Net Neutrality, Exclusivity Contracts and Internet Fragmentation*

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February 4, 2013

Abstract

Net neutrality is believed to prevent 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 among the CPs. Fragmentation arises in equilibrium when competition between 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.

*We thank Marc Bourreau, Bruno Jullien and Thibaud Vergé for very useful discussions and comments.

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1 Introduction

Net neutrality (NN) prohibits Internet access service providers (ISPs) to charge content and service providers (CPs) extra for terminating their traffic to the end users. The tradition that CPs pay only once for access to the Internet (usually to some backbone provider), and not again for the termination of their traffic, has been coined the *zero-price rule* (Hemphill, 2008; Lee and Wu, 2009). Proponents of NN argue that the zero-price rule is an indispensable principle of the Internet. This premise has been justified based on the arguments that: i) it is efficient with respect to the economics of two-sided markets, ii) it facilitates content creation and innovation, and iii) it prevents a fragmentation of the Internet. Of these arguments, the first (e.g., Sidak, 2006; Lee and Wu, 2009; Economides and Tåg, 2012; Hermalin and Katz, 2007) and second (e.g., van Schewick, 2007; Jamison and Hauge, 2008; Lee and Wu, 2009; Cheng et al., 2011; Economides and Hermalin, 2012; Krämer and Wiewiorra, 2012; Bourreau *et al.*, 2012; Reggiani and Valletti, 2012) have been analyzed extensively by the academic literature, resulting in a more differentiated view in this regard.[1] Interestingly, the third argument, which was raised in the influential article by Lee and Wu (2009), has thus far not been considered in detail. More precisely, Lee and Wu, p.67 posit that 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'." Certainly, this is a daunting hypothesis, which, if it were true, would tilt the debate in favor of NN regulation.

Currently, 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 have enacted such NN regulation, which in the case of the USA, is currently challenged in courts. Recently, Neelie Kroes, vice president of the European Commission, 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,

[1] See Schuett (2010), Faulhaber (2011) and most recently Krämer *et al.* (2012) for a comprehensive review of the literature.

democratic values, cohesion and economic growth" (Worth, 2011).

In this paper, we formally investigate the drivers of Internet fragmentation in a game-theoretic model that considers the interplay between termination fees (fees paid by the CPs to the ISPs to reach the end users), exclusivity arrangements, and competition between ISPs and CPs, respectively. 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 which imposes zero termination fees. 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 recently 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, 2012a).

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 many 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 is neither a necessary nor a sufficient condition to prevent Internet fragmentation. This finding is supported by ample empirical evidence from the communications industry. For example, all three major ISPs in the US currently offer exclusive online content.

AT&T and Verizon offer its customers, among others, free and exclusive online music events, and Comcast as well as Verizon each provide free access to live streaming of key sports events (and these CPs do not pay, currently, any termination fees). 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 CPs' outside option in favor of accepting exclusivity. However, the conditions under which fragmentation occurs are more subtle and even in the presence of termination fees, fragmentation is not the inevitable outcome.

First, we note that there are different 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 between 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. 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 (i.e., there are strong network effects for CPs on the consumer side), then each ISP seeks to have an exclusive deal with a CP, since if an ISP delivers both contents and the rival ISP delivers only one, 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 between CPs is weak and CPs' revenues from ads are high.

Concerning welfare, we find that consumers' 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 increase the subscription fees too much to reflect the increase in content. However, with respect to total welfare, which also considers the ISPs and CPs' revenues, no fragmentation is the efficient outcome only when competition among the CPs is rather weak. If 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 consumers' surplus more, or because they believe that competition between 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, (net neutrality) regulation is at best superfluous, because it cannot improve on the equilibrium outcome under no regulation. In fact, such regulation can be harmful, in the sense that the equilibrium is shifted away from the first-best. Thus, after all, net neutrality 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 to the net neutrality regulation. Policy implications are discussed in Section 6 and Section 7 concludes.

2 Related literature

The present paper relates both to the literature on NN, as well as to the literature on exclusive dealing. In a recent and comprehensive literature review on NN, Krämer *et al.* (2012) highlight that the existing academic papers can be characterized by the network and pricing regime that they consider as a deviation from NN. The network regime describes which quality of service mechanism, if any, is employed, whereas the pricing regime denotes whether it is feasible to charge only Internet users (one side) or Internet users and CPs (two sides) for access. In this paper, we abstract from different quality of service levels in order to focus on the impact of the pricing regime, i.e., the introduction of termination fees on market outcome and welfare. In this respect, our paper is most related to Economides and Tåg (2012), who, however, do not consider the possibility of exclusive dealing and thus cannot study the relationship between termination fees and Internet fragmentation. Generally, only a few papers explicitly consider the role of competition between ISPs in the context of NN, like we do. Among these are Economides and Tåg (2012), Bourreau *et al.* (2012), Choi *et al.* (2012) and Njoroge *et al.* (2012). However, neither of these papers considers competition between CPs, nor exclusivity. Thus, our paper appears to be first to model competition between ISPs *and* CPs in the context of NN. Furthermore, it is the first paper to consider exclusive dealing in this context. In this regard, our set up is similar to that in Hagiu and Lee (2011) who also consider competition between platforms that can beforehand offer exclusivity contracts to content providers. Although with a different focus,[2] 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. This difference is mainly due to the fact that we allow for different degrees of competition between the content providers, whereas Hagiu and Lee assume that content is independent, and thus, content providers are not in competition with each other. Several other papers, which are in their set up less related to ours, consider 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; Weeds, 2012a and 2012b). The only paper that we are aware of which considers the emergence of exclusive contents in the telecommunications industry is Ganuza and Viecens (2013). Their focus is very different, however. The authors argue that exclusivity between ISPs and CPs is less likely to occur when upgrading to high-speed Next Generation Networks (NGNs), because the higher quality of service level in NGNs allows the CPs to sell their content directly to the customers. In turn, exclusive contracts with an ISP, which are an alternative means to ensure the technical functionality of the CP's service in the ISP's network, become less attractive. 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 net neutrality 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, substitutive 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.

[2] The paper is not framed in the context of the NN debate and therefore it does not consider termination fees.

This is the prevalent business model on the Internet (Dou, 2004).

If the market is not regulated, an ISP may charge a termination fee for sending the CPs' content to its customers. Moreover, each CP and ISP may strike an exclusive 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 $z = 1$. Thus, a type z consumer derives utility of $U_z = u_A - p_A - tz$, when he subscribes to ISP A, whereas he obtains utility of $U_z = u_B - p_B - t(1 - z)$, when he subscribes to ISP B. Thereby, 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' natural 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 respective end user demand for ISP i by D_i. For expositional clarity, we suppress the arguments of the demand function $D_i(u_A, u_B, p_A, p_B)$, where $u_A, u_B \in \{u_{12}, u_1, u_2\}$ depending on the content that each ISP offers, and write D_i in the following.

Content providers There are two competing and differentiated CPs (denoted by $j \in \{1, 2\}$) that derive revenues from advertising and may 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. 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, the content offered by CP 1 is (weakly) more valuable to the end users compared to the content offered by CP 2, and both contents jointly do not reduce the value of any one content alone.

Following the current concerns of the policy debate, 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, $f = 0$ 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 connect to a single ISP (and pay the termination fee plus the exclusivity fee) or to both ISPs (and pay only the termination fee, but at each ISP); that is, we allow for the CPs' choice to single-home or to multi-home. Consequently, if a CP connects to ISP i, it can only be accessed by the end users connected to that ISP.[3]

CPs receive advertising revenues depending on the exposure to end users and depending on the level of competition between the two CPs. We normalize the maximum level of exposure (e.g., measured in terms of page impressions) to one. Thus, a CP that connects to both ISPs receives an exposure of $D_A + D_B = 1$. Similarly, a CP that connects to any one ISP, say i, exclusively receives an exposure of $D_i < 1$. A CP receives advertisement revenues according to its advertisement rate, r (e.g., the revenue-per-impression). The advertisement rate may either be high ($r = r_H$) or low ($r = r_L$). It is assumed to be high at those ISPs where the CP is the only CP available to the end users. Otherwise, when the CP competes for customers' clicks with the other CP, the advertisement rate is low.[4] Since we are particularly interested in how the level of competition between CPs affects Internet fragmentation, we define $a \equiv r_H/r_L$. This parameter $a \geq 1$ plays an important role in our analysis. It reflects the extent to which exclusivity can also benefit CPs via the advertising market, over and above the exclusivity fees that arise from the negotiations with the ISPs. 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. Only under exclusivity, a CP can be sure that end users on a platform will watch its own content, and thus advertising revenues will be realized in full. If instead a CP has to share the end users' attention with another CP on the same

[3] Exclusivity here is one-way, meaning that if ISP i has an exclusive deal with CP j, CP j delivers its content only to ISP i, but ISP i may serve CP $-j$ too.

[4] For example, think of end users that use 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. Similarly, an ad may be effective only when it is seen several times by the end users; thus, the probability of an ad to be clicked by an end user reduces when several CPs exist in the platform. Finally, CPs may 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).

platform, advertising revenues will be reduced. The parameter a reflects this type of competitive pressure: the higher is a, the stronger is the competition for clicks.

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

$$\Pi_j = \begin{cases} r_L - 2f & if \quad \text{both CPs non-exclusive} \\ r_L D_i + r_H D_{-i} - 2f & if \quad \text{CP } j \text{ non-exclusive \& CP } -j \text{ exclusive at ISP } i \\ r_L D_i - f - e_{ij} & if \quad \text{CP } j \text{ exclusive at ISP } i \text{ \& CP } -j \text{ non-exclusive} \\ r_H D_i - f - e_{ij} & if \quad \text{CP } j \text{ exclusive at ISP } i \text{ \& CP } -j \text{ exclusive at ISP } -i. \end{cases}$$

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.

Internet service providers In line with the previously introduced notation, the profit function of ISP i is

$$\Pi_i = \begin{cases} p_i D_i + 2f & if \quad \text{both CPs non-exclusive at ISP } i \\ p_i D_i + 2f + e_{ij} & if \quad \text{CP } j \text{ exclusive at ISP } i \text{ \& CP } -j \text{ non-exclusive at both ISPs} \\ p_i D_i + f + e_{ij} & if \quad \text{only CP } j \text{ exclusive at ISP } i \text{ \& CP } -j \text{ exclusive at ISP } -i. \end{cases} \quad (1)$$

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, 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.[6] Thus, in this case only ISP i makes an exclusivity

[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. Also notice that the sequential nature of the offers, where CP 1 is contacted first, is made for expositional convenience and does not affect the nature of our results.

offer to CP 2, e_{i2}. CP 2 either accepts this offer, or rejects it and delivers its content to both ISPs.

3. The ISPs simultaneously announce the subscription fees p_A, p_B and the end users 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.

4 The unregulated case

In the unregulated scenario, both exclusivity contracts and positive termination fees are 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).

[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.

We proceed backwards to solve for the subgame perfect equilibrium.

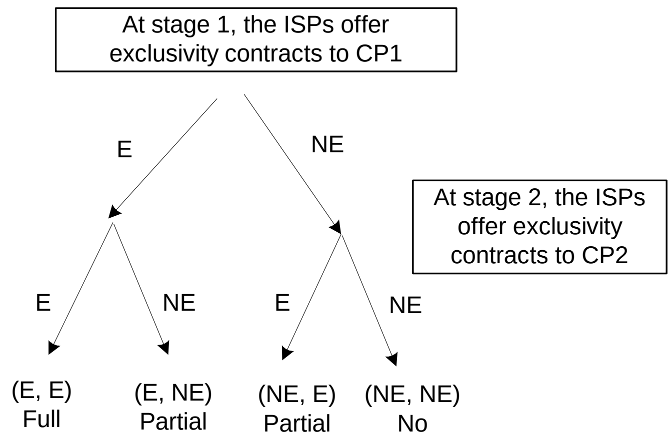

Figure 1: Potential subgames

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 $\widetilde{z}$, is derived by equating $u_A - p_A - t\widetilde{z} = u_B - p_B - t(1-\widetilde{z})$, which yields

$$\widetilde{z}(u_A, u_B, p_A, p_B) = \frac{1}{2} + \frac{u_A - u_B}{2t} + \frac{p_B - p_A}{2t}, \tag{2}$$

The end users' demands for ISP A and ISP B are thus $D_A = \widetilde{z}$ and $D_B = 1 - \widetilde{z}$, 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

$$p_A = t + \frac{u_A - u_B}{3},\ p_B = t + \frac{u_B - u_A}{3}. \tag{3}$$

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

$$D_A = 1 - D_B = \frac{1}{2} + \frac{u_A - u_B}{6t}, \tag{4}$$

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 ensure an interior solution with $D_i \in (0,1)$, we need that $-3t < u_i - u_{-i} < 3t$. A sufficient condition that satisfies this, and that we assume throughout the paper, is

$$t > (u_{12} - u_2)/3. \tag{5}$$

Stage 2: Exclusivity offered to CP 2 In this stage, there are two different types of subgames, depending on whether CP1 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, competition among the CPs is reduced which implies higher advertising rates for CP 2 (r_H instead of r_L). However, on the other hand, the CP that delivers its content to a single ISP exclusively, inevitably loses some exposure. Note also that the market shares of the two ISPs (exposure) are determined endogenously and will therefore change when exclusivity is chosen. We find that, when the competition between CPs is high (i.e., $a > \hat{a}$), the first effect dominates the second effect and, thus, full fragmentation arises in equilibrium. Exclusivity in this case is sought by CP 2 to avoid competition from CP 1, which also means that CP 2 is willing to pay a rather substantial exclusivity fee.

Fragmentation can also arise for weak competition between CPs ($a \leq \widehat{a}$), as long as the advertisement rate is generally low ($r_L < \widehat{r}$). The reason for exclusivity is now different, however. Take for example, the extreme case where r_L 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 between CPs is weak ($a \leq \widehat{a}$) *and* the advertisement rate is rather high ($r_L \geq \widehat{r}$), 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 $r_L < \overline{r}$. Again, in the presence of a high advertisement rate ($r_L \geq \overline{r}$), 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 equilibrium decision 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 competition between CPs is very strong ($a \geq \hat{a}$) or when 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_L. 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 competition between CPs is relatively high ($a \geq \widehat{a}$), or when competition between CPs is relatively low ($a < \widehat{a}$) and the advertisement rate on the Internet is low ($r_L < \widehat{r}$). When competition between CPs is relatively low ($a < \widehat{a}$) and the advertisement rate takes intermediate values ($\widehat{r} < r_L < \widetilde{r}$), partial Internet fragmentation occurs. On the contrary, no Internet fragmentation occurs when competition between CPs is relatively low ($a < \widehat{a}$) and the advertisement rate is high ($r_L \geq \widetilde{r}$).*

The relevant thresholds are as follows:

$$\widehat{a} = (u_{12} - u_2 + 3t) \,/\, (u_{12} - u_1) \tag{6}$$

$$\widehat{r} = \left(f + \frac{u_{12} - u_1}{3} + \frac{(u_1 - u_2)^2}{18t} - \frac{(u_{12} - u_2)^2}{18t} \right) / \left(\frac{3t + u_{12} - u_2 - a\,(u_{12} - u_1)}{6t} \right) \tag{7}$$

$$\widetilde{r} = \left(\frac{(3t + u_{12} - u_2)^2}{18t} - \frac{t}{2} + f \right) / \left(\frac{3t - (u_{12} - u_2)}{6t} \right). \tag{8}$$

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_L) space.[9] When a is high enough full fragmentation always occurs. Full fragmentation also emerges for low values of a and r_L: in the area to the

[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 substitutive.

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 (the latter becomes positive for relative high values of a and r_L).

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

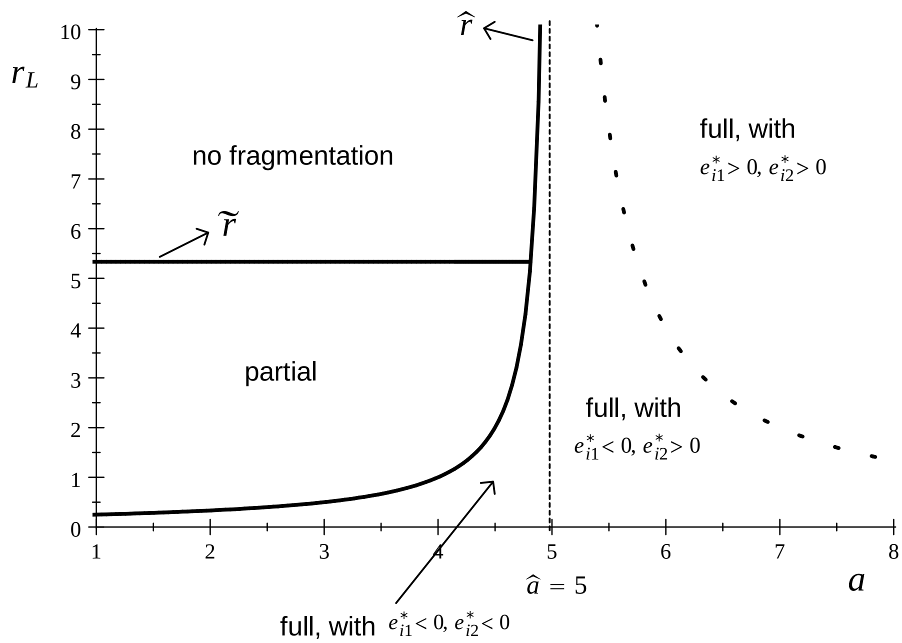

Figure 2: Equilibrium outcome for $t = 1,\ u_{12} = 3,\ u_1 = 2,\ u_2 = 1,\ f = 0$

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_L are relatively low. For relatively high a, competition between the CPs is strong enough; thus, a way to relax this competition is to opt for exclusivity at each platform. Note also that for relatively high values of a and r_L, both exclusivity fees are positive, thus, CPs should pay these fees to the ISPs. But as a and r_L become smaller, the 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 ($e_{i1} < e_{i2}$), since CP 1 can leverage its content which is more valuable to the end users. For relatively low termination fees f and a, both exclusivity fees in fact become negative, which means that these fees are slotting allowances paid by the ISPs to the CPs to achieve an exclusive dealing arrangement.

Partial fragmentation. For intermediate values of the advertising rate r_L and $a < \widehat{a}$, 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_L is high enough,[10] 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 $r_L < \widetilde{r}$, yielding (E, NE). When instead r_L is low, in the ensuing game there is no dominant strategy for CP 2: if CP1 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_L and $a < \widehat{a}$, no fragmentation occurs. All content is available to both platforms and, thus, to the 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_L 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

[10] We provide all the details of this equilibrium scenario in Appendix A.

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, identical profits arise also with full or partial fragmentation due to the 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 the substitutability of the two contents, and t, which is a measure of the intensity of competition between the two ISPs.

Substitutability of content. First, we examine how the level of substitutability (or complementarity) 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 $\widehat{r}$ and $\widetilde{r}$ increase as well ($d\widehat{r}/du_{12} > 0$, $d\widetilde{r}/du_{12} > 0$). This means that the threshold $\widehat{r}$ that characterizes the full fragmentation area increases with u_{12}, leading to more full fragmentation, and that the threshold $\widetilde{r}$ 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.*

Intuitively, 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 $\widehat{r}$ 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.

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]

Moreover, an increase in u_{12} shifts $\widetilde{r}$ 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 connect exclusively to 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 substitute contents ($u_{12} < u_1 + u_2$).

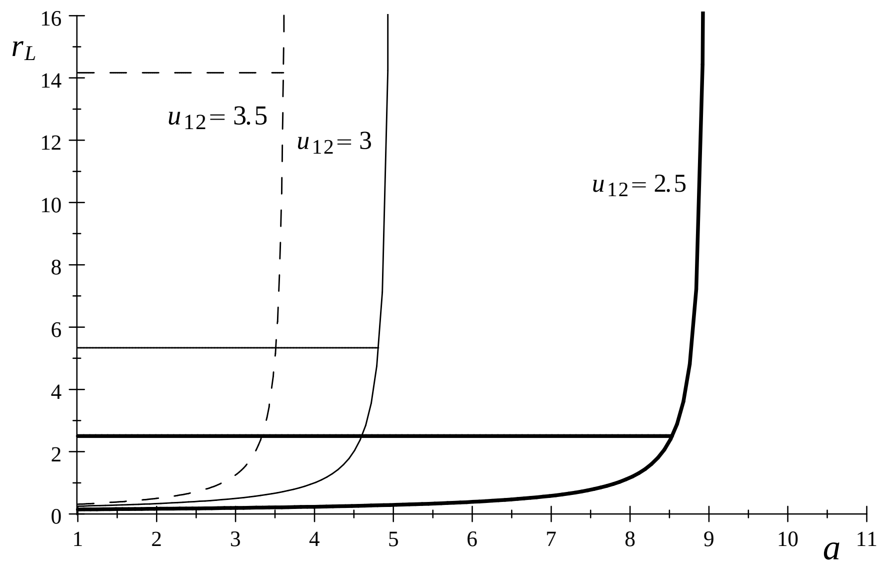

Figure 3: $t = 1,\ u_1 = 2,\ u_2 = 1,\ f = 0$

dashed line: $u_{12} = 3.5$, thin line: $u_{12} = 3$, thick line: $u_{12} = 2.5$

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 $\widetilde{r}$ always decreases with t ($d\widetilde{r}/dt < 0$), whereas the threshold $\widehat{r}$ increases for low a ($d\widehat{r}/dt \geq 0$ 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.

[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 $f \to 0$.

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 competition between CPs.*

The threshold $\widetilde{r}$ 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 $\widehat{r}$ that defines the full fragmentation area, we find that $\widehat{r}$ shifts to the right with t when a is relatively high leading to less full fragmentation, but $\widehat{r}$ shifts up for relatively low values of a. In Figure 4, we present a numerical example.

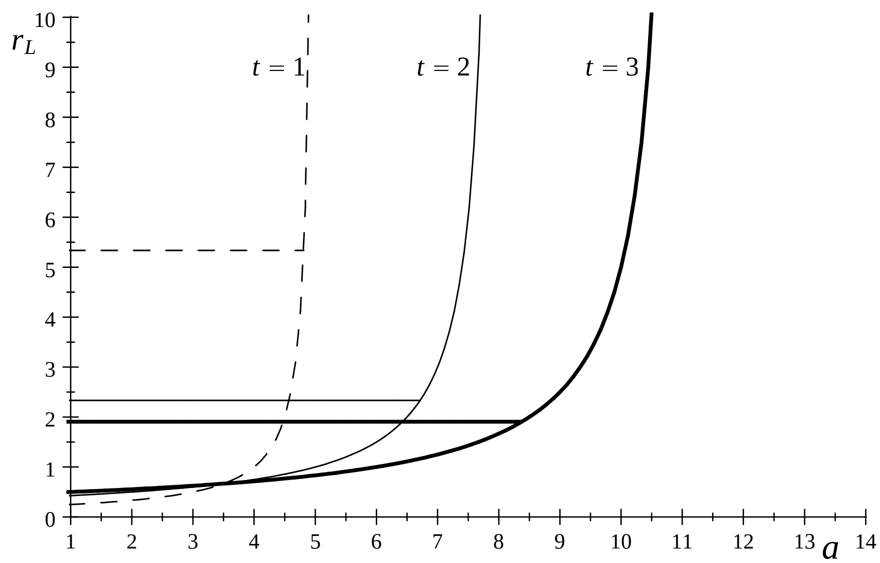

Figure 4: u_{12}= 3, u_1= 2, u_2= 1, $f = 0$

dashed line: $t = 1$, thin line: $t = 2$, thick line: $t = 3$

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

We now discuss the impact of the different approaches to net neutrality regulation on Internet fragmentation. First, NN regulation can impose a zero-price rule, which restricts 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 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, but does not impose further 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 $\partial\widehat{r}/\partial f > 0$ and $\partial\widetilde{r}/\partial f > 0$. 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.*

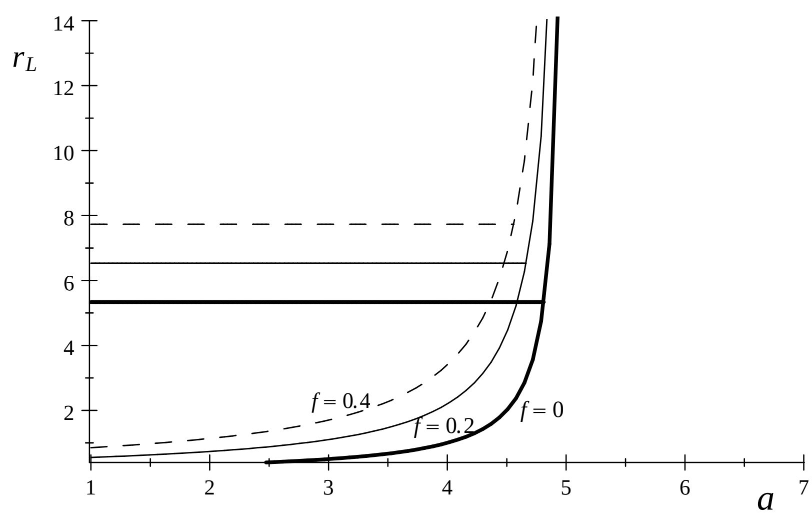

Figure 5: $t = 1,\ u_{12} = 3,\ u_1 = 2,\ u_2 = 1$

dashed line: $f = 0.4$, thin line: $f = 0.2$, thick line: $f = 0$

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 CP 2 wishes to be exclusive with the other ISP if and only if competition between the two CPs is strong ($a > \widehat{a}$). Otherwise, if CP 1 does not have an exclusivity contract with any ISP, then CP 2 always prefers not be exclusive to any ISP. Thus, partial fragmentation cannot occur in equilibrium under the strict zero-price rule. 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 competition between the CPs is strong ($a > \widehat{a}$), CP 1 opts for exclusivity exactly to mitigate this effect. Otherwise, if competition is weak, CP 1 decides to deliver its content to all ISPs and thus, no fragmentation occurs in equilibrium.

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 ($a > \widehat{a}$). Otherwise, the Internet remains unfragmented. Partial fragmentation does not emerge in equilibrium.*

In addition, by comparing the two full fragmentation cases (one is 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

[12] When the termination fees are non-zero, we have to make sure that all profits are also non-negative. A sufficient condition is $r_L \geq 2f$, which is always satisfied in Figure 5.

of the more efficient CP. In contrast, under no regulation or 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 among the unregulated case and the various net neutrality 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

$$CS = \frac{u_A + u_B}{2} + \frac{(u_A - u_B)^2}{36t} - \frac{5}{4}t. \tag{9}$$

The analysis of CS is immediate. Note that $\frac{\partial CS}{\partial u_i} = \frac{1}{2} + \frac{u_i - u_{-i}}{18t} > 0$, 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

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

By direct comparison of the consumers' surplus in the unregulated case 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,

$$W = \Pi_A + \Pi_B + \Pi_1 + \Pi_2 + CS. \tag{10}$$

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

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

We find that, whenever a is relatively low (i.e., competition 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. For $a \leq 2$, in fact, an exclusive content cannot produce more advertising revenues than those produced by both CPs together. Hence, in this case, all the welfare effects described above go in the same direction and there is no trade-off. Therefore, for not extreme 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, 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 consumers' surplus. With respect to total welfare, no fragmentation is efficient when competition between content providers is rather low ($a \leq 2$). When 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.*

A numerical example that illustrates the total welfare ranking is presented in Figure 6.[14] Figure 6 plots 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

[13] See Appendix C for a welfare comparison of all feasible outcome scenarios.

[14] We use the same numerical example as in Figure 2 and Figure A4 (b).

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).[15] 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.

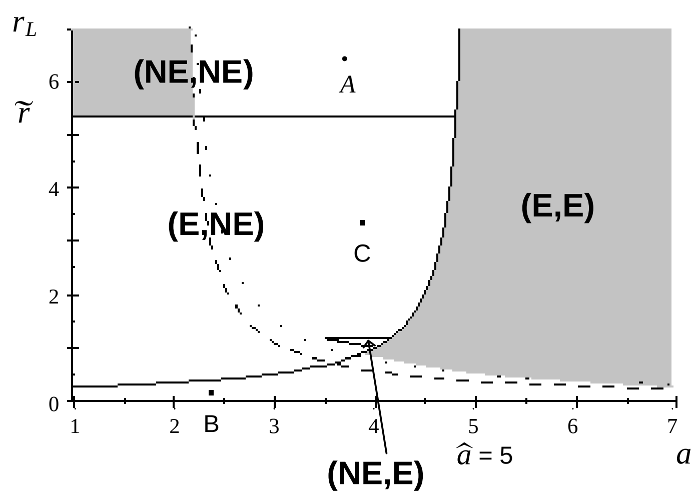

Figure 6: Equilibrium outcome in the unregulated case and socially optimal areas for $t = 1,\ u_{12} = 3,\ u_1 = 2,\ u_2 = 1, f = 0$

[15]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.

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.[16] We first discuss the 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_L which define the *type* of Internet fragmentation. When the termination fee f increases, both critical thresholds $\widehat{r}$ and $\widetilde{r}$ 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 consumers' 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 consumers' 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 between content providers 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

[16] 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.

for low values of r_L.

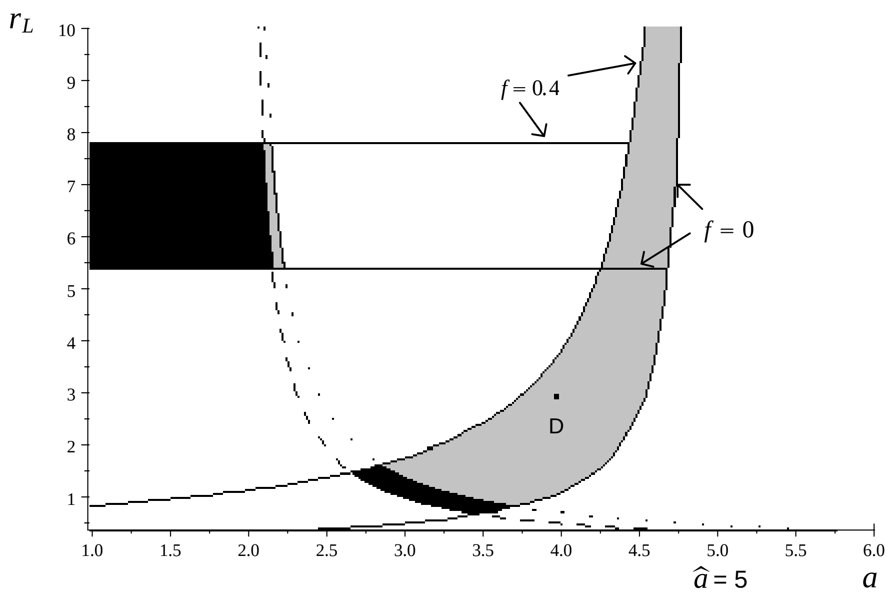

Figure 7: Performance of the zero-price rule in comparison to no regulation: Black shaded areas indicate welfare improvements towards the first-best, whereas gray shaded areas indicate welfare deteriorations away from the first-best ($t = 1,\ u_{12} = 3,\ u_1 = 2,\ u_2 = 1$)

By contrast, recall that the *strict* zero-price rule prevents partial fragmentation in equilibrium and achieves no fragmentation whenever $a \leq \widehat{a}$ (see Proposition 5). Since $\widehat{a} > 2$, 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 relatively 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.

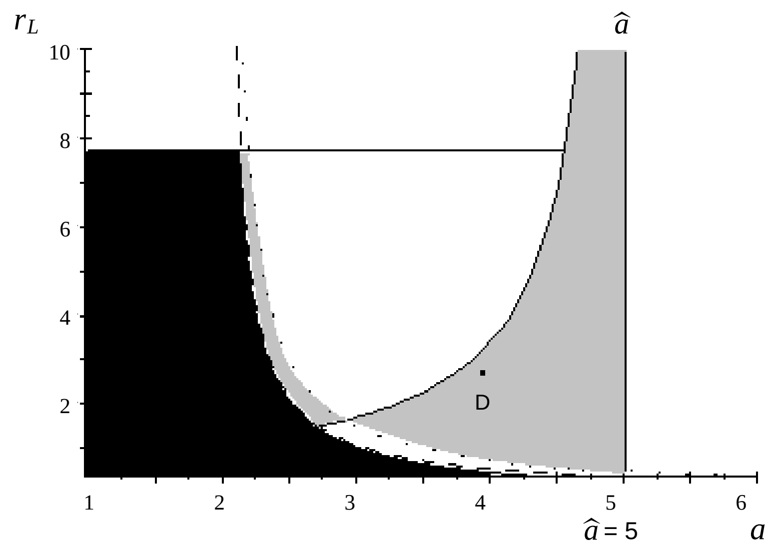

Figure 8: Performance of the strict zero-price rule in comparison to no regulation: Black shaded areas indicate welfare improvements towards the first-best, whereas gray shaded areas indicate welfare deteriorations away from the first-best

$(t = 1,\ u_{12} = 3,\ u_1 = 2,\ u_2 = 1,\ f = 0.4)$

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 consumers' 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 competition between content providers is intense ($a > \widehat{a}$), such that full fragmentation is most likely the efficient outcome, unless r_L 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 unregulated. 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 competition between content providers is at an intermediate level ($a \in (2, \widehat{a})$), a meaningful application of any one of the available policy instruments seems almost impossible. Depending on the precise parameter range and on the policy instrument under consideration, welfare can be improved or deteriorated (see Figures 7 and 8) in comparison to no 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 counter-productive 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_L 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 competition between content providers is intense ($a > \widehat{a}$), 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 provider competition ($2 < a < \widehat{a}$), 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 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 net neutrality would preserve an unfragmented Internet (Lee and Wu, 2009). More specifically, it is argued that absent net neutrality 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 competition between CPs affect the emergence of exclusive contracts and thus Internet fragmentation. We find that the zero-price rule of net neutrality 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 in the unregulated market 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 an unregulated market.

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 consumers' surplus. Consequently, if the policy makers considers consumers' 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 between CPs is not too strong. On the contrary, if competition between content providers is intense (which implies that the advertisement revenues that CPs can earn under exclusivity are much higher than under competition) then full fragmentation becomes the efficient outcome with respect to total surplus. In the latter case, none of the above policy interventions 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 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 net neutrality regulation to prevent Internet fragmentation. Although net neutrality 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 consumers' surplus but also innovations (for which total welfare is a sensible measure) are important, it is therefore reasonable not to impose net neutrality 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.

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Appendix A: Full analysis of the unregulated case

Stage 3: Subscription fees and end users' decisions The decisions in this stage have been analyzed in the main body of the paper, where the equilibrium subscription fees are given by expressions (3) and the number of end users subscribing to the ISPs are given by expression (4).

Stage 2: Exclusivity offered to CP 2 In this stage, there are two different types of subgames, depending on whether CP1 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 $e_{i2}^{(E,E)}$ 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):

$$
\begin{aligned}
&\Pi_i^{(E,E)}+\Pi_2^{(E,E)}>\Pi_i^{(E,NE)}+\Pi_2^{(E,NE)}\\
&\left(p_i^{(E,E)}D_i^{(E,E)}+f+e_{i2}^{(E,E)}\right)+\left(r_H D_i^{(E,E)}-f-e_{i2}^{(E,E)}\right)>\left(p_i^{(E,NE)}D_i^{(E,NE)}+f\right)+\left(r_L D_{-i}^{(E,NE)}+r_H D_i^{(E,NE)}-2f\right)\\
&\left(p_i^{(E,E)}+r_H\right)D_i^{(E,E)}>r_L D_{-i}^{(E,NE)}+\left(p_i^{(E,NE)}+r_H\right)D_i^{(E,NE)}-f\\
&(t+\tfrac{u_2-u_1}{3}+r_H)(\tfrac{3t+u_2-u_1}{6t})>r_L(\tfrac{3t+u_{12}-u_2}{6t})+(t+\tfrac{u_2-u_{12}}{3}+r_H)(\tfrac{3t+u_2-u_{12}}{6t})-f\\
&r_L\frac{3t+u_{12}-u_2-a(u_{12}-u_1)}{6t}<f+\frac{(u_{12}-u_1)(3t-(u_1-u_2)+3t-(u_{12}-u_2))}{18t}.
\end{aligned}
\tag{12}
$$

For $a>\widehat{a}$, where $\widehat{a}$ is given by (6), 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.[17] Note that $\widehat{a}>2$ 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 ($r_H>2r_L$). Competition between the CPs is very strong and we will further show that ISP i can extract a high exclusivity fee from CP 2.

For $a\leq\widehat{a}$, exclusivity is still offered by ISP i if and only if $r_L<\widehat{r}$, where $\widehat{r}$ is given by (7).

Finally, for $a\leq\widehat{a}$ and $r_L\geq\widehat{r}$, 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_L is relatively high).

[17] Assumption (5) ensures that the right-hand side of the inequality is positive.

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:

$$\begin{aligned}\Pi_2^{(E,E)} &= \Pi_2^{(E,NE)} \\ r_H \frac{3t + u_2 - u_1}{6t} - f - e_{i2}^{(E,E)} &= r_L \frac{3t + u_{12} - u_2}{6t} + r_H \frac{3t + u_2 - u_{12}}{6t} - 2f \\ e_{i2}^{(E,E)} &= f - r_L \frac{3t + u_{12} - u_2 - a\left(u_{12} - u_1\right)}{6t}.\end{aligned}$$

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.

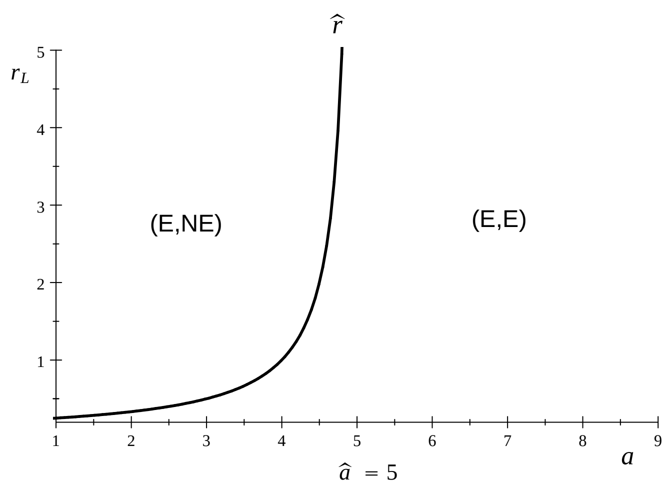

Figure A1: The choices of CP 2, given that CP 1 has delivered its content exclusively to ISP $-i$

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

By summarizing the results of this subgame, we obtain

$$e_{i2}^{(E,\cdot)}=\begin{cases} f-r_L(\frac{3t+u_{12}-u_2-a(u_{12}-u_1)}{6t}) & if \quad \{r_L<\widehat{r}\cup a\leq\widehat{a}\}\cap a>\widehat{a}\text{, i.e., } (E,E) \\ \infty & if \quad \{r_L\geq\widehat{r}\cup a\leq\widehat{a}\}\text{, i.e., } (E,NE) \end{cases}$$

$$\Pi_{-i}^{(E,\cdot)}=\begin{cases} \frac{(3t+u_1-u_2)^2}{18t}+f+e_{-i1}^{(E,E)} & if \quad \{r_L<\widehat{r}\cup a\leq\widehat{a}\}\cap a>\widehat{a} \\ \frac{(3t+u_{12}-u_2)^2}{18t}+2f+e_{-i1}^{(E,NE)} & if \quad \{r_L\geq\widehat{r}\cup a\leq\widehat{a}\} \end{cases}$$

$$\Pi_{i}^{(E,\cdot)}=\begin{cases} \frac{(3t-(u_1-u_2))^2}{18t}-r_L(\frac{3t+u_{12}-u_2-a(u_{12}-u_1)}{6t})+2f & if \quad \{r_L<\widehat{r}\cup a\leq\widehat{a}\}\cap a>\widehat{a} \\ \frac{(3t-(u_{12}-u_2))^2}{18t}+f & if \quad \{r_L\geq\widehat{r}\cup a\leq\widehat{a}\} \end{cases}$$

$$\Pi_{1}^{(E,\cdot)}=\begin{cases} ar_L(\frac{3t+u_1-u_2}{6t})-f-e_{-i1}^{(E,E)} & if \quad \{r_L<\widehat{r}\cup a\leq\widehat{a}\}\cap a>\widehat{a} \\ r_L(\frac{3t+u_{12}-u_2}{6t})-f-e_{-i1}^{(E,NE)} & if \quad \{r_L\geq\widehat{r}\cup a\leq\widehat{a}\} \end{cases}$$

$$\Pi_{2}^{(E,\cdot)}=r_L(\frac{3t+u_{12}-u_2-a\left(u_{12}-u_2-3t\right)}{6t})-2f.$$

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:

$$\begin{aligned} \Pi_i^{(NE,E)}+\Pi_2^{(NE,E)} &> \Pi_i^{(NE,NE)}+\Pi_2^{(NE,NE)} \\ \left(p_i^{(NE,E)}D_i^{(NE,E)}+2f+e_{i2}^{(NE,E)}\right)+\left(r_LD_i^{(NE,E)}-f-e_{i2}^{(NE,E)}\right) &> \left(p_i^{(NE,NE)}D_i^{(NE,NE)}+2f\right)+(r_L-2f) \\ \left(p_i^{(NE,E)}+r_L\right)D_i^{(NE,E)}+f &> p_i^{(NE,NE)}D_i^{(NE,NE)}+r_L \\ \left(t+\frac{u_{12}-u_1}{3}+r_L\right)\left(\frac{3t+u_{12}-u_1}{6t}\right)+f &> \frac{t}{2}+r_L \\ r_L &< \overline{r}, \end{aligned}$$

where

$$\overline{r}\equiv\left(\frac{(3t+u_{12}-u_1)^2}{18t}+f-\frac{t}{2}\right)/\left(\frac{3t-(u_{12}-u_1)}{6t}\right)>0. \tag{13}$$

Now let us determine the exclusivity fee. For $r_L \geq \overline{r}$, no ISP opts for an exclusivity contract with CP 2. Instead, for $r_L < \overline{r}$, 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 $e_{i2}^{(NE,E)}$ offered by ISP i is determined by

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

$$e_{i2}^{(NE,E)} = -f-\frac{2\left(u_{12}-u_1\right)}{3} < 0.$$

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 θ, 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 $r_L - 2f$. Thus, the next inequality should also be satisfied for exclusivity to occur in equilibrium

$$\Pi_2^{(NE,E)} > \Pi_2^{(NE,NE)} \tag{14}$$

$$r_L\frac{3t+u_{12}-u_1}{6t} - f - e_{i2}^{(NE,E)} > r_L - 2f$$

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

We now prove that $\overline{r} < \left(2f+\frac{2(u_{12}-u_1)}{3}\right) / \left(\frac{3t-(u_{12}-u_1)}{6t}\right)$, thus, CP 2 accepts an exclusivity offer when it receives one. The inequality (14) holds for $t > \left(u_{12}-u_1\right)^2 / \left(18f+6\left(u_{12}-u_1\right)\right)$, implying that it is sufficient that $t > \left(u_{12}-u_1\right)/6$, 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.

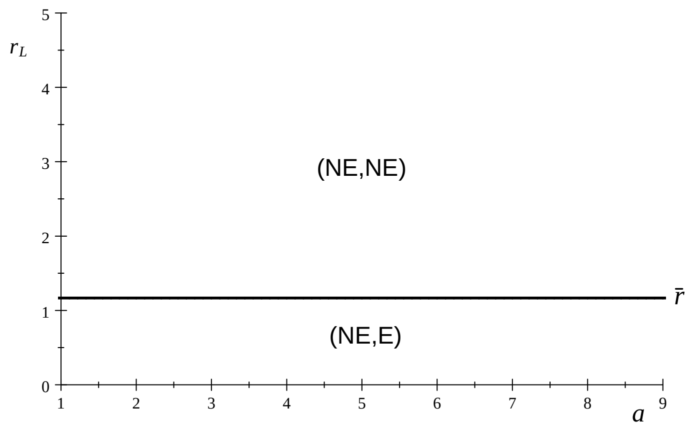

Figure A2: The choices of CP 2, given that CP 1 has delivered its content to both ISPs

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

By summarizing the results of this subgame, we obtain

$$e_{i2}^{(NE,\cdot)} = \begin{cases} -f - \frac{2(u_{12}-u_1)}{3} & if \quad r_L < \overline{r}, \text{ i.e., } (NE, E) \\ \infty & if \quad r_L \geq \overline{r}, \text{ i.e., } (NE, NE) \end{cases}$$

$$\Pi_i^{(NE,\cdot)} = \begin{cases} \frac{(3t-(u_{12}-u_1))^2}{18t} + f & if \quad r_L < \overline{r} \\ \frac{t}{2} + 2f & if \quad r_L \geq \overline{r} \end{cases}$$

$$\Pi_1^{(NE,\cdot)} = \begin{cases} r_L \frac{3t+u_{12}-u_1+a(3t-(u_{12}-u_1))}{6t} - 2f & if \quad r_L < \overline{r} \\ r_L - 2f & if \quad r_L \geq \overline{r} \end{cases}$$

$$\Pi_2^{(NE,\cdot)} = \begin{cases} r_L \frac{3t+u_{12}-u_1}{6t} + \frac{2(u_{12}-u_1)}{3} & if \quad r_L < \overline{r} \\ r_L - 2f & if \quad r_L \geq \overline{r}. \end{cases}$$

It is worth noticing that the profits $\Pi_1^{(NE,\cdot)}$ 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_L (recall that the critical thresholds are $\widehat{a}$, $\widehat{r}$, and $\overline{r}$, are given respectively by (6), (7), and (13)). After comparing these thresholds, we obtain that $\overline{r}>\widehat{r}$ if and only if $a<\overline{a}$, where

$$\overline{a}\equiv\frac{u_{12}-u_2}{u_{12}-u_1}-\frac{6t}{u_{12}-u_1}\left(\left(f+\frac{u_{12}-u_1}{3}+\frac{(u_1-u_2)^2}{18t}-\frac{(u_{12}-u_2)^2}{18t}\right)\left(\frac{3t-(u_{12}-u_1)}{6t}\right)/\left(\frac{(3t+u_{12}-u_1)^2}{18t}+f-\frac{1}{2}t\right)-\frac{1}{2}\right),$$

with $\overline{a}\leq\widehat{a}$. The various potential equilibrium regions are presented graphically in a numerical example in Figure A3.

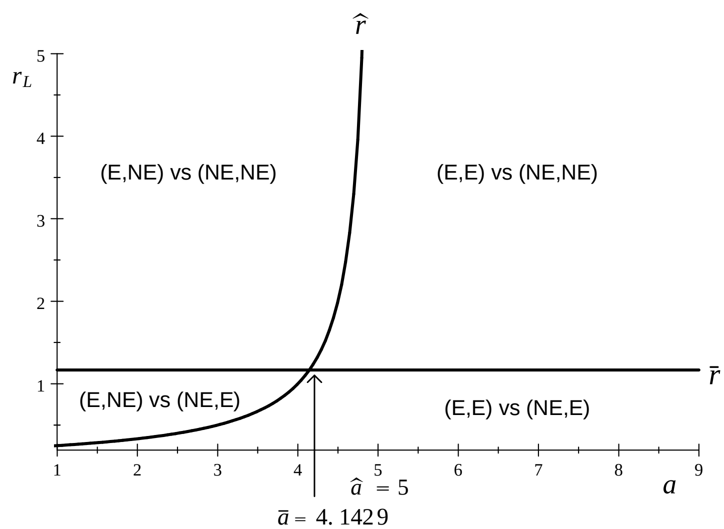

Figure A3: The potential choices of CP 1, given the continuation of the game

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

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 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_L, i.e., $r_L \leq \widetilde{r}$ where $\widetilde{r}$ is given by (8), 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.[18] More specifically, when $K \leq 0$ and $a < \overline{\overline{\overline{a}}}$, CP 1 achieves exclusivity.[19] When $K \leq 0$ and $a \in \left(\overline{\overline{\overline{a}}}, \overline{\overline{a}}\right)$, CP 1 achieves exclusivity for $r_L \in \left(\widehat{r}, \widetilde{\overline{r}}\right)$, while CP 2 achieves exclusivity for $r_L \in \left(\widetilde{\overline{r}}, \overline{r}\right)$.[20] Lastly, when $K \leq 0$ and $a \in \left(\overline{\overline{a}}, \overline{a}\right)$, CP 2 achieves exclusivity.[21]

The equilibrium outcome is illustrated in two numerical examples in Figure A4. The intuition

[18] The threshold K is given by $K \equiv -54ft^2 \left(u_1 - u_2\right) + 36ft \left(u_{12} - u_1\right)\left(u_1 - u_2\right) - 18t^2 \left(u_{12} - u_2\right)\left(u_{12} - u_1\right) - 3t \left(u_{12} - u_1\right)\left(\left(u_1 - u_2\right)\left(4u_1 - u_2\right) - 2\left(u_{12} - u_2\right)^2 - 3u_{12}\left(u_1 - u_2\right)\right) - \left(u_{12} - u_1\right)^2 \left(u_1 - u_2\right)\left(2u_{12} - \left(u_1 + u_2\right)\right)$.

[19] The threshold $\overline{\overline{\overline{a}}}$ is given by $\overline{\overline{\overline{a}}} \equiv \frac{u_1 - u_2}{3t - (u_{12} - u_1)} + \frac{36ft + (2u_{12} - u_1 - u_2)(6t + u_1 - u_2)}{18ft + (u_{12} - u_1)(6t + u_{12} - u_1)}$

[20] The threshold $\overline{\overline{a}}$ is given by $\overline{\overline{a}} = \frac{(u_1 - u_2)((u_{12} - u_1)(6t + 2u_2 - u_1 - u_{12}) + 18ft) + ((2u_{12} - (u_1 + u_2))(6t + u_1 - u_2) + 36ft)(3t + u_{12} - u_2)}{((u_{12} - u_1)((2u_{12} - (u_1 + u_2))(6t + u_1 - u_2) + 36ft) + ((u_{12} - u_1)(3t - (u_1 - u_2) + 3t - (u_{12} - u_2)) + 18ft)(3t + u_1 - u_{12}))}$ and the threshold $\widetilde{\overline{r}}$ by $\widetilde{\overline{r}} \equiv \frac{36ft + (2u_{12} - u_1 - u_2)(6t + u_1 - u_2)}{3(a(3t - (u_{12} - u_1)) - (u_1 - u_2))}$.

[21] Note that for $K < 0$ we obtain $\overline{\overline{\overline{a}}} < \overline{\overline{a}} < \overline{a}$, while for $K > 0$ we obtain $\overline{a} < \overline{\overline{a}} < \overline{\overline{\overline{a}}}$.

and equilibrium properties are discussed in Section 4.

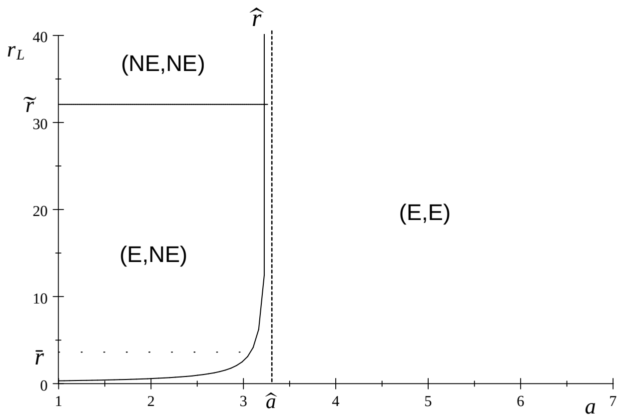

Figure A4 (a): Equilibrium outcome for $t = 1,\ u_{12}= 3.75,\ u_1= 2,\ u_2= 1,\ f = 0$ where $K = 1.3125,\ \widehat{a} = 3.2857,\ \overline{a}= 3.0783 <\overline{\overline{a}}<\overline{\overline{\overline{a}}}$

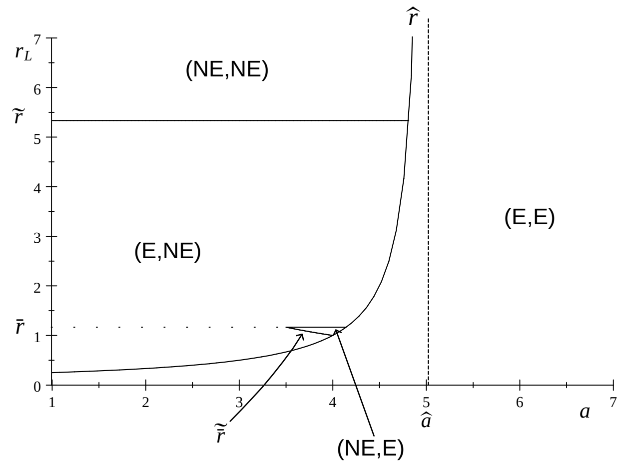

Figure A4 (b): Equilibrium outcome for $t = 1,\ u_{12}= 3,\ u_1= 2,\ u_2= 1,\ f = 0$ where $K = -9,\ \widehat{a} = 5,\ \overline{\overline{\overline{a}}}= 3.5,\ \overline{\overline{a}}= 4,\ \overline{a}= 4.1429$

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

$$\text{Fragmentation:}\begin{cases} \text{full} & if\quad \{r_L\leq \widehat{r}\cup a <\widehat{a}\}\cap a \geq\widehat{a}\text{, i.e., } (E,E) \\ \text{partial} & if\quad \{\widehat{r}< r_L < \widetilde{r}\cup a <\widehat{a}\}\text{, i.e., } (E,NE) \text{ or } (NE,E) \\ \text{no} & if\quad \{r_L\geq \widetilde{r}\cup a <\widehat{a}\}\text{, i.e., } (NE,NE)\,. \end{cases}$$

The equilibrium levels of the exclusivity fees and all firms' profits are given below.

$$e^*_{i1}=\begin{cases} f-\frac{2(u_1-u_2)}{3}-r_L\frac{3t+u_{12}-u_2-a(u_{12}-u_1)}{6t} & if\quad \text{Full fragmentation} \\ -f-\frac{2(u_{12}-u_2)}{3} & if\quad \text{Partial fragmentation } (E,NE) \\ \infty & if\quad \text{Partial fragmentation } (NE,E) \\ \infty & if\quad \text{No fragmentation} \end{cases}$$

$$e^*_{i2}=\begin{cases} f-r_L\frac{3t+u_{12}-u_2-a(u_{12}-u_1)}{6t} & if\quad \text{Full fragmentation} \\ \infty & if\quad \text{Partial fragmentation } (E,NE) \\ -f-\frac{2(u_{12}-u_1)}{3} & if\quad \text{Partial fragmentation } (NE,E) \\ \infty & if\quad \text{No fragmentation} \end{cases}$$

$$\Pi_i^* = \begin{cases} \frac{(3t-u_1+u_2)^2}{18t} - r_L \frac{3t+u_{12}-u_2-a(u_{12}-u_1)}{6t} + 2f & if \;\; \text{Full fragmentation} \\ \frac{(3t-(u_{12}-u_2))^2}{18t} + f & if \;\; \text{Partial fragmentation } (E, NE) \\ \frac{(3t-(u_{12}-u_1))^2}{18t} + f & if \;\; \text{Partial fragmentation } (NE, E) \\ \frac{t}{2} + 2f & if \;\; \text{No fragmentation} \end{cases}$$

$$\Pi_1^* = \begin{cases} r_L \left(a(\frac{3t+u_1-u_2}{6t}) + \frac{3t+u_{12}-u_2-a(u_{12}-u_1)}{6t} \right) + \frac{2(u_1-u_2)}{3} - 2f & if \;\; \text{Full fragmentation} \\ r_L \frac{3t+u_{12}-u_2}{6t} + \frac{2(u_{12}-u_2)}{3} & if \;\; \text{Partial fragmentation } (E, NE) \\ r_L \frac{3t+u_{12}-u_1+a(3t-(u_{12}-u_1))}{6t} - 2f & if \;\; \text{Partial fragmentation } (NE, E) \\ r_L - 2f & if \;\; \text{No fragmentation} \end{cases}$$

$$\Pi_2^* = \begin{cases} r_L \frac{3t+u_{12}-u_2+a(3t-(u_{12}-u_2))}{6t} - 2f & if \;\; \text{Full fragmentation} \\ r_L \frac{3t+u_{12}-u_2+a(3t-(u_{12}-u_2))}{6t} - 2f & if \;\; \text{Partial fragmentation } (E, NE) \\ r_L \frac{3t+u_{12}-u_1}{6t} + \frac{2(u_{12}-u_1)}{3} & if \;\; \text{Partial fragmentation } (NE, E) \\ r_L - 2f & if \;\; \text{No fragmentation.} \end{cases}$$

Note also that, for the parameter values where $\widetilde{r} < \widehat{r}$, the partial fragmentation result is eliminated; full fragmentation emerges when $r_L \leq \widehat{r}$, and no fragmentation emerges when $r_L > \widehat{r}$.

Appendix B: Full analysis of 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. The subscription fees are given by (3) and market shares by (4).

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 CP1 has accepted exclusivity (cases $(E,\cdot)$) or not (cases $(NE,\cdot)$).

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:

$$\Pi_2^{(E,E)} > \Pi_2^{(E,NE)}$$
$$ar_L \frac{3t-(u_1-u_2)}{6t} > r_L \frac{3t+u_{12}-u_2}{6t} + ar_L \frac{3t-(u_{12}-u_2)}{6t}$$
$$a > \widehat{a},$$

where $\widehat{a}$ is the same threshold as in expression (6).

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 $r_L \frac{3t+u_{12}-u_2}{6t}$), but on the other hand, it increases the demand of ISP i (and, thus, its advertising revenues) due to the fact that its content is only delivered at this platform ($\frac{3t-(u_1-u_2)}{6t} > \frac{3t-(u_{12}-u_2)}{6t}$), where it also benefits from reduced competition for advertising. We find that 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:

$$\Pi_2^{(NE,E)} > \Pi_2^{(NE,NE)}$$
$$r_L D_i^{(NE,E)} > r_L,$$

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 of the game. For relatively high values of a ($a>\widehat{a}$), CP 1 delivers its content to a single ISP $-i$ if and only if:

$$\begin{aligned}\Pi_1^{(E,E)} &> \Pi_1^{(NE,NE)}\\ ar_L\frac{3t+u_1-u_2}{6t} &> r_L\\ a &> \frac{6t}{3t+u_1-u_2},\end{aligned}$$

which is always satisfied for $a > \widehat{a}$. Therefore, for these values of a, full fragmentation is the equilibrium outcome. As before, with probability θ 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 ($a \leq \widehat{a}$), CP 1 delivers its content to a single ISP $-i$ if and only if:

$$\begin{aligned}\Pi_1^{(E,NE)} &> \Pi_1^{(NE,NE)}\\ r_L D_{-i}^{(E,NE)} &> r_L,\end{aligned}$$

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.

$$\text{Fragmentation under strict zero-pricing: } \begin{cases}\text{full} & if \quad a > \widehat{a}\\ \text{no} & if \quad a \leq \widehat{a}\end{cases}$$

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

$$\Pi_A^S = \begin{cases}\frac{(3t+u_1-u_2)^2}{18t} & if \quad \text{Full fragmentation \& prob. } \theta\\ \frac{(3t+u_2-u_1)^2}{18t} & if \quad \text{Full fragmentation \& prob. } 1-\theta\\ \frac{t}{2} & if \quad \text{No fragmentation}\end{cases}$$

$$\Pi_B^S = \begin{cases} \frac{(3t+u_1-u_2)^2}{18t} & if \quad \text{Full fragmentation \& prob. } \theta \\ \frac{(3t+u_2-u_1)^2}{18t} & if \quad \text{Full fragmentation \& prob. } 1-\theta \\ \frac{t}{2} & if \quad \text{No fragmentation} \end{cases}$$

$$\Pi_1^S = \begin{cases} ar_L \frac{3t+u_1-u_2}{6t} & if \quad \text{Full fragmentation} \\ r_L & if \quad \text{No fragmentation} \end{cases}$$

$$\Pi_2^S = \begin{cases} ar_L \frac{3t+u_2-u_1}{6t} & if \quad \text{Full fragmentation} \\ r_L & if \quad \text{No fragmentation.} \end{cases}$$

Appendix C: Welfare comparisons By comparing the total welfare from equation (11) under the feasible outcomes we obtain

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

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

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

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

$$W^{(NE,NE)} > W^{(E,E)} \quad if \quad a < \frac{18t(2u_{12}-(u_1+u_2))-5(u_1-u_2)^2}{36tr_L} + 2 \ .$$

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 $a < 2 - \frac{18t(u_1-u_2)-5(u_1-u_2)(2u_{12}-(u_1+u_2))}{6r_L(u_1-u_2)}$, where the last term on the right hand side may be positive or negative.