corresponding welfare result. This is because the fragmentation equilibrium depends on the joint profits of ISP and CP, and is independent of how the joint profits are divided between the two.

Finally, our welfare analysis rests on the assumption that advertising is informative. If it were purely persuasive, we should have instead given zero weight to advertising since “it has no ‘real’ value to consumers” (Bagwell, 2007, p. 1705), in which case we currently overestimate the benefits from
advertising for welfare. Moreover, a fuller model of informative advertising would need to take into account also the profits of the producers who advertise, and of the consumers/subscribers who also consume the advertised products. We have basically given a zero weight to these additional aspects, so we may be either under- or over-estimating the role of advertising rates in our social welfare function.

8 Summary and conclusion

The potential fragmentation of the Internet due to exclusivity agreements between CPs and ISPs is currently of concern to policy makers, such as the European Commission. This is because Internet fragmentation counters the idea of a global Internet in which content is ubiquitously available and benefits everybody. In this context, it has been argued that the principle of NN would preserve an unfragmented Internet (Lee and Wu, 2009). More specifically, it is argued that absent NN regulation, which imposes a zero-price rule on the termination fees that CPs must pay to ISPs, the emergence of Internet fragmentation is enkindled by the ISPs’ desire to compete on exclusive content.

In this article, we formally investigate this argument under some general assumptions. In particular, we study how termination fees (i.e., a zero-price rule), competition between ISPs, and ad competition between CPs affect the emergence of exclusive contracts and thus Internet fragmentation. We find that the zero-price rule of NN is neither a sufficient nor a necessary policy instrument to prevent Internet fragmentation. More precisely, we can show that Internet fragmentation (partial or full) emerges in equilibrium, both without NN regulation as well as under a zero-price rule. Full Internet fragmentation even continues to emerge in equilibrium under a strict notion of the zero-price rule where not only the termination fees, but all side payments (exclusivity fees) between CPs and ISPs are restricted to zero. Thus, if the ultimate regulatory goal is to prevent Internet fragmentation, then it seems more appropriate to directly target the emergence of exclusive content by means of a no-exclusivity rule. In contrast to a zero-price rule, for which the regulator would need to monitor the payments between CPs and ISPs, a no-exclusivity rule is relatively easy to administer and control. However, we can also confirm that the zero-price rule indeed increases the likelihood that the Internet remains unfragmented in equilibrium, while at the same time full fragmentation becomes less likely. Hence, all of the considered policy interventions (zero-price rule, strict zero-price rule and no-exclusivity rule) will push the market towards less or even no Internet fragmentation in comparison to a market without NN regulation.

Nevertheless, it is questionable whether any policy intervention is justified in the present context. We proved that no fragmentation is in fact always the efficient outcome with respect to consumer
surplus. Consequently, if the policy maker considers consumer surplus as its welfare standard, then
the use of a no-exclusivity rule is advisable. However, with respect to total welfare no fragmentation is
only the efficient outcome whenever the competition over ads among the CPs is not too strong. On the
contrary, if ad competition between CPs is intense (which implies that the advertisement revenues that
CPs can earn under full exclusivity are much higher than under competition) then full fragmentation
becomes the efficient outcome with respect to total surplus, provided that advertising is informative.
In the latter case, none of the above policy tools is able to improve upon the equilibrium outcome
absent regulation. Evidently, here intervention by means of a no-exclusivity rule entails a significant
type I error as it may even be detrimental to total welfare in this case. Also for intermediate levels of
ad competition between CPs, all of the surveyed policy instruments are subject to significant type I
(i.e., regulating away from the first-best) or type II (i.e., not regulating towards the first-best) errors.
Although welfare improvements may be achieved under some circumstances, it may also occur that
welfare is deteriorated. Thus, any policy intervention is very risky and should be avoided.

In conclusion, we do not find a strong case for the use of NN regulation to prevent Internet
fragmentation. Although NN regulation may lessen the extent of Internet fragmentation, it cannot
prevent it. If this is desired, a simple no-exclusivity rule seems to be more suitable to achieve this.
Moreover with respect to total welfare, Internet fragmentation is not necessarily an inefficient outcome
and any policy intervention involves significant errors and may thus be harmful. In order to avoid ill
guided regulation, especially in such a dynamic industry, where not only consumer surplus but also
innovations (for which total welfare is a sensible measure) are important, it is therefore reasonable not
to impose NN regulation ex ante. Of course, this does not limit the applicability of ex-post regulation
in the form of competition policy, which may still scrutinize termination fees and exclusivity contracts,
but on a case-by-case basis.

References


Economies 13 (4), 257-280.


At stage 1, the ISPs offer exclusivity contracts to CP1

At stage 2, the ISPs offer exclusivity contracts to CP2

(E, E) Full
(E, NE) Partial
(NE, E) Partial
(NE, NE) No

Figure 1: Potential subgames

Figure 2: Equilibrium outcome for $t = 1$, $u_{12} = 3$, $u_1 = 2$, $u_2 = 1$, $f = 0$
Figure 3: $t = 1$, $u_1 = 2$, $u_2 = 1$, $f = 0$
dashed line: $u_{12} = 3.5$, thin line: $u_{12} = 3$, thick line: $u_{12} = 2.5$

Figure 4: $u_{12} = 3$, $u_1 = 2$, $u_2 = 1$, $f = 0$
dashed line: $t = 1$, thin line: $t = 2$, thick line: $t = 3$
Figure 5: \( t = 1, \ u_{12} = 3, \ u_1 = 2, \ u_2 = 1 \)
dashed line: \( f = 0.4 \), thin line: \( f = 0.2 \), thick line: \( f = 0 \)

Figure 6: Equilibrium outcome without NN regulation and
socially optimal areas for \( t = 1, \ u_{12} = 3, \ u_1 = 2, \ u_2 = 1, f = 0 \)
Figure 7: Performance of the zero-price rule in comparison to no NN regulation:
Black shaded areas indicate welfare improvements towards the first-best, whereas gray
shaded areas indicate welfare deteriorations away from the first-best
\[(t = 1, u_{12} = 3, u_1 = 2, u_2 = 1)\]

Figure 8: Performance of the strict zero-price rule in comparison to no NN regulation:
Black shaded areas indicate welfare improvements towards the first-best, whereas gray
shaded areas indicate welfare deteriorations away from the first-best
\[(t = 1, u_{12} = 3, u_1 = 2, u_2 = 1, f = 0.4)\]
A Appendix A: Full analysis of base model without NN regulation

Stage 3: Subscription fees and end users’ decisions

The decisions in this stage is analyzed in the main body of the paper. The equilibrium subscription fees are given by (3) and the number of end users subscribing to the ISPs are given by (4), respectively.

Stage 2: Exclusivity offered to CP 2

In this stage, there are two different types of subgames, depending on whether CP 1 has accepted exclusivity (cases \((E, \cdot)\)) or not (cases \((NE, \cdot)\)).

*CP 1 has delivered its content exclusively to ISP \(i\).* ISP \(i\) cannot offer an exclusivity contract to CP 2, therefore, only ISP \(i\) is active in this stage. ISP \(i\) can either offer an exclusivity contract to CP 2 or leave CP 2 active in both platforms. Since the exclusivity fee \(e_{12}^{(E,E)}\) is a fixed transfer, ISP \(i\) offers the exclusivity contract when the joint profits of ISP \(i\) and CP 2 under exclusivity \((E, E)\) are higher compared to the joint profits under non-exclusivity \((E, NE)\):

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\[ \Pi_{ISP}^{(E,E)} + \Pi_{CP_2}^{(E,E)} > \Pi_{ISP}^{(E,N,E)} + \Pi_{CP_2}^{(E,N,E)} \]

\[ (p_i^{(E,E)} D_i^{(E,E)} + f + e_{i2}^{(E,E)}) + (ar D_i^{(E,E)} - f - e_{i2}^{(E,E)}) > (p_i^{(E,N,E)} D_i^{(E,N,E)} + f) + (r D_i^{(E,N,E)} + ar D_i^{(E,N,E)} - 2f) \]

For \( a > \hat{a} \), where \( \hat{a} \) is given by (6) in the main text, the latter inequality always holds (the left hand-side is negative, while the right hand-side is always positive), thus, exclusivity can be achieved between ISP \( i \) and CP 2.\(^1\) Note that \( \hat{a} > 2 \) which means that, in this case, a CP that delivers its content exclusively to an ISP, needs to obtain more than a double advertising rate compared to the case it delivers its content to both ISPs \( (ar > 2r) \). Competition over ads among the CPs is very strong and we will further show that ISP \( i \) can extract a high exclusivity fee from CP 2.

For \( a \leq \hat{a} \), exclusivity is still offered by ISP \( i \) if and only if \( r < \hat{r}(a) \), where \( \hat{r}(a) \) is given by (7) in the main text.

Finally, for \( a \leq \hat{a} \) and \( r \geq \hat{r}(a) \), ISP \( i \) does not offer an exclusivity contract to CP 2, since the joint profits increase with CP 2’s advertising revenues from both platforms \( (r \) is relatively high).

Now, let us determine the exclusivity fee \( e_{i2}^{(E,E)} \) set by ISP \( i \). This fee is set at the level where CP

\(^1\) Assumption (5) in the main text ensures that the right-hand side of the inequality is positive.
2 is just indifferent between accepting or rejecting exclusivity:

\[
\Pi_{CP_2}^{(E,E)} = \Pi_{CP_2}^{(E,NE)} = \frac{3t + u_2 - u_1}{6t} - f - e_{i2}^{(E,E)} = r - \frac{3t + u_{12} - u_2}{6t} + ar - \frac{3t + u_2 - u_{12} - 2f}{6t}.
\]

ISP \(i\) extracts a higher exclusivity fee from CP 2 when \(a\) increases. However, for relatively low \(a\) and \(f\), this fee may become negative, which means that ISP \(i\) should pay CP 2 a fee to remain exclusive at this platform and boost its demand. If a contract is rejected, we set the fee to infinity.

The equilibrium outcome of this subgame is illustrated in a numerical example in Figure A1.

![Figure A1: The choices of CP 2, given that CP 1 has delivered its content exclusively to ISP \(-i\)\(](image)

\((t = 1, \ u_{12} = 3, \ u_1 = 2, \ u_2 = 1, \ f = 0)\)
By summarizing the results of this subgame, we obtain

\[
\begin{align*}
\Pi^{(E,\cdot)}_{iSP_1} &= \begin{cases} 
(3t-(u_1-u_2))^2/18t + f + e_{i1}^{(E,E)} & \text{if } \{r < \hat{\tau} \cup a \leq \hat{a}\} \cap a > \hat{a} \\
(3t-(u_1-u_2))^2/18t + f & \text{if } \{r \geq \hat{\tau} \cup a \leq \hat{a}\} 
\end{cases} \\
\Pi^{(E,\cdot)}_{iSP_2} &= \begin{cases} 
(3t-(u_1-u_2))^2/18t - r(3t+u_{12}-u_2-a(u_{12}-u_1))/6t + 2f & \text{if } \{r < \hat{\tau} \cup a \leq \hat{a}\} \cap a > \hat{a} \\
(3t-(u_1-u_2))^2/18t + f & \text{if } \{r \geq \hat{\tau} \cup a \leq \hat{a}\} 
\end{cases} \\
\Pi^{(E,\cdot)}_{CP_1} &= \begin{cases} 
ar(3t+u_{12}-u_2)/6t - f - e_{i1}^{(E,E)} & \text{if } \{r < \hat{\tau} \cup a \leq \hat{a}\} \cap a > \hat{a} \\
r(3t+u_{12}-u_2)/6t - f - e_{i1}^{(E,NE)} & \text{if } \{r \geq \hat{\tau} \cup a \leq \hat{a}\} 
\end{cases} \\
\Pi^{(E,\cdot)}_{CP_2} &= r(3t+u_{12}-u_2-a(u_{12}-u_2-3t)/6t) - 2f.
\end{align*}
\]

CP 1 has delivered its content to both ISPs. In this subgame, both ISPs deliver the content of CP 1. The two ISPs compete in order to offer an exclusivity contract to CP 2. ISP \(i\) can offer an exclusivity contract to CP 2 when the joint profits of ISP \(i\) with CP 2 are higher compared to the profits when CP 2 delivers its content to both platforms:

\[
\begin{align*}
\Pi^{(NE,E)}_{ISP_1} + \Pi^{(NE,E)}_{CP_2} + 2f + e_{i2}^{(NE,E)} + (rD_i^{(NE,E)} - f - e_{i2}^{(NE,E)} + (p_i^{(NE,E)}D_i^{(NE,E)} + 2f) + (r-2f) & > \Pi^{(NE,NE)}_{ISP_1} + \Pi^{(NE,NE)}_{CP_2} \\
(p_i^{(NE,E)} + r)D_i^{(NE,E)} + f & > p_i^{(NE,E)}D_i^{(NE,E)} + r \\
(t+u_{12}-u_1)/3 + r & > \frac{3t+u_{12}-u_1}{6t} + f \geq \frac{t}{2} + r
\end{align*}
\]

\(r < \hat{\tau},\)

where

\[
\tau \equiv \left(\frac{(3t+u_{12}-u_1)^2}{18t} + f - \frac{t}{2}\right) / \left(\frac{3t-(u_{12}-u_1)}{6t}\right) > 0. \tag{A.2}
\]
Now let us determine the exclusivity fee. For \( r \geq \tau \), no ISP opts for an exclusivity contract with CP 2. Instead, for \( r < \tau \), both ISPs prefer to have an exclusivity contract with CP 2. CP 2 takes advantage of this competition between the ISPs. Bidding between ISPs stops when ISP \( i \) is just indifferent between winning exclusivity and losing it to its rival. Therefore, the exclusive fee \( e^{(NE,E)}_{i2} \) offered by ISP \( i \) is determined by

\[
\left( t + \frac{u_{12} - u_1}{3} \right) \left( \frac{3t + u_{12} - u_1}{6t} \right) + 2f + e^{(NE,E)}_{i2} = \left( t + \frac{u_1 - u_{12}}{3} \right) \left( \frac{3t + u_1 - u_{12}}{6t} \right) + f
\]

\[
e^{(NE,E)}_{i2} = -f - \frac{2(u_{12} - u_1)}{3} < 0.
\]

CP 2 obtains the same profits when it delivers its content exclusively either to ISP \( i \) or ISP \(-i\). Without loss of generality, we assume that CP 2 chooses to deliver its content to one of the two ISPs randomly; say with probability \( \theta \), CP 2 delivers its content exclusively to ISP \( A \) and with probability \( 1 - \theta \), CP 2 delivers its content exclusively to ISP \( B \) (profits are uniquely determined). However, we still have to check whether the exclusivity fee is sufficient for CP 2 to accept any offer at all. If CP 2 rejects both offers then it pays only the termination fee, connects to both ISPs and enjoys profits \( r - 2f \). Thus, the next inequality should also be satisfied for exclusivity to occur in equilibrium

\[
\Pi^{(NE,E)}_{CP2} > \Pi^{(NE,NE)}_{CP2}
\]

\[
r \frac{3t + u_{12} - u_1}{6t} - f - e^{(NE,E)}_{i2} > r - 2f
\]

\[
r < \left( 2f + \frac{2(u_{12} - u_1)}{3} \right) / \left( \frac{3t - (u_{12} - u_1)}{6t} \right),
\]

We now prove that \( \tau < \left( 2f + \frac{2(u_{12} - u_1)}{3} \right) / \left( \frac{3t - (u_{12} - u_1)}{6t} \right) \), thus, CP 2 accepts an exclusivity offer when it receives one. The inequality (A.3) holds for \( t > (u_{12} - u_1)^2 / (18f + 6(u_{12} - u_1)) \), implying that it is sufficient that \( t > (u_{12} - u_1) / 6 \), which is satisfied at an interior solution with \( D_i \in (0, 1) \).
The equilibrium outcome of this subgame is illustrated in a numerical example in Figure A2.

![Figure A2](image_url)

Figure A2: The choices of CP 2, given that CP 1 has delivered its content to both ISPs

\((t = 1, \ u_{12} = 3, \ u_1 = 2, \ u_2 = 1, \ f = 0)\)

By summarizing the results of this subgame, we obtain

\[
E_{i2}^{(NE,\cdot)} = \begin{cases} 
-f - \frac{2(u_{12} - u_1)}{3} & \text{if } r < \bar{r}, \ i.e., \ (NE, E) \\
\infty & \text{if } r \geq \bar{r}, \ i.e., \ (NE, NE)
\end{cases}
\]

\[
\Pi_{ISP_1}^{(NE,\cdot)} = \begin{cases} 
\frac{(3t - (u_{12} - u_1))^2}{18t} + f & \text{if } r < \bar{r} \\
\frac{t}{2} + 2f & \text{if } r \geq \bar{r}
\end{cases}
\]

\[
\Pi_{CP_1}^{(NE,\cdot)} = \begin{cases} 
\frac{r(3t + u_{12} - u_1 + a(3t - (u_{12} - u_1))}{6t} - 2f & \text{if } r < \bar{r} \\
r - 2f & \text{if } r \geq \bar{r}
\end{cases}
\]

\[
\Pi_{CP_2}^{(NE,\cdot)} = \begin{cases} 
\frac{r(3t + u_{12} - u_1) + 2(u_{12} - u_1)}{3} & \text{if } r < \bar{r} \\
r - 2f & \text{if } r \geq \bar{r}
\end{cases}
\]

The profits \(\Pi_{CP_1}^{(NE,\cdot)}\) of CP 1, which is passive at this stage of the game, are strictly higher when its
rival CP choose exclusivity with ISP $i$. This is because CP 1 in this subgame serves all customers in any case, but would additionally benefit from the reduced competition for advertising at ISP $-i$ where CP 2 does not deliver its content. This plays a role when going backwards in the first stage.

**Stage 1: Exclusivity offered to CP 1**

At the first stage of the game, anticipating that CP 2 will subsequently decide on exclusivity or non-exclusivity along the equilibrium path, CP 1 decides whether to deliver exclusively its content to one ISP or to deliver its content to both ISPs. From the previous analysis, there are various potential cases depending on the values of $a$ and $r$ (recall that the critical thresholds are $\hat{a}$, $\tilde{r}$, and $\tilde{r}$, are given respectively by (6), (7) in the main text and (A.2)). After comparing these thresholds, we obtain that $\tilde{r} > \hat{r}$ if and only if $a < \overline{a}$, where

$$
\overline{a} < \hat{a}.
$$

The analysis is similar to the analysis in stage 2. An exclusivity offer is accepted by CP 1 when the joint profits of CP 1 and the exclusive ISP are higher compared to the joint profits of CP 1 with both ISPs. In addition, whenever exclusivity between CP 1 and ISP $i$ is achieved, the exclusivity fee $e_{i1}$ is driven down to the level that makes ISP $i$ indifferent between obtaining exclusivity itself or the case where exclusivity is obtained by the rival ISP; the joint profits of CP 1 with either ISP are the same. The various potential equilibrium regions are presented graphically in a numerical example.
in Figure A3.

![Figure A3: The potential choices of CP 1, given the continuation of the game](image)

Figure A3: The potential choices of CP 1, given the continuation of the game

\[(t = 1, u_{12} = 3, u_1 = 2, u_2 = 1, f = 0)\]

There are four alternative joint profit comparisons in this stage. In the top-left area of Figure A3, CP 1 has to decide between exclusivity or not, given that CP 2 always opts for no exclusivity in stage 2. We find that, in this area, exclusivity is achieved for relative low values of \(r\), i.e., \(r \leq \hat{r}\) where \(\hat{r}\) is given by (8) in the main text, leading to partial Internet fragmentation with CP 1 opting for exclusivity; otherwise CP 1 delivers its content to both ISPs, leading to no fragmentation. In the right (top and bottom) area of Figure A3, CP 1 chooses to deliver its content exclusively to a single ISP, thus, full Internet fragmentation emerges. Finally, in the bottom-left area of Figure A3, partial fragmentation is the equilibrium outcome. In this area of partial fragmentation, exclusivity can be achieved by either CP. We find that, when \(K > 0\), exclusivity is always achieved by CP 1; however, when \(K \leq 0\), exclusivity may be achieved either by CP 1 or by CP 2.\(^2\) More specifically, when \(K \leq 0\)

\[^{2}\text{The threshold } K \text{ is given by } K \equiv -54ft^2(u_1 - u_2) + 36ft(u_{12} - u_1)(u_1 - u_2) - 18t^2(u_{12} - u_2)(u_{12} - u_1) - 3t(u_{12} - u_1)((u_1 - u_2)(4u_1 - u_2) - 2(u_{12} - u_2)^2 - 3u_{12}(u_1 - u_2)) - (u_{12} - u_1)^2(u_1 - u_2)(2u_{12} - (u_1 + u_2)).\]
and \( a < \bar{a}, \) CP 1 achieves exclusivity.\(^3\) When \( K \leq 0 \) and \( a \in (\bar{a}, \bar{a}) \), CP 1 achieves exclusivity for \( r \in (\tilde{r}, \bar{r}) \), while CP 2 achieves exclusivity for \( r \in (\bar{r}, \bar{r}) \).\(^4\) Lastly, when \( K \leq 0 \) and \( a \in (\bar{a}, \bar{a}) \), CP 2 achieves exclusivity.\(^5\)

The equilibrium outcome is illustrated in two numerical examples in Figure A4. The intuition and equilibrium properties are discussed in Section 4 of the main text.

By summarizing these results, we obtain the equilibrium outcome of the whole game.

\[
\text{Fragmentation:} \begin{cases} 
\text{full} & \text{if } \{r \leq \tilde{r} \cup a < \tilde{a}\} \cap a \geq \tilde{a}, \text{ i.e., } (E, E) \\
\text{partial} & \text{if } \{\tilde{r} < r < \tilde{r} \cup a < \tilde{a}\}, \text{ i.e., } (E, NE) \text{ or } (NE, E) \\
\text{no} & \text{if } \{r \geq \max \{\tilde{r}, \tilde{r}\} \cup a < \tilde{a}\}, \text{ i.e., } (NE, NE).
\end{cases}
\]

\(^3\)The threshold \( \bar{\bar{a}} \) is given by \( \bar{\bar{a}} = \frac{u_1 - u_2}{\Delta - (u_1 - u_2)^2} + \frac{36f + (2u_12 - u_1 - u_2)(6t + u_1 - u_2)}{2(2u_2 - u_1)(6t + u_1 - u_2) + 18f} + \frac{18f + (2u_2 - u_1)(6t + u_1 - u_2) + 36f)}{(3(t + u_1 - u_2) + 18f)(3(t + u_1 - u_2))} \).

\(^4\)The threshold \( \bar{\bar{a}} \) is given by \( \bar{\bar{a}} = \frac{(u_1 - u_2)(2u_12 - u_1 - u_2)(6t + u_1 - u_2)}{(2u_12 - u_1)(6t + u_1 - u_2) + 36f} + \frac{36f + (2u_12 - u_1 - u_2)(6t + u_1 - u_2) + 36f)}{(3(3t + u_1 - u_2) + 18f)(3(t + u_1 - u_2))} \).

\(^5\)Note that for \( K < 0 \) we obtain \( \bar{a} < \bar{a} < \bar{a} \), while for \( K > 0 \) we obtain \( \bar{a} < \bar{a} < \bar{a} \).
The equilibrium levels of the exclusivity fees and all firms’ profits are given below.

\[ e_{i1}^* = \begin{cases} 
  f - \frac{2(u_1 - u_2)}{3} - \frac{r(3t + u_1 - u_2 - a(u_1 - u_1))}{6t} & \text{if Full fragmentation} \\
  f - \frac{2(u_1 - u_2)}{3} & \text{if Partial fragmentation (E, NE)} \\
  \infty & \text{if Partial fragmentation (NE, E)} \\
  \infty & \text{if No fragmentation}
\end{cases} \]

\[ e_{i2}^* = \begin{cases} 
  f - \frac{r(3t + u_1 - u_2 - a(u_1 - u_1))}{6t} & \text{if Full fragmentation} \\
  \infty & \text{if Partial fragmentation (E, NE)} \\
  -f - \frac{2(u_1 - u_2)}{3} & \text{if Partial fragmentation (NE, E)} \\
  \infty & \text{if No fragmentation}
\end{cases} \]

\[ \Pi_{ISP_1}^* = \begin{cases} 
  \frac{(3t - u_1 + u_2)^2}{18t} - \frac{3t + u_1 - u_2 - a(u_1 - u_1)}{6t} + 2f & \text{if Full fragmentation} \\
  \frac{(3t - (u_1 - u_2))^2}{18t} + f & \text{if Partial fragmentation (E, NE)} \\
  \frac{(3t - (u_1 - u_1))^2}{18t} + f & \text{if Partial fragmentation (NE, E)} \\
  \frac{t}{2} + 2f & \text{if No fragmentation}
\end{cases} \]

\[ \Pi_{CP_1}^* = \begin{cases} 
  r\left(a\left(\frac{3t + u_1 - u_2}{6t}\right) + \frac{3t + u_1 - u_2 - a(u_1 - u_1)}{6t}\right) + \frac{2(u_1 - u_2)}{3} - 2f & \text{if Full fragmentation} \\
  r\frac{3t + u_1 - u_2 - a(u_1 - u_1)}{6t} + \frac{2(u_1 - u_2)}{3} & \text{if Partial fragmentation (E, NE)} \\
  r\frac{3t + u_1 - u_2 + a(3t - (u_1 - u_1))}{6t} - 2f & \text{if Partial fragmentation (NE, E)} \\
  r - 2f & \text{if No fragmentation}
\end{cases} \]

\[ \Pi_{CP_2}^* = \begin{cases} 
  r\frac{3t + u_1 - u_2 + a(3t - (u_1 - u_2))}{6t} - 2f & \text{if Full fragmentation} \\
  r\frac{3t + u_1 - u_2 + a(3t - (u_1 - u_2))}{6t} - 2f & \text{if Partial fragmentation (E, NE)} \\
  r\frac{3t + u_1 - u_1}{6t} + \frac{2(u_1 - u_1)}{3} & \text{if Partial fragmentation (NE, E)} \\
  r - 2f & \text{if No fragmentation}
\end{cases} \]

Note also that, for the parameter values where \( \tilde{r} < \hat{r} \), the partial fragmentation result is eliminated; full fragmentation emerges when \( r \leq \tilde{r} \), and no fragmentation emerges when \( r > \hat{r} \).
B  Appendix B: Full analysis of base model under the strict zero-price rule

Under the strict zero-price rule, the timing of the game remains the same as the unregulated game with the difference that, now, the CPs do not pay the termination fees \( f = 0 \) and that, when a CP delivers its content to a single ISP, then it does not pay the exclusivity fee \( e_{ij} = 0, \, i = A, \, B, \, j = 1, \, 2 \). In the first stage of this net neutrality game, CP 1 decides whether to deliver its content to both ISPs or to only one. In the second stage, CP 2 decides whether to deliver its content to both ISPs or to only one. Finally, the ISPs set simultaneously the subscription fees \( p_A, \, p_B \) and the end users choose which ISP to subscribe to. We proceed backwards to solve for the subgame perfect equilibrium.

Stage 3: Subscription fees and end users’ decisions

The subscribers’ decisions in this stage replicate the equilibrium outcome under non net neutrality as in Appendix A.

Stage 2: CP 2 decides whether to deliver its content to both ISPs or only to one.

Similar to the unregulated game, in this stage, there are two different types of subgames, depending on whether CP 1 has accepted exclusivity (cases \((E, \cdot)\)) or not (cases \((NE, \cdot)\)).

\textit{CP 1 has delivered its content exclusively to ISP \(-i\). CP 2 decides whether to deliver its content to both ISPs or only to ISP \(i\). CP 2 delivers its content only to ISP \(i\) if and only if:}

\[
\frac{\Pi_{CP_2}^{(E,E)}}{\Pi_{CP_2}^{(E,NE)}} > \frac{\frac{3t - (u_1 - u_2)}{6t}}{\frac{3t + u_{12} - u_2}{6t} + \frac{3t - (u_{12} - u_2)}{6t}}
\]

\[a > \hat{a},\]

where \(\hat{a}\) is the same threshold as in expression (6) in the main body of the paper.
When CP 2 delivers its content only to ISP $i$, on the one hand, it loses the advertising revenues obtained at ISP $-i$ (the loss equals to $r\frac{3t+u_1-u_2}{6t}$), but on the other hand, it increases the demand of ISP $i$ (and, thus, its ad revenues) due to the fact that its content is only delivered at this platform ($\frac{3t-(u_1-u_2)}{6t} > \frac{3t-(u_12-u_2)}{6t}$). When $a$ is relatively high, CP 2 delivers its content only to ISP $i$.

**CP 1 has delivered its content to both ISPs.** CP 2 decides whether to deliver its content to both ISPs or only to a single ISP, either ISP $i$ or ISP $-i$ (the two cases are symmetric and give the same profits for CP 2). CP 2 delivers its content only to ISP $i$ when:

$$\Pi_{CP_2}^{(NE,E)} > \Pi_{CP_2}^{(NE,NE)}$$
$$rD_i^{(NE,E)} > r,$$

which is never true. CP 2 always delivers its content to both ISPs, given that CP 1 has also decided to deliver its content to both ISPs. Obtaining advertising revenues at both platforms is always more profitable for CP 2 in this case.

**Stage 1: CP 1 decides whether to deliver its content to both ISPs or only to one.**

CP 1 decides whether to deliver its content to both ISPs or to a single one, anticipating the continuation game. For relatively high values of $a$ ($a > \tilde{a}$), CP 1 delivers its content to a single ISP $-i$ iff:

$$\Pi_{CP_1}^{(E,E)} > \Pi_{CP_1}^{(NE,NE)}$$
$$a \frac{3t + u_1-u_2}{6t} > r$$
$$a > \frac{6t}{3t + u_1-u_2},$$

which is always satisfied for $a > \tilde{a}$. Therefore, for these values of $a$, full fragmentation is the equilibrium outcome. As before, with probability $\theta$ exclusivity with CP 1 is achieved by ISP $A$ and with probability $1 - \theta$ by ISP $B$. These two alternative full fragmentation cases give the same equilibrium profits to the CPs (but not to the ISPs, since the ISP that achieves exclusivity with the more efficient CP obtains higher profits than the rival ISP).
For relatively low values of \( a (a \leq \tilde{a}) \), CP 1 delivers its content to a single ISP \(-i\) if and only if:

\[
\Pi_{CP_1}^{(E,NE)} > \Pi_{CP_1}^{(NE,NE)} \\
rD_{-i}^{(E,NE)} > r,
\]

which is never true. Therefore, for low values of \( a \), CP 1 delivers its content to both ISPs and no fragmentation is the equilibrium outcome.

We summarize the equilibrium outcome of the whole game under the strict zero-price rule.

Fragmentation under strict zero-pricing:

\[
\text{full if } a > \tilde{a} \\
\text{no if } a \leq \tilde{a}.
\]

The equilibrium values of all firms’ profits are given below.

\[
\Pi_{ISP_A}^S = \begin{cases} 
\frac{(3t+u_1-u_2)^2}{18r} & \text{if Full fragmentation & prob. } \theta \\
\frac{(3t+u_2-u_1)^2}{18r} & \text{if Full fragmentation & prob. } 1-\theta \\
\frac{t}{2} & \text{if No fragmentation}
\end{cases}
\]

\[
\Pi_{ISP_B}^S = \begin{cases} 
\frac{(3t+u_2-u_1)^2}{18r} & \text{if Full fragmentation & prob. } \theta \\
\frac{(3t+u_1-u_2)^2}{18r} & \text{if Full fragmentation & prob. } 1-\theta \\
\frac{t}{2} & \text{if No fragmentation}
\end{cases}
\]

\[
\Pi_{CP_1}^S = \begin{cases} 
\frac{3t+u_1-u_2}{6r} & \text{if Full fragmentation} \\
r & \text{if No fragmentation}
\end{cases}
\]

\[
\Pi_{CP_2}^S = \begin{cases} 
\frac{3t+u_2-u_1}{6r} & \text{if Full fragmentation} \\
r & \text{if No fragmentation.}
\end{cases}
\]
C Appendix C: Welfare comparisons

By comparing the total welfare from equation (11) in the main body of the paper under the feasible outcomes we obtain

\[ W^{(NE,NE)} > W^{(E,NE)} \quad \text{if} \quad a < \frac{(u_{12} - u_2)(5(3t - (u_{12} - u_2)) + 3t)}{6r(3t - (u_{12} - u_2))} + 2 \]

\[ W^{(NE,NE)} > W^{(NE,E)} \quad \text{if} \quad a < \frac{(u_{12} - u_1)(5(3t - (u_{12} - u_1)) + 3t)}{6r(3t - (u_{12} - u_1))} + 2 \]

\[ W^{(E,NE)} > W^{(E,E)} \quad \text{if} \quad a < \frac{(u_{12} - u_1)(5(3t - (u_{12} - u_1)) + 5(u_{12} - u_2) + 3t)}{6r(3t + u_{12} - u_2)} + 2 \]

\[ W^{(NE,E)} > W^{(NE,E)} \quad \text{if} \quad a < \frac{(u_{12} - u_2)(5(3t - (u_{12} - u_2)) + 5(u_{12} - u_1) + 3t)}{6r(3t + u_{12} - u_1)} + 2 \]

\[ W^{(NE,NE)} > W^{(E,E)} \quad \text{if} \quad a < \frac{18t(u_{12} - (u_1 + u_2)) - 5(u_1 - u_2)^2}{96rt} + 2 \]

Note that all these thresholds for \( a \) are greater than 2. Finally, note that either one of the partial fragmentation outcomes \((E, NE)\) or \((NE, E)\) may be more efficient. We have \( W^{(E,NE)} > W^{(NE,E)} \) iff

\[ a < 2 - \frac{18t(u_{11} - u_2) - 5(u_{12} - u_2)(2u_{12} - (u_1 + u_2))}{6r(u_1 - u_2)} \]

D Appendix D: Simultaneous exclusivity offers

We now modify the sequential nature of the exclusivity offers and study the alternative case where both ISPs simultaneously make exclusivity offers to the CPs. We consider the following two-stage game:

1. The ISPs make simultaneously a take-it-or-leave-it exclusivity offer to one of the two CPs or make no exclusivity offer at all.\(^6\) Each CP accepts one of the two offers, or rejects both in which case it delivers its content to both ISPs.

2. The ISPs simultaneously announce the subscription fees \( p_A, p_B \) and the end users choose which

\[^6\text{Again we depart from the extreme case where both contents are exclusively delivered to one ISP. See Footnote 6.}\]
ISP to subscribe to.

The last stage of this game is the same as the last stage of the sequential offers game, thus, the equilibrium subscription fees and demand are given in the main body of the paper by (3) and (4), respectively. The first stage can be sketched in a normal form game:

<table>
<thead>
<tr>
<th>ISP -i offers</th>
<th>exclusivity to CP 1</th>
<th>exclusivity to CP 2</th>
<th>no exclusivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>exclusivity to CP 1</td>
<td>cell (1,1)</td>
<td>cell (1,2)</td>
<td>cell (1,no)</td>
</tr>
<tr>
<td>ISP i offers exclusivity to CP 2</td>
<td>cell (2,1)</td>
<td>cell (2,2)</td>
<td>cell (2,no)</td>
</tr>
<tr>
<td>no exclusivity</td>
<td>cell (no,1)</td>
<td>cell (no,2)</td>
<td>cell (no,no)</td>
</tr>
</tbody>
</table>

We now derive the payoffs in each cell and then calculate the Nash equilibrium. Note also that cell (2,1), cell (no,1) and cell (no,2) are symmetric to cell (1,2), cell (1,no) and cell (2,no), respectively.

**Payoff derivation**

**Cell (1,1)** Both ISPs offer an exclusivity contract to CP 1. Notice that this will induce a bidding war for exclusivity by CP 1 and hence, the exclusivity fee is set at the level that makes each ISP indifferent between obtaining exclusivity itself or the case where exclusivity is obtained by the rival ISP:

\[
\left(t + \frac{u_{12} - u_2}{3}\right) \left(\frac{3t + u_{12} - u_2}{6t}\right) + 2f + e^{(E,NE)}_{i_1} = \left(t + \frac{u_2 - u_{12}}{3}\right) \left(\frac{3t + u_2 - u_{12}}{6t}\right) + f
\]

\[
e^{(E,NE)}_{i_1} = -f - \frac{2(u_{12} - u_2)}{3} < 0,
\]

where the exclusivity offer by ISP -i is also \(e^{(E,NE)}_{-i_1} = e^{(E,NE)}_{i_1}\). The profits are given by

\[
\Pi^{(E,NE)}_{ISP_i} = \Pi^{(E,NE)}_{ISP_{-i}} = \frac{(3t + u_2 - u_{12})^2}{18t} + f
\]

\[
\Pi^{(E,NE)}_{CP_1} = r \left(\frac{3t + u_{12} - u_2}{6t}\right) + \frac{2(u_{12} - u_2)}{3}
\]

\[
\Pi^{(E,NE)}_{CP_2} = r \frac{3t + u_{12} - u_2 + a(3t - (u_{12} - u_2))}{6t} - 2f.
\]
We still have to check whether the exclusivity fee is sufficient for CP 1 to accept any offer at all. Thus, the next inequality should be also satisfied

\[ r \left( \frac{3t + u_{12} - u_2}{6t} \right) - f - e^{(E,NE)}_{i_1} > r - 2f \]

\[ r < \left( 2f + \frac{2(u_{12} - u_2)}{3} \right) / \left( \frac{3t - (u_{12} - u_2)}{6t} \right). \]

**Cell (1,2)** ISP i offers an exclusivity contract to CP 1 and ISP \( i \) offers an exclusivity contract to CP 2. The exclusivity fees are set at the level that makes the CPs indifferent between accepting or rejecting the offers:

\[ \Pi^{(E,E)}_{CP_1} = \Pi^{(NE,E)}_{CP_1} \]

\[ ar \left( \frac{3t + u_1 - u_2}{6t} \right) - f - e^{(E,E)}_{i_1} = ar \left( \frac{3t + u_1 - u_{12}}{6t} \right) + r \left( \frac{3t + u_{12} - u_1}{6t} \right) - 2f \]

\[ e^{(E,E)}_{i_1} = f - r \frac{3t + u_{12} - u_1 - a(u_{12} - u_2)}{6t}, \]

and

\[ \Pi^{(E,E)}_{CP_2} = \Pi^{(E,NE)}_{CP_2} \]

\[ ar \left( \frac{3t + u_2 - u_1}{6t} \right) - f - e^{(E,E)}_{i_2} = r \left( \frac{3t + u_1 - u_{12}}{6t} \right) + ar \left( \frac{3t + u_{12} - u_2}{6t} \right) - 2f \]

\[ e^{(E,E)}_{i_2} = f - r \frac{3t + u_{12} - u_2 - a(u_{12} - u_1)}{6t}. \]

The profits are given by

\[ \Pi^{(E,E)}_{ISP_i} = \frac{(3t + u_1 - u_2)^2}{18t} - r \frac{3t + u_{12} - u_1 - a(u_{12} - u_2)}{6t} + 2f \]

\[ \Pi^{(E,E)}_{ISP_{-i}} = \frac{(3t - u_1 + u_2)^2}{18t} - r \frac{3t + u_{12} - u_2 - a(u_{12} - u_1)}{6t} + 2f \]

\[ \Pi^{(E,E)}_{CP_1} = r \frac{3t - u_1 + u_{12} + a(3t - (u_{12} - u_1))}{6t} - 2f \]

\[ \Pi^{(E,E)}_{CP_2} = r \frac{3t - u_2 + u_{12} + a(3t - (u_{12} - u_2))}{6t} - 2f. \]
Cell (1, no) ISP \( i \) offers an exclusivity contract to CP 1 and ISP \(-i\) offers no exclusivity contract at all. The exclusivity fee offered by ISP \( i \) is set at the level that makes CP 1 indifferent between accepting or rejecting the offer:

\[
\Pi_{CP_1}^{(E,NE)} = \Pi_{CP_1}^{(NE,NE)}
\]

\[
 r \left( \frac{3t + u_{12} - u_2}{6t} \right) - f - e_{i1}^{(E,NE)} = r - 2f
\]

\[
e_{i1}^{(E,NE)} = -r \frac{3t + u_2 - u_{12}}{6t} + f,
\]

which gives the following profits

\[
\Pi_{ISP_i}^{(E,NE)} = \frac{(3t - u_2 + u_{12})^2}{18t} + 3f - r \frac{3t + u_2 - u_{12}}{6t}
\]

\[
\Pi_{ISP_{-i}}^{(E,NE)} = \frac{(3t + u_2 - u_{12})^2}{18t} + f
\]

\[
\Pi_{CP_1}^{(E,NE)} = r - 2f
\]

\[
\Pi_{CP_2}^{(E,NE)} = r \frac{3t + u_{12} - u_2 + a(3t - (u_{12} - u_2))}{6t} - 2f.
\]

Cell (2,1) ISP \( i \) offers an exclusivity contract to CP 2 and ISP \(-i\) offers an exclusivity contract to CP 1. The payoffs in this cell are symmetric to the payoffs at cell (1,2) with the difference that now ISP \(-i\) is the one that obtains exclusivity with the more valuable CP. We obtain

\[
e_{i1}^{(E,E)} = f - r \frac{3t + u_{12} - u_1 - a(u_{12} - u_2)}{6t}
\]

\[
e_{i2}^{(E,E)} = f - r \frac{3t + u_{12} - u_2 - a(u_{12} - u_1)}{6t},
\]

and

\[
\Pi_{ISP_i}^{(E,E)} = \frac{(3t - u_1 + u_{2})^2}{18t} - r \frac{3t + u_{12} - u_2 - a(u_{12} - u_1)}{6t} + 2f
\]

\[
\Pi_{ISP_{-i}}^{(E,E)} = \frac{(3t + u_1 - u_{2})^2}{18t} - r \frac{3t + u_{12} - u_1 - a(u_{12} - u_2)}{6t} + 2f
\]

\[
\Pi_{CP_1}^{(E,E)} = r \frac{3t - u_1 + u_{12} + a(3t - (u_{12} - u_1))}{6t} - 2f
\]

\[
\Pi_{CP_2}^{(E,E)} = r \frac{3t - u_2 + u_{12} + a(3t - (u_{12} - u_2))}{6t} - 2f.
\]
Cell (2,2) Both ISPs offer an exclusivity contract to CP 2 (bidding war for CP 2). This can be analyzed in the same fashion as in cell (1,1). The exclusivity fee is set at

$$e_{i2}^{(NE,E)} = -f - \frac{2(u_{12} - u_1)}{3},$$

where the exclusivity offer by ISP $-i$ is also $e_{-i2}^{(NE,E)} = e_{i2}^{(NE,E)}$. The profits obtained are

$$\Pi_{ISP_i}^{(NE,E)} = \Pi_{ISP_{-i}}^{(NE,E)} = \frac{(3t + u_1 - u_{12})^2}{18t} + f,$$
$$\Pi_{CP_1}^{(NE,E)} = r\left(\frac{3t - u_1 + u_{12} + a(3t + u_1 - u_{12})}{6t}\right) - 2f,$$
$$\Pi_{CP_2}^{(NE,E)} = r\left(\frac{3t + u_1 - u_{12}}{6t}\right) + \frac{2(u_{12} - u_1)}{3}.$$

CP 2 accepts any offer at all as long as

$$r < \left(2f + \frac{2(u_{12} - u_1)}{3}\right) / \left(\frac{3t - (u_{12} - u_1)}{6t}\right).$$

Cell (2,no) As in cell (1,no) we have

$$e_{i2}^{(NE,E)} = -r\frac{3t + u_1 - u_{12}}{6t} + f,$$

with corresponding profits

$$\Pi_{ISP_i}^{(NE,E)} = \frac{(3t - u_1 + u_{12})^2}{18t} + 3f - r\frac{3t + u_1 - u_{12}}{6t},$$
$$\Pi_{ISP_{-i}}^{(NE,E)} = \frac{(3t + u_1 - u_{12})^2}{18t} + f,$$
$$\Pi_{CP_1}^{(NE,E)} = r\left(\frac{3t + u_{12} - u_1 + a(3t - (u_{12} - u_1))}{6t}\right) - 2f,$$
$$\Pi_{CP_2}^{(NE,E)} = r - 2f.$$

Cell (no,1) ISP $i$ offers no exclusivity and ISP $-i$ offers an exclusivity contract to CP 1. The
payoffs in this cell are symmetric to the payoffs at cell (1,no), thus, we have
\[ e_{-11}^{(E,NE)} = -r \frac{3t + u_2 - u_{12}}{6t} + f, \]

with
\[ \Pi_{ISP_i}^{(E,NE)} = \frac{(3t + u_2 - u_{12})^2}{18t} + f \]
\[ \Pi_{ISP_{-i}}^{(E,NE)} = \frac{(3t - u_2 + u_{12})^2}{18t} + 3f - r \frac{3t + u_2 - u_{12}}{6t} \]
\[ \Pi_{CP_1}^{(E,NE)} = r - 2f \]
\[ \Pi_{CP_2}^{(E,NE)} = \frac{3t + u_{12} - u_2 + a(3t - (u_{12} - u_2))}{6t} - 2f. \]

**Cell (no,2)** ISP \( i \) offers no exclusivity and ISP \( -i \) offers an exclusivity contract to CP 2. The payoffs in this cell are symmetric to the payoffs at cell (2,no), thus, we have
\[ e_{-i2}^{(NE,E)} = -r \frac{3t + u_1 - u_{12}}{6t} + f, \]

with
\[ \Pi_{ISP_i}^{(NE,E)} = \frac{(3t + u_1 - u_{12})^2}{18t} + f \]
\[ \Pi_{ISP_{-i}}^{(NE,E)} = \frac{(3t - u_1 + u_{12})^2}{18t} + 3f - r \frac{3t + u_1 - u_{12}}{6t} \]
\[ \Pi_{CP_1}^{(NE,E)} = r - 2f \]
\[ \Pi_{CP_2}^{(NE,E)} = \frac{3t + u_{12} - u_1 + a(3t - (u_{12} - u_1))}{6t} - 2f. \]

**Cell (no,no)** Both ISPs do not offer any exclusivity offer to the CPs. Each ISP receives half of the total demand and the profits are
\[ \Pi_{ISP_i}^{(NE,NE)} = \Pi_{ISP_{-i}}^{(NE,NE)} = \frac{t}{2} + 2f \]
\[ \Pi_{CP_1}^{(NE,NE)} = \Pi_{CP_2}^{(NE,NE)} = r - 2f. \]
As we have derived all payoffs at the normal form representation of the game, we now proceed to the characterization of the Nash equilibrium.

**Nash equilibrium**

To solve for the Nash equilibrium of this game, we follow the standard logic of a normal form game. A Nash equilibrium is attained whenever each ISP does not have an incentive to deviate from a given strategy. Thus, for every strategy combination (cell) we need to check for which range of parameters ISPs do not have an incentive to deviate to a different strategy (cell).

**Cell (1,1)** This strategy combination constitutes a Nash equilibrium if ISP \(i\)’s best response is to offer an exclusive contract to CP 1, given that ISP \(i\) also offers an exclusivity contract to CP 1. This is the case when ISP \(-i\) obtains (weakly) higher profits when it offers an exclusivity contract to CP 1 compared to 1) the case where it offers an exclusivity contract to CP 2 (i.e., profits at cell (1,2)) and 2) to the case where it offers no exclusivity at all (i.e., profits at cell (1,no)). The first condition is satisfied when

\[
\frac{(3t + u_2 - u_{12})^2}{18t} + f \geq \frac{(3t - u_1 + u_2)^2}{18t} - \frac{3t + u_{12} - u_2 - a(u_{12} - u_1)}{6t} + 2f \\
a \leq \tilde{a} \cup r \geq \tilde{r},
\]

while the second condition is always satisfied (the profits obtained are the same, so ISP \(-i\) is indifferent).

Additionally, as in the sequential move game, in order to constitute a stable equilibrium, we have to check whether the joint profits under exclusivity are in fact higher than under no exclusivity. Thus, the next inequality should be also satisfied

\[
\left(\frac{(3t + u_2 - u_{12})^2}{18t} + f\right) + \left(r \left(\frac{3t + u_{12} - u_2}{6t}\right) + \frac{2(u_{12} - u_2)}{3}\right) \geq \left(\frac{t}{2} + 2f\right) + (r - 2f) \\
r \leq \tilde{r}.
\]
Finally, CP 1 accepts any one of the ISPs’ offers if it is weakly better off than by not accepting, i.e., under no exclusivity. This is the case when
\[ r < \left( 2f + \frac{2(u_{12} - u_2)}{3} \right) / \left( \frac{3t - (u_{12} - u_2)}{6t} \right), \]
which is satisfied for \( r \leq \tilde{r} \). Note that cell (1,1) corresponds to partial fragmentation (E,NE), using the same notation as in the main body of the paper. This is the because only one ISP can eventually obtain exclusivity with CP 1, while CP 2 is active in both platforms. Thus, partial fragmentation (E, NE) is a Nash equilibrium for \( \tilde{r} \leq r \leq \tilde{r} \cup a \leq \hat{a} \).

**Cell (1,2)** Using the same reasoning, ISP \( i \) prefers to bid for CP 1, rather than to bid for CP 2 or to no CP; and ISP \(-i\) prefers to bid for CP 2, rather than to bid for CP 1 or to no CP when \( \{ r \leq \tilde{r} \cup a < \hat{a} \} \cap a \geq \hat{a} \). Consequently, for this parameter range the strategy combination of cell (1,2), which corresponds to full fragmentation (E,E), constitutes a Nash equilibrium.

**Cell (1,no)** After comparing the relevant profits, ISP \( i \) prefers to bid for CP 1, rather than to bid for CP 2 or to no CP; and ISP \(-i\) prefers to not bid for any CP, rather than to bid for any one of them when \( \tilde{r} \leq r \leq \tilde{r} \cup a \leq \hat{a} \). Note that partial fragmentation (E,NE) emerges here for the same parameter values as in cell (1,2). Although the joint profits of ISP \( i \) and CP 1 are the same in both cases, the distribution of the benefit from exclusivity between the two firms is different, because the ISPs do not engage in a bidding war for CP 1 in the present case.

**Cell (2,2)** In order to constitute a Nash equilibrium, here each ISP should have an incentive to bid for CP 2, given that the rival ISP bids for CP 2 as well. This holds when \( r \geq r' \cup a \leq a' \), where
\[ r' \equiv \left( \frac{(u_{12} - u_2)(6t + 2u_1 - u_2 - u_{12})}{18t} + f \right) / \left( \frac{3t + u_{12} - u_1 - a(u_{12} - u_2)}{6t} \right) \]
and \( a' \equiv \frac{3t + u_{12} - u_1}{u_{12} - u_2} \).

Additionally, we have to check again whether the joint profits under exclusivity are in fact higher than under no exclusivity:
\[ \Pi^{(NE,E)}_{ISP_1} + \Pi^{(NE,E)}_{CP_2} \geq \Pi^{(NE,NE)}_{ISP_1} + \Pi^{(NE,NE)}_{CP_2} \]
\[ \left( \frac{(3t + u_1 - u_{12})^2}{18t} + f \right) + \left( r \left( \frac{3t + u_{12} - u_1}{6t} \right) + \frac{2(u_{12} - u_1)}{3} \right) \geq \left( \frac{t}{2} + 2f \right) + (r - 2f) \]
\[ r \leq \tilde{r}. \]
Finally, as calculated before, CP 1 accepts any one of the ISPs’ offers when
\[ r < \left(2f + \frac{2(u_{12} - u_{11})}{3}\right) / \left(\frac{3t - (u_{12} - u_{11})}{6t}\right), \]
which is satisfied for \( r \leq \bar{r} \). Note that cell (2,2) corresponds to partial fragmentation (NE,E), as only one ISP can eventually obtain exclusivity with CP 2, while CP 1 is active in both platforms. This constitutes a Nash equilibrium for \( r' \leq r \leq \bar{r} \cup a \leq a' \), whenever \( r' < \bar{r} \). Note also that \( r' > \bar{r} \) and \( a' < \bar{a} \).

**Cell (2,no)** Here, given that ISP \(-i\) does not offer an exclusivity contract, ISP \(i\) will always deviate from the strategy to offer an exclusivity contract to CP 2, so as to offer an exclusivity contract to CP 1. The profits for ISP \(i\) in the cell (1,no) are always higher than the profits in the cell (2,no). Thus, this strategy combination never constitutes a Nash equilibrium.

**Cell (no,no)** Finally, this strategy combination constitutes a Nash equilibrium that leads to no fragmentation (NE, NE) whenever \( r \geq \bar{r} \).

Summarizing these results, we obtain the following equilibrium outcome for the simultaneous offer game

\[
\text{Fragmentation: } \begin{cases} 
\text{full} & \text{if } \{r \leq \bar{r} \cup a < \bar{a}\} \cap a \geq \bar{a}, \text{ i.e., } (E,E) \\
\text{partial} & \text{if } \{\bar{r} < r < \bar{r} \cup a < \bar{a}\}, \text{ i.e., } (E,NE) \text{ or } (NE,E) \\
\text{no} & \text{if } r \geq \max \{\bar{r}, \bar{a}\}, \text{ i.e., } (NE,NE).
\end{cases}
\]

The equilibrium outcome is illustrated by two numerical examples in Figure D1. Note that the qualitative results remain the same as in the sequential offer game; all three types of fragmentation occur in equilibrium. In fact, for the parameter configuration in the right panel, the equilibrium is almost identical to the equilibrium in the sequential game, as described in Figure 2 in the main text. The only difference is that no fragmentation continues to constitute a Nash equilibrium alongside with full fragmentation for high values of \( a \) and \( r \) (top right of the figure). The left panel shows again very similar regions as under the sequential game (contrast with Figure A4 (a)), with an additional equilibrium in a small region in the bottom left of the figure. Hence, the results in the main text are robust to the modification of the timing of the game. The advantage of the sequential game is in
fact to get rid of the multiplicity of equilibria that can arise for some parameter configuration under simultaneous moves.

![Figure D1 (a): Equilibrium outcome for $t = 1, u_{12} = 3.75, u_1 = 2, u_2 = 1, f = 0$](image1)

![Figure D1 (b): Equilibrium outcome for $t = 1, u_{12} = 3, u_1 = 2, u_2 = 1, f = 0$](image2)

### Appendix E: Correlation between $u_{12}$ and $a$

In the main body of the paper, the measure of the joint value or complementarity of the two contents ($u_{12}$) and the measure of ad competition among the CPs ($a$) are taken to be independent. However, it could be argued that strong CP competition over ads (i.e., high $a$) is likely to be driven by high substitutability of content (i.e., low $u_{12}$). In other words, there might be a negative correlation between $u_{12}$ and $a$. In order to demonstrate that our insights remain valid in the presence of such a correlation, we impose a relationship $x$ between $u_{12}$ and $a$ as follows: Let us assume that $u_{12}$ is a function of $u_1$ and $u_2$ of the form $u_{12} = u_1 + u_2 (1 - x),^{7}$ where $x \in (-\infty, 1)$. Thus, $x$ denotes the level of substitutability/complementarity between the two contents here. Additionally, set $ar = r + r/(1 - x)$, which means that $a = (2 - x)/(1 - x) \in [1, \infty)$. Notice that $u_{12}$ decreases in $x$ while $a$ increases in

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7As similar approach is used in Calzada and Valletti (2012).

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Thus $u_{12}$ and $a$ are negatively correlated via $x$.

In particular, under this specification, as $x \to 0$, the two contents are independent, thus, the value of both contents together is the sum of the value of the two contents separately ($u_{12} \to u_1 + u_2$) and the advertising rate is also purely additive $ar \to 2r$ with $a \to 2$. As $x \to 1$, the two contents become perfect substitutes, thus, the value of both together is not higher than the value of the more valuable content alone ($u_{12} \to u_1$). According to the above logic, competition is very intense now, thus, $ar \to \infty$ with $a \to \infty$. Finally, as $x \to -\infty$, the two contents become perfect complements, thus, the joint value of the two contents increases a lot ($u_{12} \to \infty$) as the two contents should be consumed together. In this case, it is now assumed that there is no competition for ads between the CPs and thus the advertising rate is not affected by exclusivity arrangements ($ar \to r$ and $a \to 1$).

By substituting these formulas in the thresholds derived in Proposition 1, we can now plot the equilibrium outcome in the presence of a negative correlation between $u_{12}$ and $a$. More specifically, we show the equilibrium outcomes for different levels of the advertising rate $r$ (on the vertical axis) and different level of substitutability of the two contents $x$ (on the horizontal axis) in Figure E1, using the same parameter values $t = 1$, $u_1 = 2$, $u_2 = 1$, $f = 0$ as in Figure 2. Note that condition (5) from the main body of the paper must be satisfied at all times as otherwise competition between the ISP is degenerate. This condition is equivalent to $x > (u_1 - 3t)/u_2$. Moreover, notice that inequality $a \geq \widehat{a}$ is satisfied when $3t + u_1 - 2u_2 \leq 0$. For the parameters used in Figure E1, we always get $a < \widehat{a}$.

Figure E1 demonstrates that the three areas of fragmentation, which are reported in the main body of the text, still arise in equilibrium when we assume a negative correlation between $u_{12}$ and $a$. Note that since $a < \widehat{a}$, the full fragmentation area is fairly small. If we impose a different configuration of parameter values that satisfy inequality $a \geq \widehat{a}$, we will always obtain full fragmentation in equilibrium. This is in line with Proposition 1. Finally, we can compare Proposition 2 to the illustration in Figure E1: in line with the proposition, as the two contents become more complementary, that is, as $x$ decreases, full fragmentation is more likely to arise in equilibrium, while no fragmentation is less likely.
to arise in equilibrium as $x \to 1$, that is, as $u_1$ and $u_2$ become substitutes. Therefore our results in the main text are robust to a negative correlation between $u_{12}$ and $a$.

![Figure E1: Equilibrium outcome with negatively correlated $u_{12}$ and $a$ ($t = 1$, $u_1 = 2$, $u_2 = 1$, $f = 0$)](image)

**F Appendix F: Endogenous quality choice by the CPs**

In this appendix we study the impact of termination fees and Internet fragmentation on the CPs’ optimal choice of their quality $u_1$ and $u_2$ (i.e., the value of their content). In contrast to our base model, where the CPs’ qualities are exogenous, these qualities are now determined endogenously by the CPs in the first stage of the game, i.e., before exclusivity arrangements are made. This reflects the fact that the determination of content quality is a costly long-term choice. We assume a convex cost function for investment in quality. In particular, we assume the following:

$$C(u_1) = \frac{u_1^2}{2},$$

$$C(u_2) = k\frac{u_2^2}{2} \text{ with } k \geq 1,$$
therefore, it is (weakly) more costly for CP 2 to invest in quality compared to CP 1. This allows, when \( k = 1 \), for the two CPs to be ex-ante completely symmetric. We consider the following four-stage game:

1. The CPs choose the level of content quality \( u_1 \geq 0 \) and \( u_2 \geq 0 \).\(^8\)

2. The ISPs make simultaneously a take-it-or-leave-it exclusivity offer to the more valuable CP, i.e., the one with \( \max \{u_1, u_2\} \). This CP accepts one of the two offers, or rejects both in which case it delivers its content to both ISPs.

3. (a) If there was no exclusivity reached in the first stage, the ISPs make simultaneously a take-it-or-leave-it exclusivity offer to the less valuable CP and that CP either accepts one of the two offers or rejects both and delivers its content to both ISPs.

(b) Otherwise, if ISP \( -i \) has agreed with the more valuable CP on an exclusivity contract, it cannot offer an exclusivity contract to the less valuable CP as well. Thus, in this case only ISP \( i \) makes an exclusivity offer to the less valuable CP. The less valuable CP either accepts this offer, or rejects it and delivers its content to both ISPs.

4. The ISPs simultaneously announce the subscription fees \( p_A, p_B \) and the end users choose which ISP to subscribe to.

This is the same timing as in our base model, with the addition of an initial investment stage. The solution of the last two stages is identical and therefore omitted. Some minor amendments are instead needed for stage 2.

**Stage 2: Decision of the more valuable CP**

To study the endogenous choice of qualities, we now generalize our approach and also allow for the possibility that \( u_1 \) could take values lower than \( u_2 \). Thus, we must differentiate between two cases:

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\(^8\)A zero level of quality should be interpreted as no improvement to a basic content already available.
one where CP 1 is the more valuable CP with $u_1 \geq u_2$ (we denote this case as V1 case) and the other where CP 2 is the more valuable CP with $u_1 \leq u_2$ (we denote this case as V2 case). Given $u_1$ and $u_2$, at the second stage of the game we obtain the following fragmentation scenarios (as already proved in the main body of the paper for the V1 case; analogously we obtain the V2 case):

\[
\text{Fragmentation when } u_1 \geq u_2: \begin{cases} 
\text{full} & \text{if } \{r \leq \tilde{r}_{V1} \cup a < \tilde{a}_{V1}\} \cap a \geq \tilde{a}_{V1}, \text{ i.e., } (E, E) \\
\text{partial} & \text{if } \{\tilde{r}_{V1} < r < \tilde{r}_{V1} \cup a < \tilde{a}_{V1}\}, \text{ i.e., } (E, NE) \text{ or } (NE, E) \\
\text{no} & \text{if } \{r \geq \max\{\tilde{r}_{V1}, \tilde{r}_{V1}\} \cup a < \tilde{a}_{V1}\}, \text{ i.e., } (NE, NE).
\end{cases}
\]

\[
\text{Fragmentation when } u_1 \leq u_2: \begin{cases} 
\text{full} & \text{if } \{r \leq \tilde{r}_{V2} \cup a < \tilde{a}_{V2}\} \cap a \geq \tilde{a}_{V2}, \text{ i.e., } (E, E) \\
\text{partial} & \text{if } \{\tilde{r}_{V2} < r < \tilde{r}_{V2} \cup a < \tilde{a}_{V2}\}, \text{ i.e., } (E, NE) \text{ or } (NE, E) \\
\text{no} & \text{if } \{r \geq \max\{\tilde{r}_{V2}, \tilde{r}_{V2}\} \cup a < \tilde{a}_{V2}\}, \text{ i.e., } (NE, NE).
\end{cases}
\]

In the following we use again the notation of Appendix E, which allows to study different correlations between $u_{12}$ and $a$. By substituting for the correlation expressions between $u_{12}$ and $a$, we can transform the boundary conditions as follows:

\[
r \leq \tilde{r}_{V1} \iff r - \frac{(u_2 (1 - x) (6t - 2u_1 + u_2 + xu_2) + 18ft)}{3(3t + u_1 - 2u_2)} \leq 0,
\]

\[
a < \tilde{a}_{V1} \iff \frac{3t + u_1 - 2u_2}{u_2 (x - 1)} < 0,
\]

\[
r \geq \tilde{r}_{V1} \iff r - \frac{(u_1 - xu_2) (6t + u_1 - xu_2) + 18ft}{3(3t - u_1 + xu_2)} \geq 0,
\]

\[
r \leq \tilde{r}_{V2} \iff r - \frac{(u_1 (1 - x) (6t - 2u_2 + u_1 + xu_1) + 18ft)}{3(3t + u_2 - 2u_1)} \leq 0,
\]

\[
a < \tilde{a}_{V2} \iff \frac{3t + u_2 - 2u_1}{u_1 (x - 1)} \leq 0,
\]

\[
r \geq \tilde{r}_{V2} \iff r - \frac{(u_2 - xu_1) (6t + u_2 - xu_1) + 18ft}{3(3t - u_2 + xu_1)} \geq 0.
\]

The CPs’ profit functions at the second stage are then given by

\[
\Pi_{CP_1} = \begin{cases} 
\Pi_{CP_1, V1} & \text{if } u_1 \geq u_2 \\
\Pi_{CP_1, V2} & \text{if } u_1 \leq u_2.
\end{cases}
\]

\textsuperscript{9}Notice that the V2 case mirrors the V1 case. The cases are identical with the exception that $u_1$ and $u_2$ are interchanged, and that cost functions might differ.
\[ \Pi_{CP_2} = \begin{cases} 
\Pi_{CP_2; V_1} & \text{if } u_1 \geq u_2 \\
\Pi_{CP_2; V_2} & \text{if } u_1 \leq u_2, 
\end{cases} \]

where

\[
\Pi_{CP_1; V_1} = \begin{cases} 
\frac{r(u_2(3x-4)-u_1(2x-3)-3t(2x-3))}{6t(1-x)} + \frac{2(u_1-u_2)}{3} - 2f - \frac{u^2}{2} & \text{if Full fragmentation} \\
\frac{r(3t(3-2x)-u_1(1-x))}{6t(1-x)} - 2f - \frac{u^2}{2} & \text{if Partial fragmentation } (E, NE) \\
r - 2f - \frac{u^2}{2} & \text{if No fragmentation}
\end{cases} 
\]

\[
\Pi_{CP_2; V_1} = \begin{cases} 
\frac{r(3t(3-2x)-u_1+xu_2)}{6t(1-x)} - 2f - \frac{ku^2}{2} & \text{if Full fragmentation} \\
\frac{r(3t(3-2x)-u_1+xu_2)}{6t(1-x)} - 2f - \frac{ku^2}{2} & \text{if Partial fragmentation } (E, NE) \\
u_2(1-x)(4t+r)+3tr - \frac{ku^2}{2} & \text{if Partial fragmentation } (NE, E) \\
r - 2f - \frac{ku^2}{2} & \text{if No fragmentation}
\end{cases} 
\]

\[
\Pi_{CP_2; V_2} = \begin{cases} 
\frac{r(u_1(3x-4)-u_2(2x-3)-3t(2x-3))}{6t(1-x)} + \frac{2(u_2-u_1)}{3} - 2f - \frac{ku^2}{2} & \text{if Full fragmentation} \\
\frac{r(3t(3-2x)-u_1(1-x))}{6t(1-x)} - 2f - \frac{ku^2}{2} & \text{if Partial fragmentation } (E, NE) \\
\frac{(u_2-xu_1)(4t+r)+3tr - \frac{ku^2}{2} & \text{if Partial fragmentation } (NE, E) \\
r - 2f - \frac{ku^2}{2} & \text{if No fragmentation}
\end{cases} 
\]

In order to focus on the interesting case where each ISP receives positive demand, we need that

\[-3t < u_i - u_{-i} < 3t.\]

A sufficient condition that satisfies this is

\[ t > (u_{12} - \min\{u_1, u_2\})/3, \]

that is, \( 3t - u_1 + xu_2 > 0 \) when \( u_1 \geq u_2 \) and \( 3t - u_2 + xu_1 > 0 \) when \( u_1 \leq u_2 \).
Stage 1: Determination of qualities

As it will become apparent below, the profit functions in the first stage are not concave everywhere. They take different expressions in different fragmentation areas, and may also have discontinuities at the boundaries between regions (this is because the regions of validity are determined from the joint profits between CPs and ISPs, not from the profits of the CPs alone). Thus, we first determine the interior optimal quality levels in each fragmentation area, if they exist. Then we look for global optima. By the first order conditions of the CPs profit functions we obtain:

\[
\Pi_{CP_{1,1}}(E, E), \Pi_{CP_{2,1}}(E, E) \quad \text{by FOC} \quad u_1 = \frac{4t(1-x)-r(2x-3)}{6t(1-x)}, u_2 = \frac{xy}{6kt(1-x)}
\]

\[
\Pi_{CP_{1,1}}(E, NE), \Pi_{CP_{2,1}}(E, NE) \quad \text{by FOC} \quad u_1 = \frac{4t+2r}{6t}, u_2 = \frac{xy}{6kt(1-x)}
\]

\[
\Pi_{CP_{1,1}}(NE, E), \Pi_{CP_{2,1}}(NE, E) \quad \text{by FOC} \quad \Pi_{CP_{1,1}}\text{decreasing in } u_1, u_2 = \frac{(1-x)(4t+r)}{6kt}
\]

\[
\Pi_{CP_{1,1}}(NE, NE), \Pi_{CP_{2,1}}(NE, NE) \quad \text{by FOC} \quad \Pi_{CP_{1,1}}\text{decreasing in } u_1, \Pi_{CP_{2,1}}\text{decreasing in } u_2
\]

Note that the optimal \(u_1\) in each area, which is derived from the FOC of CP 1’s profit function, is independent of \(u_2\) (and vice versa). Nevertheless, the exact choice of \(u_1\) and \(u_2\) affects the fragmentation areas selected, and therefore the best reply of each CP does depend on what the other CP does.

The general solution to the above problems can generate very rich outcomes, depending on the parameters chosen. A full characterization of the equilibria is beyond the scope of this Appendix. We instead derive the equilibrium quality levels for specific numerical examples in which \(f = 0\) (i.e., under the zero-price rule) and \(f = 0.4\) (i.e., under a positive termination fee). These two cases generate already interesting economic outcomes.

Case \(f = 0\). Let us now solve for the first stage of the game when \(x = 0, t = 1, r = 1, k = 1.5, f = 0\).
The relevant thresholds for the three fragmentation scenarios at the second stage are presented in Figure F1.

![Figure F1: Fragmentation outcomes under endogenous quality choice](image)

Thus, there are three alternative fragmentation scenarios (full, partial, no) in the \((u_1, u_2)\) space, i.e., for every potential level of \(u_1\) and \(u_2\). We have checked various alternative combinations of the strategies \((u_1, u_2)\) under alternative fragmentation scenarios to examine which combinations constitute a Nash equilibrium in qualities. Here we propose and present the strategy profile \((u_1, u_2) = (0, 0)\) and prove that this constitutes a Nash equilibrium of the whole game leading to no fragmentation. Given the specific set of parameters and by taking as given that \(u_2 = 0\), the profit function of CP 1 becomes

\[
\Pi_{CP_1} = \begin{cases} 
\Pi_{CP_1, V_1}(NE, NE) = 1 - \frac{1}{2}u_1^2 & \text{if } u_1 \in (0, 0.91) \\
\Pi_{CP_1, V_1}(E, NE) = \max \left\{ -\frac{1}{2}u_1^2 + \frac{5}{6}u_1 + \frac{1}{2}, 0 \right\} & \text{if } u_1 \in (0.91, 3),
\end{cases}
\]

i.e., given \(u_2 = 0\), moving along the vertical axis in the previous figure for low values of \(u_1\) no fragmentation (NE, NE) is obtained. However, as \(u_1\) increases (and takes values above the 0.91 threshold) partial fragmentation (E,NE) is obtained. Graphically, the profits of CP 1 are in Figure
Therefore, the best response of CP 1 to $u_2 = 0$ is to set $u_1 = 0$ as well, since its profit is maximized at this level of $u_1$ and there is no profitable deviation. In particular, there is no incentive for CP 1 to set a high $u_1$ in order to switch to the partial fragmentation area (E,NE).

Now given $u_1 = 0$, the profit function of CP 2 becomes

$$
\Pi_{CP_2} = \begin{cases} 
\Pi_{CP_2,V2}(NE,NE) = 1 - 0.75u_2^2 & \text{if } u_2 \in (0,0.91) \\
\Pi_{CP_2,V2}(NE,E) = \max \left\{-0.75u_2^2 + \frac{5}{6}u_2 + \frac{1}{2},0\right\} & \text{if } u_2 \in (0.91,3) 
\end{cases}
$$

which is shown in Figure F3.
Therefore, the best response of CP 2 to $u_1 = 0$ is to set $u_2 = 0$. We conclude that the proposed strategy profile $(u_1, u_2) = (0, 0)$ constitutes a *Nash equilibrium* in qualities that leads to no fragmentation (NE, NE).

*Case $f = 0.4$.* Now we solve for the endogenous quality choices when $x = 0, t = 1, r = 1, k = 1.5, f = 0.4$. The relevant thresholds for the three fragmentation scenarios at the second stage are presented in Figure F4.

![Diagram showing fragmentation scenarios](image)

**Figure F4:** Fragmentation scenarios under endogeneous quality choice

$$(x = 0, t = 1, r = 1, k = 1.5, f = 0.4)$$

Again there are three alternative fragmentation scenarios (full, partial, no) in the $(u_1, u_2)$ space at the second stage. However the full fragmentation area is now larger since the termination fee $f$ has increased compared to the previous case, where $f = 0$. After checking for various alternative combinations of the strategies $(u_1, u_2)$, we present the strategy profile $(u_1, u_2) = (5/6, 0)$ and prove that this constitutes a Nash equilibrium of the whole game leading to partial fragmentation (E,NE).

Given the specific set of parameters and by assuming that $u_2 = 0$, the profit function of CP 1 becomes
\[
\Pi_{CP_1} = \begin{cases}
\Pi_{CP_{1,v1}}(NE, NE) = 0.2 - \frac{1}{2} u_1^2 & \text{if } u_1 \in (0, 0.195) \\
\Pi_{CP_{1,v1}}(E, NE) = \max \left\{-\frac{1}{2} u_1^2 + \frac{7}{6} u_2 + \frac{1}{2}, 0\right\} & \text{if } u_1 \in (0.195, 3). 
\end{cases}
\]

Graphically, the profits of CP 1 are given by

![Graphical representation of CP 1's profit](image)

Figure F5: CP 1’s profit

\[(x = 0, t = 1, r = 1, f = 0.4, u_2 = 0)\]

The best response of CP 1 to \(u_2 = 0\) is to set \(u_1 = 5/6\).

Now given \(u_1 = 5/6\), the profit function of CP 2 becomes

\[
\Pi_{CP_2} = \begin{cases}
\Pi_{CP_{2,v1}}(E, NE) = 0.56 - 0.75 u_2^2 & \text{if } u_2 \in (0, 0.4) \\
\Pi_{CP_{2,v1}}(E, E) = 0.56 - 0.75 u_2^2 & \text{if } u_2 \in (0.4, 5/6) \\
\Pi_{CP_{2,v2}}(E, E) = \max \left\{-0.75 u_2^2 + \frac{7}{6} u_2 - 0.4, 0\right\} & \text{if } u_2 \in (5/6, 1.9) \\
\Pi_{CP_{2,v2}}(NE, E) = 0 & \text{if } u_2 \in (1.9, 3). 
\end{cases}
\]

Graphically, the profits of CP 2 are given by Figure F6. So the best response of CP 2 to \(u_1 = 5/6\) is to set \(u_2 = 0\). We conclude that the proposed strategy profile \((u_1, u_2) = (5/6, 0)\) constitutes a Nash equilibrium in qualities that leads to partial fragmentation (E,NE), that is, exclusivity is achieved by the more valuable CP.\(^{10}\)

---

\(^{10}\)Notice also that the partial fragmentation case (NE,E) is not symmetric to the (E,NE) case at the first stage, since CP 2 faces a higher investment cost in quality \((k \geq 1)\). We have proved that, for the proposed parameter values, there is no Nash equilibrium in qualities that yields to the alternative partial fragmentation (NE,E) outcome.
These two examples demonstrate the point that termination fees affect the fragmentation regime and thus also the endogenous incentives to invest in content. We showed a possible trade-off. When \( f = 0 \) (zero-price rule), No fragmentation emerges as the only equilibrium in our example. This is good from a welfare perspective since all content is seen by all end users. However, the advertising resources generated in this case are also low, so that CPs have very little incentives to invest in content quality. CPs in fact offer the minimum possible level of quality (zero, in our example). When instead \( f = 0.4 \) (positive termination fee), a (partially) fragmented regime arises. This has bad welfare consequences in terms of reducing the size of audiences and introducing asymmetries, but it comes with the benefit of inducing at least one CP to further improve its quality level.

**G Appendix G: Endogenous choice of the termination fees by ISPs**

In this appendix, we relax the assumption that termination fees are set exogenously (e.g., by a regulator) and assume instead that the ISPs determine the profit maximizing termination fee endogenously in the game. In order to keep the model tractable, we assume that ISPs set a non-discriminatory
termination fee, $f_A$ and $f_B$ respectively, that equally applies to all CPs that are available at a given ISP, irrespective of any exclusivity arrangement. Note, however, that in case of exclusivity arrangements between an ISP $i$ and a CP $j$, the CP $j$ pays the non-discriminatory termination fee ($f_i$) and additionally a discriminatory exclusivity fee ($e_{ij}$). Thus, the CP that signs an exclusivity deal ends up paying a total fee ($f_i + e_{ij}$) to ISP $i$. Formally, we extend our base model as follows:

1. ISP $A$ and ISP $B$ simultaneously set a non-discriminatory termination fee $f_A$ and $f_B$, respectively, that applies to all CPs.

2. The ISPs make simultaneously a take-it-or-leave-it exclusivity offer to CP 1, $e_{i1}$. CP 1 accepts one of the two offers, or rejects both in which case it delivers its content to both ISPs.

3. (a) If there was no exclusivity reached in the second stage, the ISPs make simultaneously a take-it-or-leave-it exclusivity offer to CP 2 and CP 2 either accepts one of the two offers or rejects both and delivers its content to both ISPs.

(b) Otherwise, if ISP $-i$ has agreed with CP 1 on an exclusivity contract, it cannot offer an exclusivity contract to CP 2 as well. Thus, in this case only ISP $i$ makes an exclusivity offer to CP 2. CP 2 either accepts this offer, or rejects it and delivers its content to both ISPs.

4. The ISPs simultaneously announce the subscription fees $p_A$, $p_B$ and the end users choose which ISP to subscribe to.

This is the same timing as in our base model, with the addition of an initial stage in which the termination fees are determined endogenously. Before we proceed to solving the game, we need to make two remarks on notation. First, since ISPs are symmetric ex-ante, we assume without loss of generality that $f_A \geq f_B$ throughout our analysis. Second, since ISPs are not symmetric anymore ex-post, we supplement the notation of the base model on the fragmentation outcome by a subscript that
denotes the ISP (A or B) with whom exclusivity has been achieved. For example, \((E_A, E_B)\) denotes that CP 1 is exclusive with ISP A, while CP 2 is exclusive with ISP B. Similarly, \((E_B, NE)\) denotes that CP 1 is exclusive with ISP B while CP 2 is not exclusive to any ISP.

The analysis of this game parallels in large part the analysis of our base model. In order to keep the present analysis accessible, we leave the key parameters of our analysis, \(a\) and \(r\), variable, but otherwise adopt the same numerical example that we have already used previously, i.e., \(u_{12} = 3\), \(u_1 = 2\), \(u_2 = 1\), \(t = 1\).

**Stage 4: Subscription fees and end users’ decisions**

The analysis in stage 4 is identical to that of the base model and therefore omitted here.

**Stage 3: Exclusivity offered to CP 2**

*CP 1 has delivered its content exclusively to ISP A \((E_A, \cdot)\)* Exclusivity occurs if the joint profits of ISP B with CP 2 are higher with exclusivity than without, i.e., if \(\Pi_{ISP_B}^{(E_A, E_B)} + \Pi_{CP_2}^{(E_A, E_B)} > \Pi_{ISP_B}^{(E_A, NE)} + \Pi_{CP_2}^{(E_A, NE)}\), which, after some rearranging and substitution of the numerical values for \(u_{12}, u_1, u_2\) and \(t\) yields the threshold: \(r < \hat{r}_B(f_A, a) \equiv \frac{6f_A + 1}{3 - a}\). In case exclusivity with CP 2 occurs, the ISP offers an exclusivity fee that makes CP 2 indifferent between accepting the exclusivity offer and remaining non-exclusive, i.e., such that \(\Pi_{CP_2}^{(E_A, E_B)} = \Pi_{CP_2}^{(E_A, NE)}\). This is achieved by setting \(e_{B2}^{(E_A, E_B)} = f_A - r \frac{5 - a}{6}\). Given that CP 1 has delivered its content exclusively to ISP A, CP 2 then delivers its content exclusively to ISP B when \(r < \hat{r}_B\). Otherwise for \(r \geq \hat{r}_B\), CP 2 delivers its content to both ISPs (Figure G1).
Figure G1: The choices of CP 2, given that CP 1 has delivered its content exclusively to ISP A

\[(t = 1, \, u_{12} = 3, \, u_1 = 2, \, u_2 = 1)\]

\textit{CP 1 has delivered its content exclusively to ISP B} \((E_B, \cdot)\) Analogously to the previous case, CP 1 will be exclusive at ISP A if and only if \(r < \hat{r}_A(f_B, a) \equiv \frac{6f_B+1}{5-a}\) and pays an exclusivity fee of 

\[e^{(E_B, E_A)} = f_B - r \frac{5-a}{6}.\]

Note that \(f_A \geq f_B\) implies that \(\hat{r}_B \geq \hat{r}_A\). Given that CP 1 has delivered its content exclusively to ISP B, CP 2 then delivers its content exclusively to ISP A when \(r < \hat{r}_A\). Otherwise for \(r \geq \hat{r}_A\), CP 2 delivers its content to both ISPs (Figure G2).

Figure G2: The choices of CP 2, given that CP 1 has delivered its content exclusively to ISP B

\[(t = 1, \, u_{12} = 3, \, u_1 = 2, \, u_2 = 1)\]

\textit{CP 1 has delivered its content to both ISPs} \((NE, \cdot)\) As ISPs are not necessarily symmetric anymore
ex-post (when \( f_A > f_B \)), the analysis of the case where both ISPs simultaneously bid for exclusivity of a CP is slightly more involved compared to the base model. Suppose first that neither one of the ISPs makes an exclusivity offer to CP 2. This can only be an equilibrium of this subgame if none of the two ISPs has an incentive to deviate, i.e., if \( \Pi^{(NE,NE)}_{ISP_A} \geq \Pi^{(NE,E_A)}_{ISP_A} \) and \( \Pi^{(NE,NE)}_{ISP_B} \geq \Pi^{(NE,E_B)}_{ISP_B} \).

Consider first the decision of ISP B: It is evident that in case \((NE,NE)\), the exclusivity fee for ISP B is

\[
\Pi^{(NE,NE)}_{ISP_B} = \frac{1}{2} + 2f_B. \tag{G.1}
\]

If ISP B deviates from \((NE,NE)\) to \((NE,E_B)\), then it will be the only ISP that makes an exclusivity offer to CP 2. Thus, ISP B will offer an exclusivity fee that makes CP 2 indifferent between accepting and rejecting the offer, i.e., the exclusivity fee is determined by \( \Pi^{(NE,E_B)}_{CP_2} = \Pi^{(NE,NE)}_{CP_2} \). The respective fee is \( e^{(NE,E_B)}_{B2} = f_A - \frac{r}{3} \), which gives ISP B a deviation profit of

\[
\Pi^{(NE,E_B)}_{ISP_B} = \frac{16}{18} + 2f_B + f_A - \frac{r}{3}. \tag{G.2}
\]

Comparing the profit from G.1 and G.2 yields that ISP B will not deviate from \((NE,NE)\) if \( r > \overline{r}_B(f_A) = \frac{7}{6} + 3f_A \). Likewise, the respective threshold for ISP A is \( \overline{r}_A(f_B) = \frac{7}{6} + 3f_B \). Note that \( f_A \geq f_B \) implies \( \overline{r}_B(f_A) \geq \overline{r}_A(f_B) \). Thus \((NE,NE)\) is the equilibrium of the subgame if and only if \( r > \overline{r}_B \).

Otherwise, if \( r \leq \bar{r}_B \), both ISPs will be in competition for exclusivity of CP 2. ISP \( i \) is willing to lower its exclusivity fee to CP 2 until it is indifferent between obtaining exclusivity with CP 2 itself and losing exclusivity of CP 2 to the rival ISP \(-i\). Thus, for ISP \( i \) the lowest feasible exclusivity fee is determined by \( \Pi^{(NE,E_i)}_{ISP_i} = \Pi^{(NE,E_{-i})}_{ISP_{-i}} \). It follows that \( e^{(NE,E_A)}_{A2} = -f_A - \frac{2}{3} \) and \( e^{(NE,E_B)}_{B2} = -f_B - \frac{2}{3} \). Notice that, given these exclusivity fees, CP 2 receives \( \Pi^{(NE,E_A)}_{CP_2} = \Pi^{(NE,E_B)}_{CP_2} = \frac{5}{6} + \frac{2}{3} \) and thus, it is indifferent between the two ISPs. It will choose one ISP at random and, since the ISPs are indifferent between obtaining exclusivity or not, in equilibrium each ISP makes the same profit in either case, i.e., \( \Pi^{(NE,E_i)}_{ISP_i} = \Pi^{(NE,E_{-i})}_{ISP_{-i}} = \frac{4}{18} + f_i \).

Given that CP 1 has delivered its content to both ISPs, CP 2 then delivers its content exclusively
to either ISP when \( r < \tilde{r}_B \). Otherwise for \( r \geq \tilde{r}_B \), CP 2 delivers its content to both ISPs (Figure G3).

![Figure G3: The choices of CP 2, given that CP 1 has delivered its content exclusively to both ISPs](image)

Figure G3: The choices of CP 2, given that CP 1 has delivered its content exclusively to both ISPs

\((t = 1, u_{12} = 3, u_1 = 2, u_2 = 1)\)

**Stage 2: Exclusivity offered to CP 1**

The three relevant thresholds identified in stage 3, \( \tilde{r}_A, \tilde{r}_B, \tilde{r}_B \), with \( \tilde{r}_B \geq \tilde{r}_A \) yield 6 different parameter regions that must be considered separately now in stage 2:

<table>
<thead>
<tr>
<th>( r &gt; \tilde{r}_B )</th>
<th>( \tilde{r}_B \geq r &gt; \tilde{r}_A )</th>
<th>( r \leq \tilde{r}_A )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case II.1</td>
<td>Case II.2</td>
<td>Case II.3</td>
</tr>
<tr>
<td>Case II.4</td>
<td>Case II.5</td>
<td>Case II.6</td>
</tr>
</tbody>
</table>

In each case, the ISPs compete for exclusivity with CP 1, thereby considering the continuation of the game in the subsequent stages as determined by the specific parameter region.

**Case II.1: \((NE, NE)\) vs. \((E_A, NE)\) vs. \((E_B, NE)\)** Following the same logic as before, we first identify under which conditions both ISPs refrain from offering exclusivity to CP 1 in equilibrium. In this case, it must hold that \( \Pi_{ISP_A}^{(NE,NE)} \geq \Pi_{ISP_A}^{(E_A,NE)} \) and \( \Pi_{ISP_B}^{(NE,NE)} \geq \Pi_{ISP_B}^{(E_B,NE)} \). As above, the deviation profit is determined by setting the exclusivity fee such that CP 1 is indifferent between accepting and
rejecting the exclusivity offer. By comparing the profits when no exclusivity is offered to CP 1 with the profits when there is deviation and an ISP offers exclusivity to CP 1, we obtain the thresholds 
\[ r_A(f_B) = \frac{16}{3} + 6f_B \] and 
\[ r_B(f_A) = \frac{16}{3} + 6f_A, \]
for ISP A and ISP B respectively. As \( f_A \geq f_B \) it follows that 
\((NE, NE)\) is the equilibrium of this subgame if \( r > r_B \) (i.e., there is no deviation from \((NE, NE)\)).

Also notice that \( r_B > r_B = \frac{7}{3} + 3f_A \).

Otherwise, if \( r \leq r_B \), the ISPs compete for exclusivity with CP 1. The lowest feasible exclusivity fee that is offered by ISP \( i \) is determined by \( \Pi_{ISP_i}^{(E_i,NE)} = \Pi_{ISP_i}^{(E_i,NE)} \). It follows that \( \epsilon_{i1}^{(E_i,NE)} = -\frac{4}{3} \).

Notice that, given these exclusivity fees, CP 1 receives \( \Pi_{CP_1}^{(E_A,NE)} = \Pi_{CP_1}^{(E_B,NE)} = r \frac{5}{6} + \frac{4}{3} \), and thus, it is indifferent between the two ISPs. It will choose one ISP at random and, since the ISPs are indifferent between obtaining exclusivity or not, in equilibrium each ISP makes the same profit in either case, i.e., \( \Pi_{ISP_i}^{(E_i,NE)} = \Pi_{ISP_i}^{(E_i,NE)} = \frac{1}{3} + \frac{1}{3} \).

**Case II.2:** \((NE, NE)\) vs. \((E_A, E_B)\) vs. \((E_B, NE)\)

Again, we first identify under which conditions both ISPs refrain from offering exclusivity to CP 1 in equilibrium. However, notice that in this case, the continuation of the game depends on which ISP achieves exclusivity with CP 1. Thus, \((NE, NE)\) can only be an equilibrium of this subgame if \( \Pi_{ISP_A}^{(NE,NE)} = \Pi_{ISP_A}^{(E_A,NE)} \) and \( \Pi_{ISP_B}^{(NE,NE)} = \Pi_{ISP_B}^{(E_B,NE)} \).

Evidently, the profit comparison of ISP B is the same as in case II.1 and yields a threshold of \( r > r_B \).

However, the threshold of ISP A is different here. Its deviation profit, which makes CP 1 indifferent between accepting exclusivity with ISP A and rejecting it, is given by \( \Pi_{ISP_A}^{(E_A,E_B)} = \frac{16}{18} + f_A + f_B + \frac{2a-3}{3} \).

By contrast, \( \Pi_{ISP_A}^{(NE,NE)} = \frac{1}{2} + 2f_A \). It follows that ISP A will always prefer to deviate in this parameter region. Thus \((NE, NE)\) cannot be an equilibrium in this subgame.

Thus, the ISPs compete for exclusivity with CP 1. First we determine again the lowest feasible exclusivity fee that can be offered by each ISP. ISP A is willing to lower its exclusivity fee to CP 1 until it is indifferent between winning exclusivity and losing it to ISP B. Formally, \( \Pi_{ISP_A}^{(E_A,E_B)} = \Pi_{ISP_A}^{(E_B,NE)} \) yields \( \epsilon_{A1,min}^{(E_A,E_B)} = -\frac{15}{18} \). Likewise, for ISP B, from \( \Pi_{ISP_B}^{(E_B,NE)} = \Pi_{ISP_B}^{(E_A,E_B)} \) we obtain \( \epsilon_{B1,min}^{(E_B,NE)} = f_A - f_B - \frac{7}{6} - r \frac{5-a}{6} \).

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Given these exclusivity fees, CP 1 makes profits of $\Pi^{(E_A,E_B)}_{C_P 1} = \frac{2a}{3} - f_A + \frac{5}{6}$ and $\Pi^{(E_B,NE)}_{C_P 1} = r \frac{10-a}{6} - f_A + \frac{7}{6}$, respectively and will, of course, select the ISP that offers the higher profit. For the case where $a > 2$, it follows that ISP B will achieve exclusivity with CP 1 if $r \leq \hat{r} = \frac{2}{5(a-2)}$ and, in reverse, ISP A will achieve exclusivity if $r > \hat{r}$. For the case where $a < 2$ it follows that ISP B will always achieve exclusivity.

While the minimum feasible exclusivity fees are relevant to determine which ISP will eventually obtain exclusivity with CP 1, notice that the minimum fees are not the equilibrium exclusivity fees. Each ISP will just lower the exclusivity fee far enough to outbid the rival ISP. Thus, in case that $r > \hat{r}$ (i.e., ISP A wins exclusivity), ISP A’s exclusivity offer must just grant CP 1 a slightly better profit than the profit that CP 1 would achieve under ISP B’s minimum fee. Formally, we set $\Pi^{(E_A,E_B)}_{C_P 1} = \frac{4a}{6} - f_A - c_{A 1}^{(E_A,E_B)} = \Pi^{(E_B,NE)}_{C_P 1, max} = r \frac{10-a}{6} - f_A + \frac{7}{6}$ and derive $c_{A 1}^{(E_A,E_B)} = \frac{5(a-2)r-7}{6}$. Likewise, in case $r \leq \hat{r}$ (i.e., ISP B wins exclusivity) we obtain $c_{B 1}^{(E_B,NE)} = \frac{5-4a}{6} + (f_A - f_B) - \frac{5}{6}$ as the equilibrium exclusivity fee of ISP B.

In summary, this yields ISPs’ equilibrium profits of $\Pi^{(E_A,E_B)}_{ISP A} = f_A + r \frac{5(a-2)}{6} - \frac{5}{18}$ and $\Pi^{(E_A,E_B)}_{ISP B} = \frac{4}{18} + f_A + f_B - r \frac{5-a}{6}$ if $r > \hat{r}$. Otherwise, if $r \leq \hat{r}$, equilibrium profits are $\Pi^{(E_B,NE)}_{ISP A} = \frac{1}{18} + f_A$ and $\Pi^{(E_B,NE)}_{ISP B} = \frac{10}{18} + 2f_A + r \frac{5-4a}{6}$.

Case II.3: $(NE,NE)$ vs. $(E_A,E_B)$ vs. $(E_B,E_A)$ Following the same reasoning as in the previous cases, we find that $(NE,NE)$, i.e., no ISP offers exclusivity to CP 1, is not an equilibrium in this parameter region. Consequently, ISPs compete for exclusivity with CP 1. The ISPs are willing to lower their exclusivity fees until $\Pi^{(E_i,E_{-i})}_{ISP i} = \Pi^{(E_{-i},E_i)}_{ISP i}$. It follows that $c_{i i}^{(E_i,E_{-i})} = -\frac{2}{3} + f_{-i} - r \frac{5-a}{6}$.

Given these exclusivity fees, CP 1 receives $\Pi^{(E_A,E_B)}_{C_P 1} = \Pi^{(E_B,E_A)}_{C_P 1} = \frac{2}{3} - f_A - f_B + r \frac{5+3a}{6}$, and thus, it is indifferent between the two ISPs. It will choose one ISP at random and, since the ISPs are indifferent between obtaining exclusivity or not, in equilibrium each ISP makes the same profit in either case, i.e., $\Pi^{(E_i,E_{-i})}_{ISP i} = \Pi^{(E_{-i},E_i)}_{ISP i} = \frac{4}{18} + f_A + f_B - r \frac{5-a}{6}$.

Case II.4: $(NE,E)$ vs. $(E_A,NE)$ vs. $(E_B,NE)$ This case differs to case II.1 only with respect
to the continuation of the game when no ISP makes an exclusivity offer to CP 1. If no ISP offers exclusivity, then \((NE, E)\), i.e., either \((NE, EA)\) or \((NE, EB)\), is obtained. Therefore, we only need to re-evaluate the condition for which no ISP makes an exclusivity offer. The equilibrium fees and profits in case ISPs compete for exclusivity will be the same as in case II.1.

Following the previous reasoning, no ISP will offer an exclusivity contract to CP 1 if \(\Pi^{(NE,E)}_{ISP_A} \geq \Pi^{(EA,NE)}_{ISP_A}\) and \(\Pi^{(NE,E)}_{ISP_B} \geq \Pi^{(EB,NE)}_{ISP_B}\). Thereby, the deviation profit is again determined by setting the exclusivity fee such that CP 1 is indifferent between accepting and rejecting the exclusivity offer. This yields the threshold \(\tilde{r} = \frac{7+6(f_B+f_D)}{2a-1}\) and it follows that \((NE, E)\) is the equilibrium of this subgame if \(r > \tilde{r}\). Otherwise, if \(r \leq \tilde{r}\), with equal probability either \((EA, NE)\) or \((EB, NE)\) is the equilibrium of this subgame.

**Case II.5:** \((NE, E)\) vs. \((EA, EB)\) vs. \((EB, NE)\) This case is similar to II.2, but has a different continuation of the game in case no ISP makes an exclusivity offer. We follow the same reasoning as in case II.2 and find that \((NE, E)\) is never an equilibrium of this subgame, because at least one ISP always prefers to make an exclusivity offer to CP 1 in this parameter region.

Thus, ISPs compete for exclusivity with CP 1. From II.2 we know that in case \(a < 2\) or \(a > 2\ & r \leq \tilde{r}\), ISP B will achieve exclusivity, and ISP A otherwise. The profits and exclusivity fees in these cases are the same as under II.2.

**Case II.6:** \((NE, E)\) vs. \((EA, EB)\) vs. \((EB, EA)\) This case is similar to case II.3 and differs only with respect to the continuation of the game in case no ISP makes an exclusivity offer. Following the same reasoning as above we find that \((NE, E)\) is never an equilibrium of this subgame. Exclusivity fees and profits under \((EA, EB)\) and \((EB, EA)\), which are obtained with equal probability in equilibrium, are the same as under II.3.

The various equilibrium outcomes and relevant thresholds identified in this stage are summarized
by Figure G4 and Table G1:

Figure G4: Equilibrium fragmentation regions

\[(t = 1, \ u_{12} = 3, \ u_1 = 2, \ u_2 = 1)\]

<table>
<thead>
<tr>
<th>Scenario</th>
<th>(\Pi_{ISP_A})</th>
<th>(\Pi_{ISP_B})</th>
<th>(\Pi_{CP_1})</th>
<th>(\Pi_{CP_2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>((NE, NE))</td>
<td>(\frac{1}{3} + 2f_A)</td>
<td>(\frac{1}{3} + 2f_B)</td>
<td>(r - f_A - f_B)</td>
<td>(r - f_A - f_B)</td>
</tr>
<tr>
<td>((E_A, NE)) or ((E_B, NE))</td>
<td>(\frac{1}{18} + f_A)</td>
<td>(\frac{1}{18} + f_B)</td>
<td>(\frac{5}{6} + \frac{4}{3})</td>
<td>(r - f_A - f_B)</td>
</tr>
<tr>
<td>((NE, E_A)) or ((NE, E_B))</td>
<td>(\frac{4}{18} + f_A)</td>
<td>(\frac{4}{18} + f_B)</td>
<td>(r - f_A - f_B)</td>
<td>(\frac{5}{6} + \frac{2}{3})</td>
</tr>
<tr>
<td>((E_B, NE))</td>
<td>(\frac{1}{18} + f_A)</td>
<td>(\frac{10}{18} + 2f_A + f_B - \frac{5+4a}{6})</td>
<td>(\frac{7}{6} + \frac{10-a}{6} - f_A)</td>
<td>(r - f_A - f_B)</td>
</tr>
<tr>
<td>((E_A, E_B)) or ((E_B, E_A))</td>
<td>(r F + f_B - \frac{5+a}{6})</td>
<td>(\frac{4}{18} + f_A + f_B - r \frac{5+a}{6})</td>
<td>(\frac{2}{3} + r \frac{5+a}{6})</td>
<td>(\frac{5+a}{6} - f_A - f_B)</td>
</tr>
</tbody>
</table>

Table G1: ISPs’ and CPs’ profits in each equilibrium scenario

\[(t = 1, \ u_{12} = 3, \ u_1 = 2, \ u_2 = 1)\]

Stage 1: Determination of termination fees

Finally, we can analyze the ISPs’ strategic choice of the termination fees, \(f_A\) and \(f_B\) in the first stage of
the game. First see that, for every specific value of the parameters \( a \) and \( r \), a change in the termination fees will shift the respective fragmentation boundaries. Thus, in order to exemplify the strategic choice of the termination fees, we fix a specific \((a, r)\) combination and resolve the fragmentation boundaries as a function of \( f_A \) and \( f_B \). Specifically, set \( a = 3 \) and \( r = 6 \). Then the boundaries can be transformed as follows:

\[
\begin{align*}
  r > \tilde{r}_A & \iff f_B < \frac{33}{18} \\
  r > \tilde{r}_B & \iff f_A < \frac{33}{18} \\
  r > \tilde{r}_B & \iff f_A < \frac{29}{18} \\
  r > \tilde{r}_B & \iff f_A < \frac{2}{18} \\
  r > \tilde{r} & \iff f_B < \frac{69}{18} - f_A \\
  r > \tilde{r} & \iff \text{always true}
\end{align*}
\]

Correspondingly, Figure G5 depicts the equilibrium scenarios in the \((f_A, f_B)\) space. Recall that we have considered that \( f_A \geq f_B \) and thus only the area below the 45 degrees line is relevant. This assumption is without loss of generality since ISPs are symmetric ex-ante. In total there are five different scenarios that must be considered. For each the profits of the ISPs and CPs are given below in Table G2:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>( \Pi_{ISP_A} )</th>
<th>( \Pi_{ISP_B} )</th>
<th>( \Pi_{CP_1} )</th>
<th>( \Pi_{CP_2} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>((NE, NE))</td>
<td>(\frac{1}{2} + 2f_A)</td>
<td>(\frac{1}{2} + 2f_B)</td>
<td>(6 - f_A - f_B)</td>
<td>(6 - f_A - f_B)</td>
</tr>
<tr>
<td>((E_A, NE)) or ((E_B, NE))</td>
<td>(\frac{1}{18} + f_A)</td>
<td>(\frac{1}{18} + f_B)</td>
<td>(\frac{10}{18})</td>
<td>(8 - f_A - f_B)</td>
</tr>
<tr>
<td>((NE, E_A)) or ((NE, E_B))</td>
<td>(\frac{4}{18} + f_A)</td>
<td>(\frac{4}{18} + f_B)</td>
<td>(8 - f_A - f_B)</td>
<td>(\frac{17}{3})</td>
</tr>
<tr>
<td>((E_A, E_B))</td>
<td>(\frac{85}{18} + f_A)</td>
<td>(\frac{32}{18} + f_A + f_B)</td>
<td>(\frac{40}{6} - f_A)</td>
<td>(8 - f_A - f_B)</td>
</tr>
<tr>
<td>((E_A, E_B)) or ((E_B, E_A))</td>
<td>(-\frac{32}{18} + f_A + f_B)</td>
<td>(-\frac{32}{18} + f_A + f_B)</td>
<td>(\frac{44}{3} - f_A - f_B)</td>
<td>(8 - f_A - f_B)</td>
</tr>
</tbody>
</table>

Table G2: ISPs’ and CPs’ profits in each equilibrium scenario

\((t = 1, u_{12} = 3, u_1 = 2, u_2 = 1, a = 3, r = 6)\)
It is evident that, in each fragmentation scenario ISPs would like to increase the termination fees as this will directly increase their profits. Therefore, it suffices to compare the profits at the boundary of each fragmentation scenario. In addition, in each fragmentation scenario, the ISP can only raise termination fees insofar as both CPs still receive nonnegative profits. In particular, as can be seen from the dashed curve in Figure G5, CP 2’s participation constraint constitutes the boundary of the full fragmentation scenario. Comparing the ISPs’ profits at the scenario boundaries immediately reveals that ISPs will increase termination fees until CP 2’s participation constraint is reached, yielding full fragmentation. In fact, there exists a continuum of equilibria along $f_A + f_B = 8$ (CP 2’s participation constraint). Among these, there is a unique symmetric Nash equilibrium $f_A = f_B = 4$ (point $\alpha$ in Figure G5), which yields full fragmentation. Clearly, at point $\alpha$, no ISP has an incentive to deviate here: For both ISPs, $A$ or $B$, an increase in $f_A$ or $f_B$, respectively, would violate the participation constraint. In reverse, a decrease in termination fees would decrease profits.
In this appendix, we allow the end users to multi-home, that is, subscribe to both ISPs. The timing of the game is the same as in our base model, with the difference that now end users at the final stage may choose to multi-home. The analysis of this game parallels in large part the analysis of our base model. We proceed by solving the game backwards.

Stage 3: Subscription fees and end users’ decisions

At the third stage, each consumer chooses whether to subscribe to ISP $A$, ISP $B$ or both. A type $z$ consumer derives utility of $U_A = b + u_A - p_A - tz$, when he subscribes to ISP $A$, utility of $U_B = b + u_B - p_B - t(1 - z)$, when he subscribes to ISP $B$, whereas he obtains utility of $U_{AB} = b + u_{12} - p_A - p_B - t$ when he subscribes to both ISPs. Clearly, multi-homing may occur when $u_A$ and/or $u_B$ is not equal to $u_{12}$, otherwise the consumer can consume both contents by just subscribing to the ISP that offers both contents (there is no reason to travel also to the rival ISP, i.e., they single-home as in our base model). Thus, multi-homing may occur only when both CPs are exclusive in one ISP, the $(E, E)$ case. Under all other configurations, our analysis in the main text would still be valid.

The consumer that is indifferent between subscribing to ISP $A$ or both ISPs, denoted by $z_{AB}$, is derived by equating $u_A - p_A - tz_{AB} = u_{12} - p_A - p_B - t$, which yields

$$z_{AB} = 1 - \frac{u_{12} - u_A - p_B}{t},$$

while the consumer that is indifferent between subscribing to ISP $B$ or both ISPs, denoted by $z_{BA}$, is derived by equating $u_B - p_B - t(1 - z_{BA}) = u_{12} - p_A - p_B - t$, which yields

$$z_{BA} = \frac{u_{12} - u_B - p_A}{t}.$$

Multi-homing occurs when $0 < z_{AB} < z_{BA} < 1$, or, equivalently, when

$$u_{12} \in \left( \frac{t}{2} + \frac{p_A + p_B + u_A + u_B}{2}, \min\{t + p_A + u_B, t + p_B + u_A\} \right).$$
The joint value of consuming both contents should be high enough (also in relation to the increased transportation cost) for the consumers to multi-home. We have that consumers located at \([0, z_{AB}]\) subscribe only to ISP A, consumers located at \((z_{BA}, 1]\) subscribe only to ISP B, while consumers located in between, i.e., at \([z_{AB}, z_{BA}]\), subscribe to both ISPs.

<table>
<thead>
<tr>
<th>ISP A</th>
<th>(z_{AB})</th>
<th>ISP B</th>
</tr>
</thead>
<tbody>
<tr>
<td>subscribe to ISP A</td>
<td>subscribe to both ISPs</td>
<td>subscribe to ISP B</td>
</tr>
</tbody>
</table>

Figure H1: Indifferent consumers

The end users’ demands for ISP A and ISP B are thus \(D_A = z_{BA}\) and \(D_B = 1 - z_{AB}\), respectively, when multi-homing occurs.\(^{11}\) The two ISPs compete by setting a subscription fee to the end users. Since \(f\) and \(e_{ij}\) are fixed fees, ISP \(i\) maximizes \(p_iD_i\) with respect to \(p_i\). The first-order conditions give the equilibrium subscription fees under multi-homing:

\[
p_A = \frac{u_{12} - u_B}{2} = \frac{u_{12} - u_A}{2},
\]

Notice the interesting result that the multi-homing equilibrium prices are monopoly-like. Only rival quality – but not rival price – affects demand. In other words, prices are strategically independent, though they are determined by the quality of both goods. These prices then yield the ISPs’ demands and revenues

\[
D_A = \frac{u_{12} - u_B}{2t}, D_B = \frac{u_{12} - u_A}{2t},
\]

\[
p_AD_A = \frac{(u_{12} - u_B)^2}{4t}, p_BD_B = \frac{(u_{12} - u_A)^2}{4t}.
\]

For inequality to occur, the sequence of inequalities \(0 < z_{AB} < z_{BA} < 1\) must hold. This is true for

\[
t \in \left( \max\left\{ \frac{u_{12} - u_A}{2}, \frac{2u_{12} - u_A - u_B}{2} \right\}, \frac{2u_{12} - u_A - u_B}{2} \right) = \left( \frac{u_{12} - u_1}{2}, \frac{u_{12} - u_1 + u_2}{2} \right). \tag{H.1}
\]

\(^{11}\)The relevant expressions for single-homing are given in the main text of the paper.
Conversely, when \( t > u_12 - \frac{u_1 + u_2}{2} \), it can never be that \( z_{AB} < z_{BA} \). Hence, when \( t \) is larger than this threshold value, multi-homing never arises as an equilibrium feature even when possible. ISPs’ set prices such that it not convenient for a user to have two subscriptions. Also notice that this condition is obviously satisfied for identical non-complementary goods, in which case \( u_{12} = \frac{u_1 + u_2}{2} = 0 \). However, when the benefits from complementarity increase, so that \( u_{12} \) increases, the threshold becomes more stringent. Still, even for large complementarities, it is possible a sufficiently high value of the transportation costs, \( t \), such that our results hold unchanged even when allowing for multi-homing.

We discuss next what happens in case multi-homing can arise along the equilibrium path, i.e., when \( t < u_{12} - \frac{u_1 + u_2}{2} \).

**Stage 2: Exclusivity offered to CP 2**

*CP 1 has delivered its content exclusively to ISP \(-i\).* ISP \(-i\) cannot offer an exclusivity contract to CP 2, therefore, only ISP \( i \) is active in this stage. ISP \( i \) can either offer an exclusivity contract to CP 2 or leave CP 2 active in both platforms. Since the exclusivity fee \( e_{i2}^{(E,E)} \) is a fixed transfer, ISP \( i \) offers the exclusivity contract when the joint profits of ISP \( i \) and CP 2 under exclusivity \((E, E)\) are higher compared to the joint profits under non-exclusivity \((E, NE)\). Note that under \((E, NE)\), ISP \( i \) delivers both contents \((u_{-i} = u_{12})\), thus, multi-homing does not occur and profits are the same as in our base model.\(^{12}\) Therefore, ISP \( i \) offers an exclusivity contract to CP 2 when:

\[
\Pi_{ISP_1}^{(E,E)} + \Pi_{CP_2}^{(E,E)} > \Pi_{ISP_1}^{(E,NE)} + \Pi_{CP_2}^{(E,NE)} \Leftrightarrow
\left( p_i^{(E,E)} D_i^{(E,E)} + f + e_{i2}^{(E,E)} \right) + \left( ar \left( 1 - D_{-i}^{(E,E)} \right) + r \left( z_{BA} - z_{AB} \right) - f - e_{i2}^{(E,E)} \right) > \\
\left( p_i^{(E,NE)} D_i^{(E,NE)} + f \right) + \left( r D_{-i}^{(E,NE)} + ar D_i^{(E,NE)} - 2f \right) \Leftrightarrow
\frac{(u_{12} - u_{1})^2}{4t} + ar \left( 1 - \frac{u_{12} - u_{2}}{2t} \right) + r \left( \frac{2u_{12} - u_{1} - u_{2}}{2t} - 1 \right) > \\
r \left( \frac{3t + u_{12} - u_{2}}{6t} + \left( t + \frac{u_{2} - u_{12}}{3} + ar \right) \left( \frac{3t + u_{2} - u_{12}}{6t} \right) - f \right) \Leftrightarrow
\frac{9t + 3u_{1} + 2u_{2} - 5u_{12} - a \left( 3t + 2u_{2} - 2u_{12} \right)}{6t} < f + \frac{(u_{12} - u_{1})^2}{4t} - \frac{(3t + u_{2} - u_{12})^2}{18t}.
\]

\(^{12}\)As in our base model, under single-homing, each ISP receives positive demand, if and only if \( t > (u_{12} - u_{2})/3 \).
We have that for \( \Delta = \frac{9t+3u_1+2u_2-5u_{12}-a(3t+2u_2-2u_{12})}{6t} < 0 \), we obtain \((E, E)\) when \( r > \hat{r}_m(a) \equiv f + \frac{(u_{12}-u_1)^2}{4t} - \frac{(3t+u_2-u_{12})^2}{16t} \). Otherwise, for \( \Delta > 0 \), we obtain \((E, E)\) when \( r < \hat{r}_m \). By summarizing the equilibrium outcome of this subgame, we get \((E, E)\) when \( r > b_r \) and whereas we get \((E, NE)\) when \( r < b_r \).

Now, let us determine the exclusivity fee \( e_{i2}^{(E,E)} \) set by ISP \( i \). This fee is set at the level where CP \( 2 \) is just indifferent between accepting or rejecting exclusivity:

\[
e_{i2}^{(E,E)} = f + r a \left( \frac{3t+u_{12}+5u_{12}-3u_1-2u_2-9t}{6t} \right).
\]

CP \( 1 \) has delivered its content to both ISPs. In this subgame, both ISPs deliver the content of CP 1. The two ISPs compete in order to offer an exclusivity contract to CP 2, thus, in any event, one of the two ISPs will deliver both contents \((u_{12})\), so multi-homing does not occur in this subgame. The analysis of this subgame parallels the analysis of our base model, so it is omitted here. We have proved in Appendix A that \((NE, E)\) occurs for \( r < \bar{r} \) (where \( \bar{r} \) is given by (13)), otherwise the equilibrium outcome in this subgame is \((NE, NE)\).

Stage 1: Exclusivity offered to CP 1

At the first stage of the game, anticipating that CP 2 will subsequently decide on exclusivity or non-exclusivity along the equilibrium path, CP 1 decides whether to deliver exclusively its content to one ISP or to deliver its content to both ISPs. From the previous analysis, there are various potential cases depending on the parameter values. Due to the multiplicity of these cases, to simplify the exposition, we focus on a numerical example at this stage of the game \((u_{12} = 3, u_1 = 1, u_2 = 1, f = 0)\). For these parameter values, multi-homing occurs when \( t \in \left( \frac{u_{12}-u_2}{2}, \frac{2u_{12}-u_1-u_2}{2} \right) = (1, 2) \). Thus, we may further assume that \( t = 3/2 \) to ensure multi-homing. The various potential equilibrium regions, depending also on the decisions in stage 2, are presented graphically in the numerical example in Figure H2 (we
have $\hat{r}_m = 47/6 (7 - a)$ and $\overline{r} = 44/15$).

![Figure H2: The potential choices of CP 1, given](image)

The analysis is similar to the analysis in stage 2. An exclusivity offer is accepted by CP 1 when the joint profits of CP 1 and the exclusive ISP are higher compared to the joint profits of CP 1 with both ISPs. In addition, whenever exclusivity between CP 1 and ISP $i$ is achieved, the exclusivity fee $e_{i1}$ is driven down to the level that makes ISP $i$ indifferent between obtaining exclusivity itself or the case where exclusivity is obtained by the rival ISP; the joint profits of CP 1 with either ISP are the same.

There are four alternative joint profit comparisons as indicated in Figure H2. In the top and bottom-left area multi-homing does not occur, thus, the analysis parallels the analysis of the base model. The critical threshold for the top-left area is $\overline{r}$ given by (8) in our main paper. When $r > \overline{r}$, CP 1 delivers its content to both ISPs (thus, $(NE,NE)$ is the equilibrium outcome, i.e., no fragmentation), whereas when $r < \overline{r}$ CP 1 opts for exclusivity ($(E,NE)$). For the numerical example,
we obtain \( r = 44/15 \), thus, we always obtain no fragmentation in the top-left area. In the bottom-left area, partial fragmentation occurs, either \((E, NE)\) or \((NE, E)\), while, in the right area (top and bottom) multi-homing occurs under \((E, E)\). In the bottom-right area, exclusivity is accepted by CP 1 when:

\[
P_{\text{ISP}}^{(E,E)} + P_{\text{CP}}^{(E,E)} > P_{\text{ISP}}^{(NE,NE)} + P_{\text{CP}}^{(NE,NE)} \iff \\
\left( p_i^{(E,E)} D_i^{(E,E)} + f + \epsilon_{i1}^{(E,E)} \right) + ar \left( 1 - D_{-i}^{(E,E)} \right) + r \left( z_{BA} - z_{AB} \right) - f - \epsilon_{i1}^{(E,E)} > \\
\left( p_i^{(NE,NE)} D_{i}^{(NE,NE)} + 2f + \epsilon_{i2}^{(NE,NE)} \right) + ar D_{-i}^{(NE,NE)} - 2f \iff \\
\left( u_{12} - u_2 \right)^2 + ar \left( 1 - \frac{u_{12} - u_1}{2t} \right) + r \left( \frac{2u_{12} - u_1 - u_2}{2t} - 1 \right) > \\
\frac{(3t + u_{12} - u_1)^2}{18t} + \left( -f - 2 \frac{(u_{12} - u_1)}{3} \right) + r \left( \frac{3t + u_{12} - u_1}{6t} \right) + ar \left( \frac{3t + u_1 - u_{12}}{6t} \right) \iff \\
f + \frac{2(u_{12} - u_1)}{3} + \frac{(u_{12} - u_2)^2}{4t} - \frac{(3t + u_{12} - u_1)^2}{18t} > r \left( \frac{9t + 2u_1 + 3u_2 - 5u_{12}}{6t} - a \frac{3t + 2u_1 - 2u_{12}}{6t} \right).
\]

For the numerical example, the above inequality always hold, thus, in the bottom-right area we obtain exclusivity also with CP 1, i.e. full fragmentation. In the top-right area, exclusivity is accepted by CP 1 when:

\[
P_{\text{ISP}}^{(E,E)} + P_{\text{CP}}^{(E,E)} > P_{\text{ISP}}^{(NE,NE)} + P_{\text{CP}}^{(NE,NE)} \iff \\
\left( p_i^{(E,E)} D_i^{(E,E)} + f + \epsilon_{i1}^{(E,E)} \right) + ar \left( 1 - D_{-i}^{(E,E)} \right) + r \left( z_{BA} - z_{AB} \right) - f - \epsilon_{i1}^{(E,E)} > \\
\left( p_i^{(NE,NE)} D_{i}^{(NE,NE)} + 2f \right) + ar D_{-i}^{(NE,NE)} - 2f \iff \\
\left( u_{12} - u_2 \right)^2 + ar \left( 1 - \frac{u_{12} - u_1}{2t} \right) + r \left( \frac{2u_{12} - u_1 - u_2}{2t} - 1 \right) > \frac{t}{2} + r.
\]

For the numerical example, the above inequality always hold, thus, in the top-right area we obtain full fragmentation.

The equilibrium outcome of the whole game is presented in the Figure H3. The equilibrium configurations under multi-homing correspond to the thin curves.
Discussion of the equilibrium under endogenous multi-homing

The first remark is that the three different regions that we characterize in the main paper under single-homing (full/partial/no fragmentation) still arise also when multi-homing by customers is allowed for. In this sense, our main results are robust. Figure H3 also reports, for comparison, the equilibrium configurations when instead single-homing is imposed (see the bold lines in the figure). In line with the intuition, if we allow for multi-homing, fragmentation becomes less likely as users themselves can ‘undo’ full fragmentation by subscribing to both ISPs. While we have just solved the equilibrium under some parameter configuration, we do not see any reason to suspect that these insights would not be valid more in general.

As for welfare, expressions are still given by eq. (11) in the main paper, with the exception of the area under full fragmentation.

Under single-homing it is
Instead, under multi-homing, when \( t \in \left( \frac{u_{12} - u_1}{2}, \frac{2u_{12} - u_1 - u_2}{2} \right) \), when ISP A is exclusive with CP 1 and ISP B is exclusive with CP 2, we obtain

\[
W^{(E,E)}_m = ar + \int_0^{D_A} (u_1 - tz) \, dz + \int_{D_A}^1 (u_2 - t(1-z)) \, dz = \frac{u_1 + u_2}{2} + \frac{5(u_1 - u_2)^2}{36t} - \frac{1}{4} t + ar.
\]

Compared to single-homing, there are several changes. Even if multi-homing arises in equilibrium, not everybody on the Hotelling line will multi-home (only the consumers in the middle). Thus, in case of full fragmentation, both contents are not seen by all consumers, but only by those in the middle, contrary to single-homing where both contents cannot be seen by anybody. This tends to increase welfare under multi-homing compared to single-homing. However, when multi-homing occurs, users pay higher transportation costs \((t)\) because they go to both ISPs, which tends to decrease welfare under multi-homing. From the perspective of the content providers, there is less exclusivity ad revenues under multi-homing, but there is also additional demand (viewers) due to multi-homing. Specifically, the additional revenues from advertising \((ar)\) under multi-homing are now earned over only a subset of consumers (those who do not multi-home).

In other words, we can identify several trade-offs but we cannot expect that multi-homing generally delivers better welfare results compared to single-homing: it depends on parameters.
This can be seen by calculating the welfare difference

\[ W^{(E,E)} - W_m^{(E,E)} = \frac{1}{72} \left( \begin{array}{c}
-72r u_1 - 72r u_2 + 36 t u_1 + 36 t u_2 + 144 r u_{12} - 72 t u_{12} + 17 u_1^2 \\
-1 17 u_2^2 + 54 u_{12}^2 + 20 u_1 u_2 - 54 u_1 u_{12} - 54 u_2 u_{12} - 144 r t + 18 t^2 \\
-1 36 a r u_1 + 36 a r u_2 - 72 a r u_{12} + 72 a r t \\
-1 36 a r u_1 + 36 a r u_2 - 72 a r u_{12} + 72 a r t \\
\end{array} \right) \]

that cannot be signed in general. In the example of Figure H3, this welfare difference simplifies to

\[ W^{(E,E)} - W_m^{(E,E)} = \frac{8 r (a - 2) - 9}{24}, \]

thus, even in this case, the sign depends on the combinations of \( a \) and \( r \). \(^{13}\)

References


\(^{13}\) Note that we obtain full fragmentation for \( r < \bar{r}_m = 47/6 (7 - a) \).