

# Zero-Rating and Vertical Content Foreclosure

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## Abstract

We study zero-rating, a practice whereby an Internet service provider (ISP) that limits retail data consumption exempts certain content from that limit. This practice is particularly controversial when zero-rated services are provided by an ISP that is vertically integrated into content because the data limit and ensuing overage charges impose an additional cost on rival content. As we show, the incentives to offer zero-rating and the resulting welfare consequences with and without vertical integration depend on two factors (i) the degree of differentiation between content providers' services and (ii) whether or not the ISP can charge zero-rated content providers for exempting their data from the limit.

**Keywords:** Data Caps; Sponsored Data; Two-Sided Market; Vertical Content Foreclosure; Zero-Rating

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# 1 Introduction

Internet service providers (ISPs) offer a large variety of subscription plans to consumers, many of these consisting of a periodic fee and overage charges for exceeding a predetermined limit or cap on data consumption. Among mobile wireless ISPs like Verizon Wireless, a typical plan involves a monthly fee  $H$  for  $X$  GB of data and an overage charge for each additional  $Y$  GB of data beyond  $X$  GB.<sup>1</sup> Home Internet service providers have also started to limit the service that their monthly subscription fee buys, but the limits are typically much higher than those of mobile wireless providers.<sup>2</sup>

In this manuscript, we study a hybrid pricing strategy that several ISPs have introduced to distinguish their service offers whereby the ISPs do not subject a subset of available content to caps or overage charges. Such content is said to be zero-rated, meaning that its consumption is not counted when tabulating consumers' monthly data consumption toward or beyond the cap. Additionally, ISPs may offer to zero-rate certain content providers' data in exchange for a fee, a practice referred to as sponsored data.

There are numerous examples of zero-rating and sponsored data programs. For example, under Verizon's "Go90" and "FreeBee" sponsored data programs, content providers (CPs) pay Verizon to zero-rate their content.<sup>3</sup> Similar, T-Mobile's "Binge On" allows consumers to watch unlimited HBO, Hulu, Netflix, Sling TV, and other content without eating into their data allowances. To offer the service, T-Mobile reduces video quality to 480p+, but does not collect fees from video providers.<sup>4</sup> Comcast's Stream TV service presents an example of zero-rating by an ISP that is vertically integrated into content. Stream TV competes with other streaming services like Amazon Video, Hulu, and Netflix, but does not count toward Comcast's data allowance (see Comcast 2016; Public Knowledge 2016). More generally, any ISP that sets a cap on Internet service but also provides other content using a means beside the Internet (i.e., cable) effectively zero-rates the other content.

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<sup>1</sup>Periodically, mobile wireless providers instead offer unlimited service plans, but plans with data caps remain common (FCC 2017c ¶¶50-51).

<sup>2</sup>For example, Comcast, which currently uses data caps, caps usage at a terabyte of Internet data. Comcast claims that more than 99 percent of customers do not use a terabyte of data. See XFINITY. XFINITY Data Usage Center, Frequently Asked Questions. Available at <https://dataplan.xfinity.com/faq/>.

<sup>3</sup>See Verizon, go90 FAQs. Available at <https://www.verizonwireless.com/support/go90-faqs/>; Verizon, FreeBee Data, What is FreeBee DataFigure Available at <https://freebee.verizonwireless.com/>.

<sup>4</sup>T-Mobile, Binge On. Available at <https://www.t-mobile.com/offer/binge-on-streaming-video.html>.

On the surface, zero-rating appears to benefit consumers by allowing them to consume certain content without being concerned about overage charges. In principle, this can increase broadband consumption and foster greater innovation and competition among CPs. Nevertheless, zero-rating has spurred a heated debate over its merits among scholars, public interest groups, and industry advocates,<sup>5</sup> and raised regulator concerns as a potentially harmful discriminatory practice. For instance, possibly worried that zero-rating was a violation of net neutrality antidiscrimination principles, the Federal Communications Commission (FCC) in 2016 conditioned its approval of the merger between Charter Communications and Time Warner on an agreement that the parties not impose data caps or usage based pricing and in 2017 released a report (later retracted) putting forward a framework for evaluating mobile zero-rated offerings (see FCC 2016 ¶457, FCC 2017a, b).<sup>6</sup> Taking a sterner approach, in 2016, India prohibited data service providers from offering or charging different prices for data—even if it is free. This had the effect of banning Facebook’s Internet.org Free Basics program, which provided a pared-down version of Facebook and weather and job listings.<sup>7</sup> Similarly, regulators in Canada, Chile, Norway, the Netherlands, and Slovenia have made explicit statements against zero-rating as anti-competitive or contravening national net neutrality regulation (OECD 2015). A primary concern is that zero-rating can give an unfair advantage to zero-rated services, allowing ISPs to favor some content over other. Verizon, for instance, excluded its own video streaming service “go90” from data charges, thereby advantaging the service over rival CPs, who would need to pay a fee to register on Freebee in order to be similarly exempt from data overages.

The debate over zero-rating raises several interesting research questions. On what grounds will ISPs and CPs agree to a zero-rating deal if CPs are asymmetric in the quality of content that they provide? Under what conditions is zero-rating harmful or alternatively beneficial to market competition and social welfare? Finally, how does vertical integration together with zero-rating of affiliated content alter competition from rival CPs and how does vertical integration impact

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<sup>5</sup>Crawford (2015), Drossos (2015), and van Schewick (2015, 2016) argue that zero-rating is an anti-competitive violation of net neutrality, whereas Brake (2016), Eisenach (2015), and Rogerson (2016) view the practice as an efficient competitive ISP response to market conditions.

<sup>6</sup>In its 2015 Open Internet Order, the FCC explicitly banned providers of broadband Internet access service from blocking, impairing or degrading, or charging for prioritization of lawful Internet content. However, the FCC has not banned zero-rating, which enables ISPs to discriminate across CPs via consumer pricing without charging CPs different prices for termination.

<sup>7</sup>See Gowen, A. “India bans Facebook’s ‘free’ Internet for the poor.” *The Washington Post*. February 8, 2016. Available at [https://www.washingtonpost.com/world/indian-telecom-regulator-bans-facebooks-free-internet-for-the-poor/2016/02/08/561fc6a7-e87d-429d-ab62-7cdec43f60ae\\_story.html?utm\\_term=.12778fed9821](https://www.washingtonpost.com/world/indian-telecom-regulator-bans-facebooks-free-internet-for-the-poor/2016/02/08/561fc6a7-e87d-429d-ab62-7cdec43f60ae_story.html?utm_term=.12778fed9821).

ISP incentives to offer sponsored data options?

In attempt to answer the questions above, we set up a model in which a monopolistic ISP offers consumers a three-part tariff consisting of a hookup fee  $H$ , data cap  $L$ , and linear data overage charge  $\tau$ , and where two asymmetric CPs sell content to consumers. CPs are asymmetric in terms of the content quality that they provide. CP content is substitutable to some degree. We characterize and compare the set of equilibria when zero-rating is banned as well as when it is permitted with and without monetary transfers. There are two conflicting effects of zero-rating on the ISP's profit, one operating through the hookup fee, the other through the overage charge. Moreover, for each CP, zero-rating not only directly affects content demand, but also indirectly influences demand by affecting the content price. The aggregate effect of zero-rating on both of ISP's and CPs' profits depends on content quality and the degree of content substitutability.

Suppose first that CPs cannot offer monetary transfers for zero-rating. Then, the ISP zero-rates the lower quality CP to take advantage of a higher overage charge for higher quality content. Also, a zero-rating equilibrium emerges under a sufficiently large level of substitutability. The intuition for this result is as follows. If the ISP zero-rates any content if CP content is highly differentiated (low level of substitutability), the loss to ISP from an overage charge that could be charged on low quality content is relatively large: there are distinct demands for both content regardless of content quality. Consequently, the ISP chooses not to zero-rate to take advantage of consumers' relatively inelastic demand if both CPs' content is relatively independent.

If instead, CPs must pay to be zero-rated — i.e. sponsored data programs—, both CPs end up being zero-rated in equilibrium, which we call as full zero-rating in the paper. If content is sufficiently differentiated, both CPs always pay a positive fee for zero-rating, which increases ISP's incentive to lead to full zero-rating. As both CPs' content becomes more substitutable, however, the low quality CP has no incentive to pay a positive fee for full zero-rating. For this high range of substitutability, ISP rather pays a positive subsidy to the low quality CP to have full zero-rating because the fee obtained from the high quality CP is large enough to offset the subsidy paid to the low quality CP.

In Section 5, we permit the ISP platform to integrate with one of the CPs. The ISP has an incentive to vertically integrate with the high quality CP. That is because integration with

the high quality CP and zero-rating its content lead to greater additional profit from selling content. Moreover, without a monetary transfer, the integrated firm only wants to zero-rate its affiliated content while it optimally does not zero-rate the rival’s content in an attempt to vertically foreclose its rival. However, if there is a monetary transfer, full zero-rating can emerge in equilibrium if content is sufficiently differentiated. Thus, as long as there is a monetary transfer for zero-rating, forming a vertical integration does not exclude full zero-rating. Still, the low quality CP can be worse off from the vertical integration because it deprives him of the chance to be zero-rated if not paying for zero-rating.

Finally, we find that full zero-rating is likely to attain the highest level of social welfare because the sum of CPs’ profits under full zero-rating is large enough to offset any possible loss to the ISP from full zero-rating. Thus, zero-rating with monetary transfers (sponsored data plan) is welfare-enhancing relative to zero-rating without monetary transfers because the latter does not induce full zero rating. Also, vertical integration is welfare-enhancing than no integration but this result comes at the expense of the unaffiliated CP which loses market share and profit due to the vertical integration and the consequential no zero-rating offer.

The rest of the paper is organized as follows. In Section 2 introduces the relevant literature. Section 3 provides the basic model setup. Section 4 and 5 solve the game for no vertical integration and vertical integration, respectively. In Section 6, welfare implications are drawn, and the conclusion follows in Section 7.

## 2 Literature

Our model setup leans heavily on the framework of Economides and Hermalin (2015), who analyze a monopoly ISP that can impose download limits on rival CPs. Economides and Hermalin show that these limits can place downward pressure on CP prices, permitting ISPs to profit from an increase in demand.<sup>8</sup> Using a variant of the model of Economides and Hermalin (2015) in which content is *ex ante* substitutable (to account for limits on consumers’ time that

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<sup>8</sup>Downward pricing pressure occurs through one of two mechanisms. First, if caps are binding, then the more binding, the more consumers will perceive the digital products they acquire from different content providers (CPs) as substitutes. This, in turn will increase the competitive pressures on the CPs, who will respond by lowering their prices. Alternatively, if download limits can be exceeded by paying an overage fee, a positive per-unit fee acts like an excise tax that falls on consumers, but whose incidence is split between consumers and CPs.

can be devoted to content) we investigate when an ISP might wish to relax download limits. As in Economides and Hermalin (2015), an overage charge leads to lowering content subscription fees. That is, zero-rating that sets zero overage charge allows the ISP to fine-tune how it wants different CPs to behave by adjusting its pricing to consumers. Note that this allows the ISP to discriminate among different CPs without actually charging the CPs different prices for termination.

To our knowledge, there are presently two other working papers, Jullien and Sand-Zantman (2016) and Somogyi (2017), that use economic models of two-sided markets to analyze zero-rating.<sup>9</sup> Both Jullien and Sand-Zantman (2016) and Somogyi (2017) model an ISP that intermediates traffic between consumers and CPs who receive benefits proportional to consumer traffic, but do not charge a retail price for content. Jullien and Sand-Zantman (2016) show that in the absence of regulation, the ISP can use sponsored data to improve efficiency by facilitating the transmission of information between CPs and consumers. In equilibrium, CPs that derive greater benefits from being on the network will sponsor consumption while other providers will reduce their costs by letting consumers pay for traffic. Nevertheless, this mechanism results in socially suboptimal consumption levels because the ISP charges excessive prices to CPs.

As we do, Somogyi (2017) models zero-rating more explicitly than Jullien and Sand-Zantman (2016), by viewing it as a three-part tariff.<sup>10</sup> Somogyi finds that zero-rating is an optimal ISP strategy when CP revenue per click is relatively large, whereas the ISP subscription fee is relatively small.<sup>11</sup> Specifically, in his model, when it is optimal to do so, the ISP trades off serving a greater number of consumers by zero-rating the CP that can extract a higher amount of revenue per click in order to extract revenue from that CP directly. Zero-rating can improve (worsen) consumer surplus and social welfare if content is relatively attractive (unattractive).

Our model differs from both those of Jullien and Sand-Zantman (2016) and Somogyi (2017) along a number of important dimensions. First, in contrast to Jullien and Sand-Zantman (2016),

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<sup>9</sup>Additionally, Koning and Yankelevich (2017) briefly analyze zero-rating using a standard model of vertically integrated firms who supply their rivals.

<sup>10</sup>Broadly speaking, three-part tariffs differ from two-part tariffs in that the former additionally offer allowances of free units of the service. Working outside the two-sided market setting explored in this manuscript, Ascaria, Lambrecht, and Vilcassim (2012) empirically study how three-part tariffs affect customer service usage, Chao (2013) theoretically investigates why they may be offered by a dominant firm in an oligopoly setting, Bagh and Bhargava (2013) find that they can be preferable to more complex menus of two-part tariffs, and Fibich et al. (2015) show how to derive an optimal three-part tariff under general conditions.

<sup>11</sup>Both the revenue per click and subscription fee are exogenous in the most recent version of the working paper.

who view content as non-rival and Somogyi (2017), who views it as perfectly substitutable,<sup>12</sup> we view CPs as offering imperfectly substitutable content. Aside from being realistic—many rival CPs offer both exclusive and duplicative content—this allows us to examine how the level of content differentiation influences the desirability and optimality of zero-rating. Second, following Economides and Hermalin (2015), we suppose that CPs can charge consumers directly. Although we acknowledge that there is a significant amount of content available to consumers for free, this modeling choice permits us to focus on major providers of streaming services and to also account for the important case of cable ISPs who set data caps. Third, we distinguish between zero-rating programs with and without monetary transfers to the ISP, allowing us to account for the incremental impact of sponsored data on incentives and welfare. Finally, in our manuscript, we extend our results to a scenario where the ISP can vertically integrate into content provision in order to study how zero-rating could be used as a means of vertical foreclosure.<sup>13</sup>

Aside from being broadly related to the theoretical literature on pricing in multi-sided markets (Armstrong 2006; Rochet and Tirole 2003, 2006; Rysman 2009, Weyl 2010), the analysis in this manuscript is closely related to the study of net neutrality. The static and dynamic impact of violations of net neutrality—simply put, a ban on discrimination at the point where content terminates—has been shown to vary widely according to the framework under analysis (i.e., the means of modeling prioritization, the level of ISP competition, etc.). For example, Economides and Hermalin (2012) show that price discrimination via paid prioritization diminishes welfare if it diminishes content diversity while Choi and Kim (2010) and Cheng, Bandyopadhyay, Guo (2011) show that prioritization could incentivize ISPs to keep network capacity scarce. Conversely, paid prioritization has been shown to lead to higher broadband investment and increased diversity of content (Krämer and Wiewiorra 2012; Bourreau, Kourandi, Valletti 2015).<sup>14</sup>

As we have already pointed out, paid prioritization differs from zero-rating from both a technical/economic perspective and a legal one. The central technical distinction is that paid

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<sup>12</sup>More accurately, in Somogyi (2017), the content of CPs who can be zero-rated is perfectly substitutable.

<sup>13</sup>This is the aspect of zero-rating that Koning and Yankelevich (2017) are also interested in, though in that paper, the authors' do not account for the two-sided nature of the market of interest.

<sup>14</sup>Moreover, a number of authors have explored the welfare “neutrality” of net neutrality (Gans 2015; Gans and Katz 2016; Greenstein, Peitz, and Valletti 2016).

prioritization permits an ISP to offer different service quality tiers to different CPs, whereas zero-rating operates via the opposite end of the market, by presenting consumers with a clear pricing distinction between different CPs. Besides having the potential to lead to quantitatively different outcomes, this distinction has clearly been scrutinized by regulators who have made different determinations with regard to whether or not zero-rating violates net neutrality.

### 3 Model

Assume that there are two content providers (CPs) and one Internet service provider (ISP). As in Economides and Hermalin (2015), the monopolistic ISP has a network bandwidth of  $B$ . Given that a consumer has decided to connect to the platform, she chooses the amount of content to purchase from each CP. The content provided by two CPs may be substitutes or independent goods to each other with the degree of content substitutability of  $\gamma$ . Assuming that there is a unit mass of consumer, the utility for each consumer is defined by a variation of typical quadratic utility function and the utility specification in Economides and Hermalin (2015).

$$u_i = [\alpha_1 x_1 - \frac{1}{2} \delta(X|B) x_1^2 - \frac{\gamma}{2} x_1 x_2 + \alpha_2 x_2 - \frac{1}{2} \delta(X|B) x_2^2 - \frac{\gamma}{2} x_1 x_2] - H - \sum_{n=1}^2 p_n x_n - \tau \max\{0, -L + \sum_{n=1}^2 x_n \mathbb{1}_n\}, \quad (1)$$

where  $\alpha_n$  denotes content quality provided by  $CP_n$ ,  $x_n$  is the amount of content provided by  $CP_n$ ,  $\delta(X|B)$  is the level of congestion which is a function of total content purchased ( $X$ ) given the platform's bandwidth ( $B$ ),  $\gamma$  is the degree of content substitutability,  $H$  is a hookup fee charged by the ISP,  $p_n$  is a content  $n$ 's subscription fee,  $\tau$  is a per unit overage charge set by the ISP,  $L$  is a data cap also set by the ISP, and  $\mathbb{1}_n$  is 1 if  $CP_n$  is not zero-rated and is 0 if zero-rated.

The ISP chooses a hookup fee  $H$ , a data cap  $L$ , and an overage charge  $\tau$ . With this three-part tariff pricing scheme, an overage charge is only applied to any excess usage beyond the cap  $L$ . However, if  $L$  is set to be zero, which means that there is no free data allowance in a certain monthly plan, the pricing scheme is collapsed to a typical two-part tariff and  $\tau$  means a per unit data charge rather than an overage charge. On top of that, the ISP needs to decide



whether and to which CPs to offer a zero-rating deal.

Each CP here decides whether to accept ISP's zero-rating offer if any. If it accepts the offer, the overage charge  $\tau$  is exempted for his content. Then, CPs set their optimal content prices by solving profit maximization problems. We assume zero marginal costs for providing content. In the next section, we describe important assumptions which we impose throughout the paper.

### 3.1 Assumptions

For simplicity, we normalize  $\alpha_2$  to one and denote  $\alpha_1$  as  $\alpha$  for the rest of paper. Also, we further assume that  $1 \leq \alpha \leq 2$  is assumed. The condition implies that the quality of  $CP_1$ 's content is much higher than that of  $CP_2$ 's content. By assuming asymmetric CPs, we can see that on what grounds the ISP wants to make a deal with either one of the CPs.

Also, we limit our attention to the case of  $L \leq \sum_{n=1}^2 x_n \mathbb{1}_n$  which implies that consumers overuse data beyond a data cap the ISP sets because our main interest is to see the effect of overage charges. Note that if  $L$  is equal to zero, this condition is always satisfied with any positive  $x_n$ . For simplicity, we assume that  $L = 0$  throughout the analysis.

On top of that, there is a restriction on  $\gamma$  which guarantees the interior solutions for both CPs to have positive market shares. For the interior solution assumption, we need an assumption that  $\gamma < \tilde{\gamma}$ . The thresholds can be derived later after the equilibrium is obtained.

Last, the equilibrium is derived under the assumption of  $\delta(X|B) = 1$ , which means no congestion. No congestion assumption is reasonable in some senses as for low levels of total content consumption, it might be possible that there is no congestion.<sup>15</sup>

## 4 No vertical integration

In this section, we first analyze the equilibrium under no vertical integration. Various cases which we consider are (1) no zero-rated content, (2) zero-rated content without monetary transfer, and (3) zero-rated with a monetary transfer. In all cases, the ISP's market is assumed to be fully covered, so that the ISP extracts everything from consumers.

The timing of the game is as follows. The ISP first announces its policies regarding to which

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<sup>15</sup>Economides and Hermalin(2015) also mention this in their paper.

CP(s) it offers a zero-rating deal and sets a data cap  $L$  which is assumed to be zero. Then, it also sets prices which are a hookup fee and an overage charge. After that, CPs decide whether to accept ISP's zero-rating offer if there is an offer and announce per unit content subscription fees. Last, consumers decide how much content to subscribe to each CP. The equilibrium concept is the subgame perfect equilibrium which is derived by backward induction.

#### 4.1 No zero-rated content

In this section, let's derive the equilibrium for no zero-rating case by backward induction. At the last stage, consumer decides  $x_n$  by solving the utility maximization problem with respect to each  $x_n$ . The resulting  $x_n$  for each  $CP_n$  is as follows.

$$x_1 = \frac{\alpha - p_1 - \gamma(1 - p_2) - \tau(1 - \gamma)}{1 - \gamma^2}; \quad x_2 = \frac{1 - p_2 - \gamma(\alpha - p_1) - \tau(1 - \gamma)}{1 - \gamma^2}. \quad (2)$$

Given this, each CP solves profit maximization problem to obtain the equilibrium prices as follows.

$$p_1 = \frac{\gamma + \alpha(\gamma^2 - 2) - (\gamma^2 + \gamma - 2)\tau}{\gamma^2 - 4}; \quad p_2 = \frac{\gamma\alpha + (\gamma^2 - 2) - (\gamma^2 + \gamma - 2)\tau}{\gamma^2 - 4}. \quad (3)$$

This leads to the equilibrium market share for each CP is given by

$$x_1 = \frac{\alpha(2 - \gamma^2) - \gamma + (\gamma^2 + \gamma - 2)\tau}{(\gamma^2 - 4)(\gamma^2 - 1)}; \quad x_2 = \frac{(2 - \gamma^2) - \gamma\alpha + (\gamma^2 + \gamma - 2)\tau}{(\gamma^2 - 4)(\gamma^2 - 1)}. \quad (4)$$

Given each CP's price and market share, the ISP sets a hookup fee, an overage charge, and a data cap. First, since the ISP's market is fully covered, it sets a hookup fee at the level which can extract all consumer surplus. That means,

$$H = \frac{(\alpha^2 + 1)(3\gamma^2 - 4) + 2\alpha\gamma^3 - 2\tau(\gamma + 2)^2(\gamma - 1)(\alpha + 1) + 2\tau^2(2 + \gamma)^2(\gamma - 1)}{2(\gamma^2 - 4)^2(\gamma^2 - 1)}. \quad (5)$$

Then, the profit for ISP is given by

$$\pi_{ISP} = \frac{(\alpha^2 + 1)(3\gamma^2 - 4) + 2\alpha\gamma^3 - 2(\gamma^2 + \gamma - 2)^2\tau(\alpha + 1) + 2(\gamma - 1)(\gamma + 2)^2(2\gamma - 3)\tau^2}{2(\gamma^2 - 4)^2(\gamma^2 - 1)}. \quad (6)$$

The optimal  $\tau$  can be obtained by solving profit maximization problem with respect to  $\tau$ . The set of equilibrium can be derived as follows.

$$\begin{aligned} \tau &= \frac{(\alpha + 1)(1 - \gamma)}{6 - 4\gamma} \\ H &= \frac{(\alpha^2 + 1)(-3\gamma^3 + 11\gamma^2 + 3\gamma - 13) + 2\alpha(5\gamma^3 - 5\gamma^2 - 3\gamma + 5)}{4(\gamma^2 - 1)(2\gamma^2 + \gamma - 6)^2} \\ \pi_{ISP}^{NZ} &= \frac{(\alpha^2 + 1)(7 + \gamma - 5\gamma^2 - \gamma^3) - 2\alpha(-1 + \gamma + \gamma^2 + \gamma^3)}{4(\gamma^2 - 1)(\gamma + 2)^2(2\gamma - 3)} \\ p_1 &= \frac{\alpha(3\gamma^2 - 5) - (\gamma^2 - 2\gamma - 1)}{2(2\gamma^2 + \gamma - 6)}; \quad p_2 = \frac{(3\gamma^2 - 5) - \alpha(\gamma^2 - 2\gamma - 1)}{2(2\gamma^2 + \gamma - 6)} \\ x_1 &= \frac{\alpha(5 - 3\gamma^2) + (\gamma^2 - 2\gamma - 1)}{2(2 + \gamma)(-3 + 2\gamma)(-1 + \gamma^2)}; \quad x_2 = \frac{(5 - 3\gamma^2) + \alpha(\gamma^2 - 2\gamma - 1)}{2(2 + \gamma)(-3 + 2\gamma)(-1 + \gamma^2)}. \end{aligned} \quad (7)$$

Since  $\alpha \geq 1$  is assumed, the demand for content is weighted towards  $CP_1$  from a certain level of  $\gamma$ . As  $\gamma$  increases, which means that content becomes more substitutable, consumers choose only one of the types of content. So, there is a threshold of  $\gamma$  above which  $p_2$  becomes zero, otherwise consumers would not choose  $CP_2$ 's content at all. It is easy to see that this threshold which guarantees interior solutions under no zero-rating is derived as follows.

$$x_2 > 0 \iff \gamma < \frac{\alpha - \sqrt{2\alpha^2 - 8\alpha + 15}}{\alpha - 3} \equiv \tilde{\gamma}_{NZ}, \quad (8)$$

where the subscript  $NZ$  denotes no zero-rating. This interior solution condition on  $\gamma$  is assumed to be satisfied throughout the paper.<sup>16</sup>

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<sup>16</sup>Assuming that  $\alpha = 2$ ,  $\tilde{\gamma}_{NZ} \approx 0.645751$

## 4.2 Zero rated content without monetary transfer

### 4.2.1 Partial zero-rated content

In this section, let's consider the case that the ISP makes a zero-rating deal with one of the CPs but without any monetary transfer for zero-rating. First, consider the case in which the ISP makes a deal with  $CP_1$ . Then, the market share for each CP derived from consumer's utility maximization problem is given by

$$x_1 = \frac{\alpha - p_1 - \gamma(1 - p_2) + \gamma\tau}{1 - \gamma^2}; \quad x_2 = \frac{1 - p_2 - \gamma(\alpha - p_1) - \tau}{1 - \gamma^2}. \quad (9)$$

Also, by solving CP's profit maximization problem, we can obtain the following optimal price.

$$p_1 = \frac{\alpha(\gamma^2 - 2) + \gamma - \tau\gamma}{\gamma^2 - 4}; \quad p_2 = \frac{\gamma\alpha + (\gamma^2 - 2) - \tau(\gamma^2 - 2)}{\gamma^2 - 4}. \quad (10)$$

The set of equilibrium is given by as follows.<sup>17</sup>

$$\begin{aligned} \tau &= \frac{2\alpha\gamma(\gamma^2 - 2) + (4 - 3\gamma^2 + \gamma^4)}{12 - 9\gamma^2 + 2\gamma^4} \\ H &= \frac{\alpha^2(-36 + 59\gamma - 28\gamma^4 + 4\gamma^6) + 2\alpha\gamma(-8 + 18\gamma^2 - 11\gamma^4 + 2\gamma^6) + (3\gamma^2 - 4)(\gamma^2 - 2)^2}{2(\gamma^2 - 1)(12 - 9\gamma^2 + 2\gamma^4)^2} \\ \pi_{ISP}^{ZR_1} &= \frac{\alpha^2(2\gamma^2 - 3) + 2\alpha\gamma - (\gamma^2 - 2)^2}{2(\gamma^2 - 1)(12 - 9\gamma^2 + 2\gamma^4)} \\ p_1 &= \frac{(\gamma^2 - 2)(\alpha(2\gamma^2 - 3) + \gamma)}{12 - 9\gamma^2 + 2\gamma^4}; \quad p_2 = \frac{-\alpha\gamma + (\gamma^2 - 2)^2}{12 - 9\gamma^2 + 2\gamma^4} \\ x_1 &= \frac{(\gamma^2 - 2)(\alpha(2\gamma^2 - 3) + \gamma)}{(1 - \gamma^2)(12 - 9\gamma^2 + 2\gamma^4)}; \quad x_2 = \frac{-\alpha\gamma + (\gamma^2 - 2)^2}{(1 - \gamma^2)(12 - 9\gamma^2 + 2\gamma^4)}. \end{aligned} \quad (11)$$

For interior solution, we need the assumption on  $\gamma$  which guarantees positive  $p_2$  and  $x_2$ . Let's denote this threshold for zero-rating with  $CP_1$  case as  $\tilde{\gamma}_{ZR_1}$ . Thus, for  $\gamma < \tilde{\gamma}_{ZR_1}$ , there are interior solutions.<sup>18</sup>

<sup>17</sup>As in no zero-rating case, let's fix  $L$  at zero, which means full data cap.

<sup>18</sup>Assuming that  $\alpha = 2$ ,  $\tilde{\gamma}_{ZR_1} \approx 0.839287$ .

Similarly, the set of equilibrium when the ISP makes a deal with  $CP_2$  is given by as follows.

$$\begin{aligned}
\tau &= \frac{2\gamma(\gamma^2 - 2) + \alpha(4 - 3\gamma^2 + \gamma^4)}{12 - 9\gamma^2 + 2\gamma^4} \\
H &= \frac{(-36 + 59\gamma - 28\gamma^4 + 4\gamma^6) + 2\alpha\gamma(-8 + 18\gamma^2 - 11\gamma^4 + 2\gamma^6) + \alpha^2(3\gamma^2 - 4)(\gamma^2 - 2)^2}{2(\gamma^2 - 1)(12 - 9\gamma^2 + 2\gamma^4)^2} \\
\pi_{ISP}^{ZR_2} &= \frac{(2\gamma^2 - 3) + 2\alpha\gamma - \alpha^2(\gamma^2 - 2)^2}{2(\gamma^2 - 1)(12 - 9\gamma^2 + 2\gamma^4)} \\
p_1 &= \frac{-\gamma + \alpha(\gamma^2 - 2)^2}{12 - 9\gamma^2 + 2\gamma^4}; \quad p_2 = \frac{(\gamma^2 - 2)((2\gamma^2 - 3) + \alpha\gamma)}{12 - 9\gamma^2 + 2\gamma^4} \\
x_1 &= \frac{-\gamma + \alpha(\gamma^2 - 2)^2}{(1 - \gamma^2)(12 - 9\gamma^2 + 2\gamma^4)}; \quad x_2 = \frac{(\gamma^2 - 2)((2\gamma^2 - 3) + \alpha\gamma)}{(1 - \gamma^2)(12 - 9\gamma^2 + 2\gamma^4)}.
\end{aligned} \tag{12}$$

As above, for interior solution, we assume that  $\gamma < \tilde{\gamma}_{ZR_2} \equiv \frac{\sqrt{\alpha^2 + 24} - \alpha}{4}$ .<sup>19</sup>

#### 4.2.2 Full zero-rated content

In this section, we consider the case of full zero-rating, which means that the ISP zero-rates all content provided by both CPs. Under full zero-rating, the market share for each CP derived from consumer's utility maximization problem is given by

$$x_1 = \frac{\gamma - \alpha - \gamma p_2 + p_1}{\gamma^2 - 1}; \quad x_2 = \frac{\alpha\gamma - 1 - \gamma p_1 + p_2}{\gamma^2 - 1}. \tag{13}$$

By solving CP's profit maximization problem, we can obtain the following optimal price.

$$p_1 = \frac{\alpha(\gamma^2 - 2) + \gamma}{\gamma^2 - 4}; \quad p_2 = \frac{(\gamma^2 - 2) + \alpha\gamma}{\gamma^2 - 4}. \tag{14}$$

By the same logic as in no zero-rating content case, the set of equilibrium is given by as follows.<sup>20</sup>

$$\begin{aligned}
H &= \pi_{ISP}^{FZ} = \frac{2\alpha\gamma^3 + (\alpha^2 + 1)(3\gamma^2 - 4)}{2(\gamma^2 - 4)^2(\gamma^2 - 1)} \\
p_1 &= \frac{\alpha(\gamma^2 - 2) + \gamma}{\gamma^2 - 4}; \quad p_2 = \frac{(\gamma^2 - 2) + \alpha\gamma}{\gamma^2 - 4} \\
x_1 &= -\frac{\alpha(\gamma^2 - 2) + \gamma}{\gamma^4 - 5\gamma^2 + 4}; \quad x_2 = -\frac{(\gamma^2 - 2) + \alpha\gamma}{\gamma^4 - 5\gamma^2 + 4}.
\end{aligned} \tag{15}$$

<sup>19</sup>Assuming that  $\alpha = 2$ ,  $\tilde{\gamma}_{ZR_2} \approx 0.822876$

<sup>20</sup>As in no zero-rating case, let's fix  $L$  at zero, which means full data cap.

For interior solution, we assume that  $\gamma < \tilde{\gamma}_{FZ} = \frac{\sqrt{\alpha^2+8}-\alpha}{2}$ .<sup>21</sup>

### 4.2.3 Equilibrium

To characterize the equilibrium, we first need to see whether the ISP has any incentive to offer zero-rating deals to both CPs, i.e., full zero-rating, by comparing ISP's profit from full zero-rating to that from either no zero-rating or partial zero-rating. After some algebra, it is easy to show that the ISP never wants to fully zero-rate all content from both CPs if there is no monetary transfer for zero-rating. This suggests that either partial zero-rating or no zero-rating emerges in equilibrium.

Now let's see to which CP the ISP offers a zero-rating deal and whether the CP accepts the offer or not. First, in order to see whether  $CP_1$  accepts the zero-rating offer, we need to compare  $CP_1$ 's profits with and without zero-rating. In other words, the following condition needs to be satisfied for  $CP_1$  to accept the offer.

$$\pi_1^{NZ} = \frac{(\alpha(5 - 3\gamma^2) + (\gamma^2 - 2\gamma - 1))^2}{4(1 - \gamma^2)(2\gamma^2 + \gamma - 6)^2} \leq \frac{(-2 + \gamma^2)^2(\alpha(2\gamma^2 - 3) + \gamma)^2}{(1 - \gamma^2)(12 - 9\gamma^2 + 2\gamma^4)^2} = \pi_1^{ZR_1}. \quad (16)$$

Although there is no closed form solution to  $\gamma$  which satisfies the above inequality, there is a condition on  $\gamma$  which guarantees that  $CP_1$  obtains greater profit from zero-rating. For example, under the assumption of  $\alpha = 2$ , Figure 1 shows that  $CP_1$  always accepts the offer if the assumption for an interior solution on  $\gamma$  is satisfied. By the similar logic, Figure 2 shows that  $CP_2$  always accepts the offer under the interior solution assumption. In other words, CPs have higher incentive to accept ISP's zero-rating offer if their content is independent of each other to some extent.

Given that CPs accept the offer, which means that  $\gamma < \tilde{\gamma}_{ZR_2}$ , it remains to show to which CP that the ISP offers zero-rating.

$$\pi_{ISP}^{ZR_1} - \pi_{ISP}^{ZR_2} = \frac{(\alpha^2 - 1)(\gamma^2 - 1)}{(24 - 18\gamma^2 + 4\gamma^4)} < 0 \quad \because \alpha \geq 1. \quad (17)$$

Thus, if the ISP chooses only one of the CPs for zero-rating without any monetary transfer, he chooses  $CP_2$  regardless of  $\gamma$ .

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<sup>21</sup>Under  $\alpha = 2$ ,  $\tilde{\gamma}_{FZ} \approx 0.732051$ .

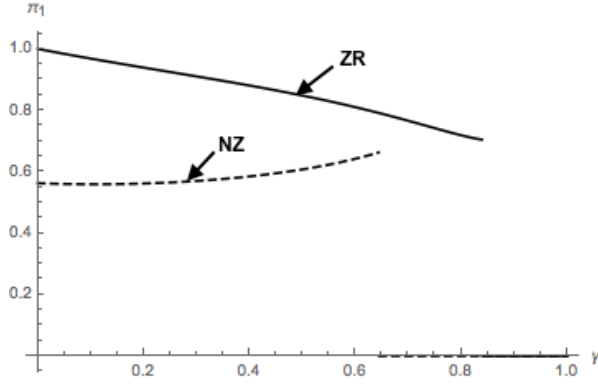


Figure 1:  $CP_1$ 's profits as a function of  $\gamma$  under  $\alpha = 2$

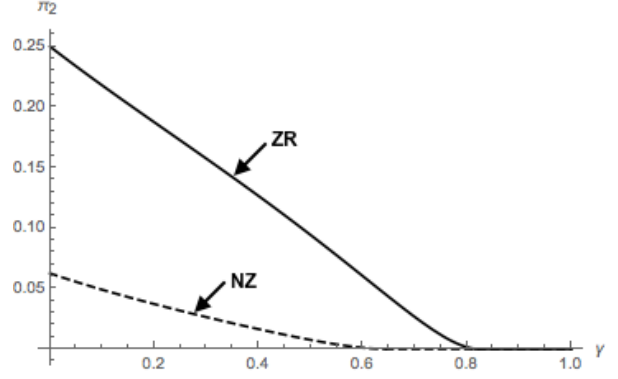


Figure 2:  $CP_2$ 's profits as a function of  $\gamma$  under  $\alpha = 2$

Last, given that the ISP offers a deal with  $CP_2$  and  $CP_2$  accepts it, i.e.,  $\gamma$  is sufficiently small, let's see whether it has an incentive to make the offer in the first place by comparing ISP's profit under no zero-rating to that under zero-rating with  $CP_2$ .

After some algebra, we can see that  $\pi_{ISP}^{ZR_2} < \pi_{ISP}^{NZ}$  if  $\gamma$  is sufficiently small whereas  $\pi_{ISP}^{ZR_2} > \pi_{ISP}^{NZ}$  if  $\gamma$  is large enough. Thus, the ISP offers a zero-rating deal only when content is sufficiently substitutable. Proposition 1 summarizes this finding.<sup>22</sup>

**Proposition 1.** *When there is no monetary transfer for zero-rating, the ISP offers zero-rated service to a content provider whose quality of content is lower if content is sufficiently substitutable ( $\gamma > \gamma_I$ ). The low quality CP always wants to accept the offer under the interior solution assumption on  $\gamma$ ,  $\gamma < \tilde{\gamma}_{ZR_2}$ . Thus, zero-rating with low quality  $CP_2$  occurs for  $\gamma \in (\gamma_I, \tilde{\gamma}_{ZR_2})$ .*

Here is the intuition for this finding. Given that the ISP zero-rates  $CP_2$ 's content, ISP's total profit is the sum of the hookup fee which depends on total content demand,  $x_1 + x_2$ , and overage charge from  $x_1$  only. If  $\gamma < \gamma_I$ , there are distinct demands for both content because it is sufficiently differentiated, which means that even  $CP_2$  whose content is lower quality has relatively large demand. Then, the profit loss to the ISP from overage charge that would be paid by  $CP_2$ 's subscribers under no zero-rating,  $\tau x_2$ , is large in this range of  $\gamma$ , therefore, the ISP does not offer zero-rating in the first place. Consequently, it chooses not to zero-rate to take advantage of consumers' relatively inelastic demand if both CPs' content is relatively independent.

<sup>22</sup>Under the same numerical example of  $\alpha = 2$ , the relevant thresholds on  $\gamma$  which constitutes Proposition 1 are as follows:  $\gamma_I = 0.237235$  and  $\tilde{\gamma}_{ZR_2} = 0.822876$

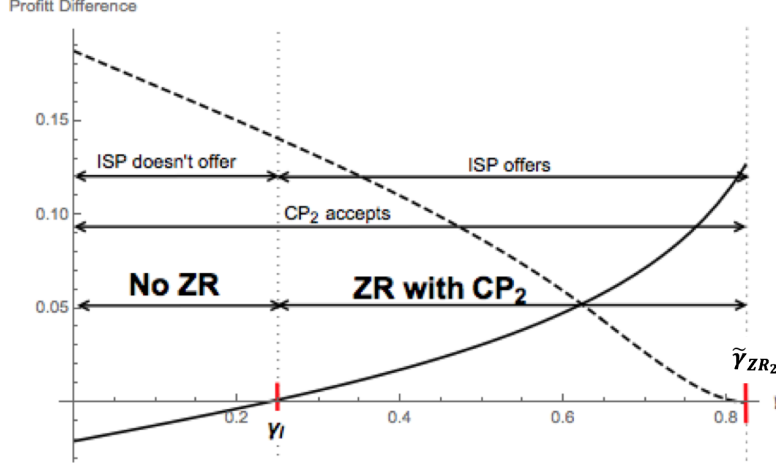


Figure 3: Solid line is  $\pi_{ISP}^{ZR_2} - \pi_{ISP}^{NZ}$  and dashed line is  $\pi_2^{ZR_2} - \pi_2^{NZ}$  when  $\alpha=2$

### 4.3 Zero-rated content with monetary transfer (Sponsored Data)

Here, let's assume that CPs need to pay a fixed fee to be zero-rated. Assume that the ISP makes a take-it-or-leave-it-offer to CPs and  $\gamma$  is small enough for CPs to accept the ISP's offer. Table 1 represents each CP's profit.

Table 1: CP's Equilibrium Profits

	Accept	Reject
Accept	$\frac{-(\alpha(\gamma^2-2)+\gamma)^2}{(\gamma^2-4)^2(\gamma^2-1)} - r_1^{FZ}, \frac{-((\gamma^2-2)+\alpha\gamma)^2}{(\gamma^2-4)^2(\gamma^2-1)} - r_2^{FZ}$	$\frac{-(\gamma^2-2)^2(\alpha(2\gamma^2-3)+\gamma)^2}{(\gamma^2-1)(2\gamma^4-9\gamma^2+12)^2} - r_1^{PZ}, -\frac{(\alpha\gamma-(\gamma^2-2)^2)^2}{(\gamma^2-1)(2\gamma^4-9\gamma^2+12)^2}$
Reject	$\frac{-(\alpha(\gamma^2-2)^2-\gamma)^2}{(\gamma^2-1)(2\gamma^4-9\gamma^2+12)^2}, \frac{-(\gamma^2-2)^2((2\gamma^2-3)+\alpha\gamma)^2}{(\gamma^2-1)(2\gamma^4-9\gamma^2+12)^2} - r_2^{PZ}$	$\frac{-(\alpha(3\gamma^2-5)+(1-(\gamma-2)\gamma))}{4(\gamma^2-1)(2\gamma^2+\gamma-6)^2}, \frac{-((5-3\gamma^2)+\alpha((\gamma-2)\gamma-1))^2}{4(\gamma^2-1)(2\gamma^2+\gamma-6)^2}$

There can be two different levels of equilibrium fees depending on rival's decision: the fee in which the rival also accepts zero-rating offer is different from that in which the rival rejects the offer. The superscripts  $FZ$  and  $PZ$  denote Full Zero-rating and Partial Zero-rating, respectively.



### 4.3.1 Partial zero-rated content

If the ISP zero-rates only one of the CP's content, the fixed fee  $r$  should be small enough as follows.

$$\begin{aligned} r_1^{PZ} \leq \pi_1^{ZR_1} - \pi_1^{NZ} &= -\frac{(\gamma^2 - 2)^2 (\alpha (2\gamma^2 - 3) + \gamma)}{(\gamma^2 - 1) (2\gamma^4 - 9\gamma^2 + 12)^2} + \frac{(\alpha (3\gamma^2 - 5) + (1 - (\gamma - 2)\gamma))}{4 (\gamma^2 - 1) (2\gamma^2 + \gamma - 6)^2} \\ r_2^{PZ} \leq \pi_2^{ZR_2} - \pi_2^{NZ} &= -\frac{(\gamma^2 - 2)^2 ((2\gamma^2 - 3) + \alpha\gamma)}{(\gamma^2 - 1) (2\gamma^4 - 9\gamma^2 + 12)^2} + \frac{((5 - 3\gamma^2) + \alpha((\gamma - 2)\gamma - 1))}{4 (\gamma^2 - 1) (2\gamma^2 + \gamma - 6)^2}. \end{aligned} \quad (18)$$

Given that the reference point for each CP to decide whether to accept the offer or not is its profit from no zero-rating, we assume that the interior solution on  $\gamma$  for no zero-rating ( $\gamma < \tilde{\gamma}_{NZ}$ ) is satisfied. Assuming that CPs accept the offer, it remains to show to which CP the ISP makes the offer. To check this, let's compare ISP's profit under zero-rating with  $CP_1$  to that under zero-rating with  $CP_2$ . For notational convenience, we denote  $\hat{\pi}$  for profits with monetary transfer.

$$\hat{\pi}_{ISP}^{ZR_1} - \hat{\pi}_{ISP}^{ZR_2} = -\frac{(\alpha^2 - 1) (\gamma - 2)(\gamma + 1)(2\gamma + 3) (\gamma ((2\gamma(\gamma + 1) - 15)\gamma^2 + \gamma + 24) - 12)}{2 (2\gamma^2 + \gamma - 6) (2\gamma^4 - 9\gamma^2 + 12)^2}. \quad (19)$$

We can find that  $\hat{\pi}_{ISP}^{ZR_1} - \hat{\pi}_{ISP}^{ZR_2}$  is greater than zero if  $\gamma$  is small while the reverse holds otherwise. Thus, as content becomes less substitutable, the ISP has more incentive to make a deal with  $CP_1$ . In other words, unlike the case of no monetary transfer for zero-rating, the ISP offers the deal to  $CP_1$  for a certain range of  $\gamma$  but does the same thing to  $CP_2$  for a different level of  $\gamma$ . Therefore, when there is a monetary transfer for zero-rating, we need to compare all of the following; ISP's profit under no zero-rating, ISP's profit under zero-rating with  $CP_1$  and  $CP_2$ , respectively. As we can see from Figure 4, ISP's profit under no zero-rating is the lowest compared to either partial zero-rating with  $CP_1$  with a monetary transfer or with  $CP_2$ . Between the profit under zero-rating with  $CP_1$  and that under  $CP_2$ , there exists another threshold on  $\gamma$ , denoted as  $\tilde{\gamma}_{PZ}$  such that if  $\gamma < \tilde{\gamma}_{PZ}$ , the ISP offers a deal to  $CP_1$  but offers to  $CP_2$  if  $\gamma > \tilde{\gamma}_{PZ}$ . Proposition 2 summarizes the findings.<sup>23</sup>

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<sup>23</sup> $\tilde{\gamma}_{PZ}$  is the  $\gamma$  satisfying  $\hat{\pi}_{ISP}^{ZR_1} - \hat{\pi}_{ISP}^{ZR_2} = 0$ . Note that  $\tilde{\gamma}_{PZ} < \tilde{\gamma}_{NZ}$  is guaranteed under our assumption on  $\alpha$ .

**Proposition 2.** Assume that there is a monetary transfer between the ISP and CP for zero-rating and the ISP does not offer full zero-rating. There are thresholds on  $\gamma$ ,  $\tilde{\gamma}_{PZ}$ , such that (1) the ISP makes an offer to high quality  $CP_1$  and  $CP_1$  accepts it by paying a positive fee to the ISP for  $0 < \gamma < \tilde{\gamma}_{PZ}$ , and (2) the ISP has an incentive to make a deal with low quality  $CP_2$  and  $CP_2$  accepts it by paying a positive fee to the ISP for  $\tilde{\gamma}_{PZ} < \gamma < \tilde{\gamma}_{NZ}$ .

The intuition behind choosing low quality  $CP_2$  for large  $\gamma$  is similar to why the ISP chooses  $CP_2$  as zero-rating partner without a monetary transfer. If content becomes more substitutable, demand for content shifts toward high quality content, so there will be a greater profit from an overage charge on  $CP_1$ . Thus, the ISP optimally chooses  $CP_2$  and does not zero-rate  $CP_1$ 's content if  $\gamma$  is sufficiently large.

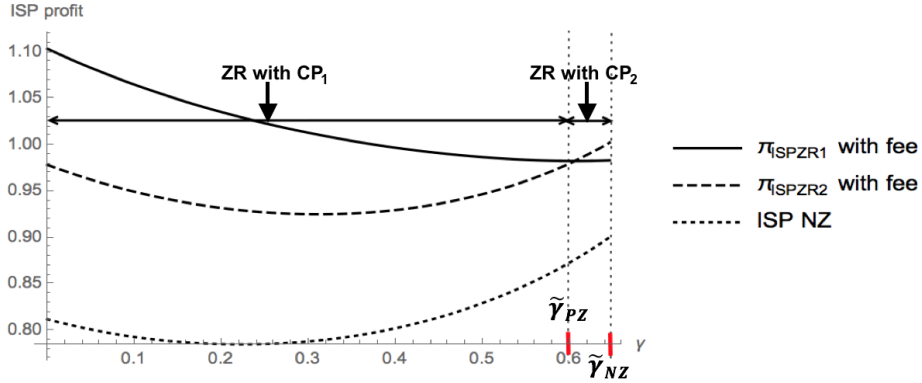


Figure 4: Partial Zero-rating Equilibrium if  $\alpha = 2$

### 4.3.2 Full zero-rated content

First, assuming that the ISP zero-rates both CPs' content, the fixed fee should be determined as follows.

$$\begin{aligned}
 r_1^{FZ} \leq \pi_1^{FZ} - \pi_1^{ZR_2} &= \frac{(\alpha(\gamma^2 - 2)^2 - \gamma)^2}{(\gamma^2 - 1)(2\gamma^4 - 9\gamma^2 + 12)^2} - \frac{(\alpha(\gamma^2 - 2) + \gamma)^2}{(\gamma^2 - 4)^2(\gamma^2 - 1)} \\
 r_2^{FZ} \leq \pi_2^{FZ} - \pi_2^{ZR_1} &= \frac{(\alpha\gamma - (\gamma^2 - 2)^2)^2}{(\gamma^2 - 1)(2\gamma^4 - 9\gamma^2 + 12)^2} - \frac{((\gamma^2 - 2) + \alpha\gamma)^2}{(\gamma^2 - 4)^2(\gamma^2 - 1)}.
 \end{aligned} \tag{20}$$

By the similar logic in the partial zero-rating case, we first need to assume that the interior solution assumption on  $\gamma$  is satisfied. The sufficient condition is  $\gamma < \min\{\tilde{\gamma}_{ZR_1}, \tilde{\gamma}_{ZR_2}\}$ . Under

the assumption, it can be shown that  $r_1^{FZ}$  is always positive whereas  $r_2^{FZ}$  can be negative if  $\gamma$  is sufficiently large. If content is easily substitutable, or less differentiated, more demand shifts toward high quality content, thus, high (low) quality CP charges higher (lower) price for its content. Here, zero-rating softens price competition because it increases product—i.e. content— differentiation. Thus, full zero-rating that symmetrically exempts overage charges on both CPs induces more intense price competition than any asymmetric partial zero-rating such as zero-rating  $CP_1$ 's content only. This implies that low quality content price falls much more in full zero-rating case (with intense price competition) than in partial zero-rating case (with soft price competition). For sufficiently large substitutability levels, the effect of lower price on boosting demand for low quality content is small. Therefore, lowering content price in full zero-rating leads to lower profit for the low quality CP. Because of that, as content becomes more substitutable,  $r_2^{FZ}$  not only decreases but can be negative. For the high quality CP, however, lower content price induces much higher demand, in turn, leads to greater profit, which increases its willingness to pay for full zero-rating. Thus, if both content is sufficiently substitutable, say  $\gamma > \gamma_{Subsidy}$ ,<sup>24</sup> the ISP can extract more rent from  $CP_1$  under full zero-rating because  $CP_1$ 's willingness to pay for full zero-rating ( $r_1^{FZ}$ ) is large enough. Since the ISP wants full zero-rating for sufficiently large  $\gamma$ , it rather pays a positive subsidy to  $CP_2$ . Lemma 1 summarizes the finding. Figure 5 demonstrates different fee levels under  $\alpha = 2$ .

**Lemma 1.** *High quality CP is willing to pay a higher fee for zero-rating if low quality content is zero-rated. However, the low quality CP is willing to pay a higher fee if high quality content is not zero-rated than if it is zero-rated. If content is sufficiently substitutable ( $\gamma > \gamma_{Subsidy}$ ), the ISP needs to pay a positive subsidy to the low quality CP to attain full zero-rating.*

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<sup>24</sup> $\gamma_{Subsidy} = \frac{1}{2} \left( \sqrt{2(\sqrt{\alpha^2 - 1} + \alpha)} \alpha + 7 - \sqrt{\alpha^2 - 1} - \alpha \right)$

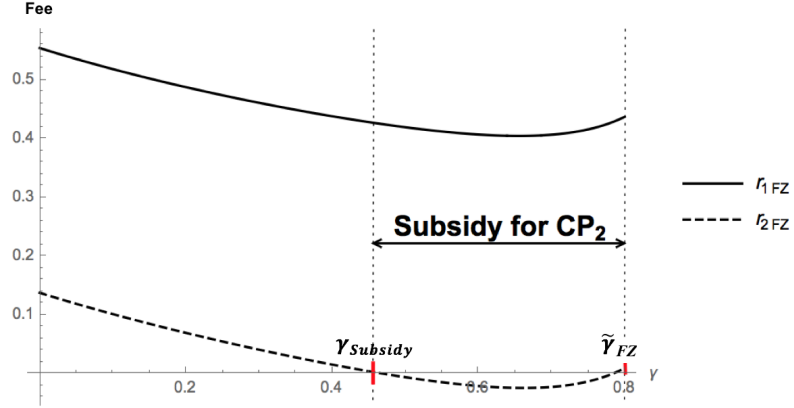


Figure 5: Fixed fee comparison

### 4.3.3 Equilibrium

Let's now see how the ISP makes a decision. Under full zero-rating, ISP's total profit is given as follows.

$$\hat{\pi}_{ISP}^{FZ} = \frac{\frac{3(\alpha^2+1)\gamma^2-4(\alpha^2+1)+2\alpha\gamma^3}{(\gamma^2-4)^2} + 2 \left( \frac{((\gamma^2-2)^2-\alpha\gamma)^2}{(2\gamma^4-9\gamma^2+12)^2} - \frac{(\gamma(\alpha+\gamma)-2)^2}{(\gamma^2-4)^2} \right) + 2 \left( \frac{(\gamma-\alpha(\gamma^2-2))^2}{(2\gamma^4-9\gamma^2+12)^2} - \frac{(\alpha(\gamma^2-2)+\gamma)^2}{(\gamma^2-4)^2} \right)}{2(\gamma^2-1)} \quad (21)$$

By comparing  $\hat{\pi}_{ISP}^{FZ}$  to  $\hat{\pi}_{ISP}^{ZR_1}$  and  $\hat{\pi}_{ISP}^{ZR_2}$ , it can be shown that  $\hat{\pi}_{ISP}^{FZ}$  is always greater than the other two partial zero-rating cases. Unlike the result from no monetary transfer case, when there is a monetary transfer for zero-rating, the ISP always wants to fully zero-rate as we can see from Figure 6. In addition, as in Lemma 1, if  $\gamma$  is sufficiently large, the ISP pays a positive subsidy to  $CP_2$  to have full zero-rating. Proposition 3 summarizes the equilibrium under zero-rating with monetary transfer.

**Proposition 3.** *If there is a monetary transfer for zero-rating, the ISP always wants to fully zero-rate all content from both CPs. If content is sufficiently substitutable, the ISP pays a positive subsidy for lower quality CP to attain full zero-rating.*

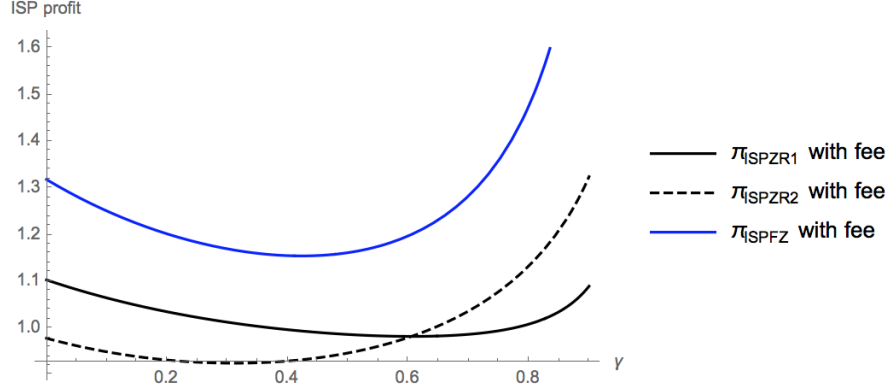


Figure 6: ISP profit comparison

## 5 Vertical integration

In the previous section, we characterize zero-rating equilibrium with and without monetary transfer between the ISP and CPs. It is worth noting that zero-rating with a positive fee from CPs is one typical example of sponsored data plan in a sense that consumers do not pay any overage charge of consuming zero-rated content but CPs pay instead. As mentioned in the Introduction, we can easily find real case examples of such sponsored data plan. However, in reality, most ISPs zero-rates its affiliated content for free but charges fees to any unaffiliated content. In this section, our focus is to see whether this behavior poses any anti-competitive threat such as vertical content foreclosure.

### 5.1 Zero-rated content without monetary transfer

#### 5.1.1 Integrated with $CP_1$ who provides higher quality of content

Suppose that the ISP and  $CP_1$  are vertically integrated and the vertically integrated firm zero-rates its affiliated content. The timing of the game is as follows. The integrated firm makes a take-it-or-leave-it zero-rating offer to  $CP_2$  and sets the hookup fee and overage charge. Then,  $CP_2$  first decides whether to accept the offer and both of integrated firm and  $CP_2$  set per unit content subscription fee. Last, consumers decide how much content to subscribe to each CP.

First, let's see what happens if  $CP_2$  rejects the offer, which means no zero-rating with  $CP_2$ . The set of equilibrium here is as follows.

$$\begin{aligned}
\tau_{VICP_1}^R &= \frac{\gamma^2(\alpha\gamma(2\gamma^2-5)+7)-4}{3(\gamma^4+3\gamma^2-4)} \\
H_{VICP_1}^R &= \frac{\alpha^2(8\gamma^8+52\gamma^6-36\gamma^4-99\gamma^2+108)-2\alpha(8\gamma^4-11\gamma^2+36)\gamma+9\gamma^4+8\gamma^2+16}{18(\gamma^4+3\gamma^2-4)^2} \\
\pi_{VICP_1}^R &= \frac{\alpha^2(4\gamma^6-18\gamma^2+15)+2\alpha\gamma(5\gamma^2-6)-3\gamma^2+4}{6(\gamma^2-1)^2(\gamma^2+4)} \\
p_{VICP_1}^R &= \frac{\gamma^3-\alpha(\gamma^4-2\gamma^2+2)}{\gamma^4+3\gamma^2-4}; \quad p_2^R = \frac{1}{3}\left(\frac{13\alpha\gamma-8}{\gamma^2+4}-4\alpha\gamma+3\right) \\
x_{VICP_1}^R &= \frac{2(\alpha(\gamma^4-3)+2\gamma)}{3(\gamma^4+3\gamma^2-4)}; \quad x_2^R = \frac{\alpha(4\gamma^2+3)\gamma-3\gamma^2-4}{3(\gamma^4+3\gamma^2-4)}.
\end{aligned} \tag{22}$$

Note that the subscript  $VICP_1$  denotes vertical integrated with  $CP_1$ . To have an interior solution ( $x_2^R \geq 0$ ), we need to restrict our attention to  $\gamma < \gamma_{VICP_1}^R$ .<sup>25</sup> Let's now see the equilibrium for zero  $\tau$  (full zero-rating) for the case in which  $CP_2$  accepts the offer.

$$\begin{aligned}
H_{VICP_1}^A &= \frac{\alpha^2(3-2\gamma^2)-2\alpha\gamma+1}{2(\gamma^4-5\gamma^2+4)} \\
\pi_{VICP_1}^A &= \frac{\alpha^2(-4\gamma^4+19\gamma^2-20)+2\alpha\gamma(8-3\gamma^2)-\gamma^2-4}{2(\gamma^2-4)^2(\gamma^2-1)} \\
p_{VICP_1}^A &= \frac{\alpha(\gamma^2-2)+\gamma}{\gamma^2-4}; \quad p_2^A = \frac{\alpha\gamma+\gamma^2-2}{\gamma^2-4} \\
x_{VICP_1}^A &= -\frac{\alpha(\gamma^2-2)+\gamma}{\gamma^4-5\gamma^2+4}; \quad x_2^A = \frac{2-\gamma(\alpha+\gamma)}{\gamma^4-5\gamma^2+4}.
\end{aligned} \tag{23}$$

To have an interior solution ( $x_2^A \geq 0$ ), we need to restrict our attention to  $\gamma < \gamma_{VICP_1}^A$ .<sup>26</sup> To see whether  $CP_2$  accepts or rejects the offer, we need to compare  $\pi_2^A$  to  $\pi_2^R$  where the superscript A denotes *Accept* and R denotes *Reject*. We can show that the profit under zero-rating (*Accept*) is always greater than that under no zero-rating (*Reject*) if  $\gamma$  is sufficiently small as in Section 4.3.2.

Let's now see the integrated firm makes an offer in the first place. It is easy to see that  $\pi_{VICP_1}^A - \pi_{VICP_1}^R = -\frac{(\gamma^2(\alpha\gamma(2\gamma^2-5)+7)-4)^2}{6(\gamma^2+4)(\gamma^4-5\gamma^2+4)^2} < 0$  for  $\gamma \in (0, 1)$ . Thus, the integrated firm does not have an incentive to make a zero-rating to  $CP_2$ . Therefore, there is no zero-rating with  $CP_2$

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<sup>25</sup>When  $\alpha = 2$ ,  $\gamma_{VICP_1}^R \approx 0.577$ .

<sup>26</sup>When  $\alpha = 2$ ,  $\gamma_{VICP_1}^A \approx 0.7321$ .

when the ISP and  $CP_1$  are vertically integrated even if  $CP_2$  wants to be zero-rated.

### 5.1.2 Integrated with $CP_2$ who provides lower quality of content

Suppose now that the ISP and  $CP_2$  are vertically integrated and the integrated firm zero-rates its affiliated content and offers zero-rating deal to unaffiliated  $CP_1$ . The timing of the game is analogous to Section 5.1.1. First, let's characterize the equilibrium in which  $CP_1$  rejects the offer.

$$\begin{aligned}
\tau_{VICP_2}^R &= \frac{7\alpha\gamma^2 - 4\alpha + 2\gamma^5 - 5\gamma^3}{3(\gamma^4 + 3\gamma^2 - 4)} \\
H_{VICP_2}^R &= \frac{\alpha^2(9\gamma^4 + 8\gamma^2 + 16) - 2\alpha(8\gamma^4 - 11\gamma^2 + 36)\gamma + 8\gamma^8 + 52\gamma^6 - 36\gamma^4 - 99\gamma^2 + 108}{18(\gamma^4 + 3\gamma^2 - 4)^2} \\
\pi_{VICP_2}^R &= \frac{-3(\alpha^2 + 6)\gamma^2 + 4\alpha^2 + 10\alpha\gamma^3 - 12\alpha\gamma + 4\gamma^6 + 15}{6(\gamma^2 - 1)^2(\gamma^2 + 4)} \\
p_{VICP_2}^R &= \frac{\gamma^2(\gamma(\alpha - \gamma) + 2) - 2}{\gamma^4 + 3\gamma^2 - 4}; \quad p_1^R = \frac{13\gamma - 8\alpha}{3(\gamma^2 + 4)} + \alpha - \frac{4\gamma}{3} \\
x_{VICP_2}^R &= \frac{2(2\alpha\gamma + \gamma^4 - 3)}{3(\gamma^4 + 3\gamma^2 - 4)}; \quad x_1^R = \frac{-3\alpha\gamma^2 - 4\alpha + 4\gamma^3 + 3\gamma}{3(\gamma^4 + 3\gamma^2 - 4)}.
\end{aligned} \tag{24}$$

To have an interior solution ( $x_{VICP_2}^R \geq 0$ ), we need to restrict our attention to  $\gamma < \gamma_{VICP_2}^R$ .<sup>27</sup> Let's now characterize the equilibrium in which  $CP_1$  accepts the offer.

$$\begin{aligned}
H_{VICP_2}^A &= \frac{\alpha^2 - 2\alpha\gamma - 2\gamma^2 + 3}{2\gamma^4 - 10\gamma^2 + 8} \\
\pi_{VICP_2}^A &= -\frac{\alpha^2(\gamma^2 + 4) + 2\alpha(3\gamma^2 - 8)\gamma + 4\gamma^4 - 19\gamma^2 + 20}{2(\gamma^2 - 4)^2(\gamma^2 - 1)} \\
p_{VICP_2}^A &= \frac{\gamma(\alpha + \gamma) - 2}{\gamma^2 - 4}; \quad p_1^A = \frac{\alpha(\gamma^2 - 2) + \gamma}{\gamma^2 - 4} \\
x_{VICP_2}^A &= \frac{2 - \gamma(\alpha + \gamma)}{\gamma^4 - 5\gamma^2 + 4}; \quad x_1^A = -\frac{\alpha(\gamma^2 - 2) + \gamma}{\gamma^4 - 5\gamma^2 + 4}.
\end{aligned} \tag{25}$$

To have an interior solution ( $x_{VICP_2}^A \geq 0$ ), we need to restrict our attention to  $\gamma < \gamma_{VICP_2}^A$ .<sup>28</sup> Comparing  $\pi_1^A$  to  $\pi_1^R$  to see whether  $CP_1$  accepts or rejects the offer, we can show that  $CP_1$  always wants to be zero-rated. However, as in the previous section, there is no incentive

<sup>27</sup>When  $\alpha = 2$ ,  $\gamma_{VICP_2}^R \approx 0.692505$ .

<sup>28</sup>When  $\alpha = 2$ ,  $\gamma_{VICP_2}^A \approx 0.7321$ .

for the integrated firm to offer zero-rating to unaffiliated  $CP_1$  because  $\pi_{VICP_2}^A - \pi_{VICP_2}^R = -\frac{(-7\alpha\gamma^2+4\alpha-2\gamma^5+5\gamma^3)^2}{6(\gamma^2+4)(\gamma^4-5\gamma^2+4)^2} < 0$  for  $\gamma \in (0, 1)$ .

### 5.1.3 Equilibrium

We have shown that the integrated firm, regardless of integration partner, does not offer zero-rating to its unaffiliated CP. From the comparison between profits from *Reject* for the integrated firm, we can show that the ISP wants to be vertically integrated with  $CP_1$  whose content is high quality since  $\pi_{VICP_1}^R - \pi_{VICP_2}^R = \frac{(\alpha^2-1)(4(\gamma^4+\gamma^2)-11)}{6(\gamma^4+3\gamma^2-4)} > 0$  for  $\gamma \in (0, 1)$ . This finding completes the equilibrium under vertical integration without monetary transfer as summarized in Proposition 4.

**Proposition 4.** *When there is no monetary transfer for zero-rating, the ISP and high quality CP make an integration deal. The integrated firm only wants to zero-rate its affiliated content, but has no incentive to zero-rate unaffiliated low quality content even if the unaffiliated low quality CP wants to be zero-rated.*

On the contrary to no vertical integration game without a fee where the ISP zero-rates  $CP_2$ 's content (low quality) for intermediate levels of content substitutability, allowing the ISP to vertically integrate leads to a completely opposite situation. Under vertical integration game, the ISP and high quality CP ( $CP_1$ ) integrate and do not zero-rate  $CP_2$ 's content. As an integrated firm, the ISP takes into account CP's profit from selling content. Intuitively, high quality  $CP_1$  can earn great profit if zero-rated. Also, if the unaffiliated content is not zero-rated, there is additional profit coming from overage charge as long as content provided by both CPs independent to some extent. Due to this additional profit effects, the ISP wants to integrate with  $CP_1$ .<sup>29</sup>

## 5.2 Zero-rated content with monetary transfer (Sponsored Data)

From above, we saw that the integrated firm always wants to foreclose the unaffiliated CP from being zero-rated. However, if there is a fee for zero-rating, the integrated firm might want to

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<sup>29</sup>From comparing the joint profits of the ISP and  $CP_1$  under no vertical integration game without a fee to the integrated firm's profit under vertical integration game, it can be shown that there is an incentive to vertically integrate with each other.



fully zero-rate. As in Section 4.3, we assume that the ISP makes a take-it-or-leave-it offer to CPs.

### 5.2.1 Integrated with $CP_1$ who provides higher quality of content

Given that the fee  $r_2$  is determined at  $\pi_2^A - \pi_2^R$ , the integrated firm's profit from full zero-rating with fee (which means *Accept*) is always greater than that from no zero-rating (which means *Reject*) if content is sufficiently independent. That is,  $\hat{\pi}_{VICP_1}^A - \pi_{VICP_1}^R > 0$  under  $\gamma < \gamma_{VI}$  where  $\hat{\pi}$  denotes the profit with monetary transfer.<sup>30</sup> Thus, when there is a monetary transfer, full zero-rating occurs in vertical integration equilibrium if  $\gamma < \gamma_{VI}$ . Also, for  $\gamma > \gamma_{VI}$ , the integrated firm only wants to zero-rate its own content as in no monetary transfer case.

### 5.2.2 Integrated with $CP_2$ who provides lower quality of content

We can show that  $\hat{\pi}_{VICP_2}^A - \pi_{VICP_2}^R > 0$  for  $\gamma \in (0, 1)$ . Thus, if the ISP and  $CP_2$  integrate with each other, it always fully zero-rates all content at a fee.

### 5.2.3 Equilibrium

As long as  $CP_1$ 's content quality is sufficiently higher than  $CP_2$ 's, it is easy to show that  $\max\{\hat{\pi}_{VICP_1}^A, \pi_{VICP_1}^R\} > \hat{\pi}_{VICP_2}^A$ . This suggests that no matter whether there is a fee for zero-rating, the ISP and high quality CP makes a vertical integration. However, if the integrated firm can charge a fee for zero-rating, it is willing to zero-rate the unaffiliated CP's content for some range of  $\gamma$ , unlike in the previous finding. Proposition 5 summarizes this findings.

**Proposition 5.** *If there is a monetary transfer for zero-rating, the ISP and high quality CP vertically integrate. If content is sufficiently independent ( $\gamma < \gamma_{VI}$ ), the integrated firm wants to zero-rate its unaffiliated CP in exchange for a positive fee. If content is sufficiently substitutable ( $\gamma > \gamma_{VI}$ ), the integrated firm does not offer zero-rating, which may lead to vertical content foreclosure.*

Thus, allowing the integrated firm to charge a fee for zero-rating somewhat alters the result. If content is independent, so that there are distinct demands for both types of content, the

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<sup>30</sup>Under  $\alpha = 2$ ,  $\gamma_{VI} \approx 0.4775$ .

integrated firm is able to charge a higher fee for zero-rating. Therefore, it wants to fully zero-rate all content and enjoy additional benefit from higher zero-rating fee paid by the unaffiliated low quality CP. However, if content becomes sufficiently substitutable, the integrated firm does not want to offer zero-rating to its rival because the unaffiliated low quality CP's willingness to pay for zero-rating becomes smaller as  $\gamma$  becomes larger. Also, as in Lemma 1,  $CP_2$ 's fee for zero-rating can be negative if  $\gamma$  is sufficiently large. However, unlike in the no vertical integration game, the integrated firm does not want to pay subsidy to induce full zero-rating: it takes into consideration the positive competitive effect toward affiliated CP from not zero-rating the rival's content, which dominates any positive effects toward the ISP from having full zero-rating. Corollary 1 summarizes this finding.

**Corollary 1.** *Vertical integration with high quality content provider makes its rival, low quality content provider, worse off because it does not allow the chance to be zero-rated if not paying for zero-rating.*

## 6 Welfare Analysis

In this section, let's compare welfare levels under different zero-rating regimes. The purpose of this analysis is to see how zero-rating equilibrium under vertical integration can be welfare-enhancing or -reducing compared to that under no vertical integration. Total social welfare is the sum of consumer's surplus, CPs' profits, and ISP's profit. Since the ISP takes all rents from consumers by setting up his optimal hookup fee, consumer's surplus is always zero. Thus, we need to compare CPs' and ISP's profits only.

For the sake of simplicity, we restrict our attention to  $\gamma$  in the middle range. In other words,  $\gamma$  is sufficiently large but smaller enough to guarantee the interior solutions. We first compare total social welfare levels for no monetary transfer cases. Suppose  $\gamma_I < \gamma$ , which implies that zero-rating with  $CP_2$  is the only equilibrium under no vertical integration game as in Proposition 1. Also, Proposition 4 states that only affiliated  $CP_1$ 's content is zero-rated. First, let us compare total social welfare levels under those two scenarios.

$$SW_{VICP_1}^R - SW_{ZR_2} = \underbrace{[\pi_{VICP_1}^R - \pi_{ISP}^{ZR_2} - \pi_1^{ZR_2}]}_{(+)} + \underbrace{[\pi_2^R - \pi_2^{ZR_2}]}_{(-)} > 0 \quad (26)$$

As above, total surplus from vertical integration case attains greater level than that from no integration case when there is no monetary transfer. However, this welfare-enhancing result comes at the expense of the unaffiliated  $CP_2$  which loses its market share and profit due to the integration and no zero-rating offer. We now compare total social welfare levels for monetary transfer cases. From Proposition 3, we check that full zero-rating emerges in equilibrium under no vertical integration. Under vertical integration, either full zero-rating or no zero-rating for the unaffiliated  $CP_2$ 's content emerges as in Proposition 5. By the same logic as above, we can find that vertical integration is weakly welfare-enhancing. First, if the integrated firm does not zero-rate the unaffiliated content, the profit increasing effect for the integrated firm dominates the profit decreasing effect for the unaffiliated  $CP_2$ . Even for the case in which the integrated firm zero-rates  $CP_2$ 's content, which is the same as full zero-rating, total social welfare with vertical integration is greater than that without vertical integration because of no double marginalization effect. Still, the unaffiliated  $CP_2$  becomes worse off due to vertical integration because it does not receive any positive subsidy for zero-rating as in no vertical integration case. Proposition 6 summarizes the finding.

**Proposition 6.** *Vertical integration with high quality content provider is welfare-enhancing than no vertical integration case because profit increasing effect for the integrated firm is large enough. However, the unaffiliated content provider suffers from lower market share and profit under the integration.*

Lastly, it is worth examining whether sponsored data plan is welfare-enhancing. For no vertical integration case, allowing monetary transfers for zero-rating which leads to full zero-rating case attains greater social welfare level. For vertical integration case, sponsored data plan is welfare-enhancing as long as it induces full zero-rating in the equilibrium, i.e., if  $\gamma < \gamma_{VI}$ . Proposition 7 summarizes this finding.

**Proposition 7.** *Sponsored data plan which may lead to full-zero rating equilibrium is welfare-enhancing than no monetary transfer for zero-rating.*

## 7 Conclusion

In this paper, we have shown what makes the ISP want to zero-rate CP's content and how different zero-rating equilibrium affects total social welfare. If there is no monetary transfer for zero-rating, the ISP wants to offer the deal to lower quality CP. However, if there is a fee, full zero-rating equilibrium emerges. Similarly, assuming that the ISP and one of the CPs are vertically integrated, the integrated firm wants to foreclose the unaffiliated CP from being zero-rated if there is no fee. If the integrated firm can receive a fee for zero-rating, it wants to zero-rate its rival's content. From the welfare analysis, we have shown that vertical integration is the most socially desirable but at the expense of the unaffiliated content provider which loses its market share and profit due to the integration and no zero-rating offer. Also, full zero-rating is welfare-enhancing in most cases. Therefore, in order to enhance total social welfare, we might need a policy that encourages a monetary transfer for zero-rating which leads to full zero-rating.

We have not looked into how zero-rating affects the competitive structure in the ISP market. In this regard, it would be interesting for future research to see how zero-rating can be used as a late entrant strategy by providing marketing collaboration to newer ISP entrants.<sup>31</sup>

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<sup>31</sup>For example, hoping to boost subscribership, in 2011, urban centered fledgling mobile wireless service provider MetroPCS partnered with Rhapsody to offer a zero-rated music streaming service. Similarly, in 2015, Cell-C, South Africa's third largest mobile wireless service provider, began to offer zero-rated access to Facebook's Intrenet.org app.

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## Appendix

**Proof of Proposition 1.** As shown in the paper, we need to first show whether each CP has an incentive to accept any zero-rating offer when there is no fee. The profit difference for each CP can be obtained as follows.

$$\begin{aligned}\pi_1^{ZR_1} - \pi_1^{NZ} &= \frac{\frac{(\alpha(5-3\gamma^2)+(\gamma-2)\gamma-1)^2}{(2\gamma^2+\gamma-6)^2} - \frac{4(\gamma^2-2)^2(\alpha(2\gamma^2-3)+\gamma)^2}{(2\gamma^4-9\gamma^2+12)^2}}{4(\gamma^2-1)} \\ \pi_2^{ZR_2} - \pi_2^{NZ} &= \frac{\frac{(-\alpha(\gamma-2)\gamma+\alpha+3\gamma^2-5)^2}{(2\gamma^2+\gamma-6)^2} - \frac{4(\gamma^2-2)^2(\gamma(\alpha+2\gamma)-3)^2}{(2\gamma^4-9\gamma^2+12)^2}}{4(\gamma^2-1)}\end{aligned}\quad (27)$$

Both equations above are positive for  $1 \leq \alpha \leq 2$  and  $0 < \gamma < \gamma_{NZ}$ , which implies that each CP wants to be zero-rated. Next, As in Equation (17),  $\pi_{ISP}^{ZR_1} - \pi_{ISP}^{ZR_2} = \frac{(\alpha^2-1)(\gamma^2-1)}{(24-18\gamma^2+4\gamma^4)} < 0 \quad \because \alpha \geq 1$ . Thus, if the ISP chooses low quality  $CP_2$  as a zero-rating partner here. Last, we need to check whether the ISP has any deviation incentive. We compare  $\pi_{ISP}^{ZR_2}$  to  $\pi_{ISP}^{NZ}$  and  $\pi_{ISP}^{FZ}$ . First,

$$\pi_{ISP}^{ZR_2} - \pi_{ISP}^{FZ} = -\frac{(\alpha(\gamma^4 - 3\gamma^2 + 4) + 2\gamma(\gamma^2 - 2))^2}{2(\gamma - 1)(\gamma + 1)(\gamma^2 - 4)^2(2\gamma^4 - 9\gamma^2 + 12)}, \quad (28)$$

which is always positive. Second,

$$\begin{aligned}\pi_{ISP}^{ZR_2} - \pi_{ISP}^{NZ} &= \frac{1}{4} \left( \frac{2\alpha^2(\gamma^2 - 2)^2 - 4\alpha\gamma - 4\gamma^2 + 6}{(\gamma^2 - 1)(2\gamma^4 - 9\gamma^2 + 12)} \right. \\ &\quad \left. + \frac{\alpha^2(-(\gamma + 5)\gamma^2 + \gamma + 7) - 2\alpha(\gamma^3 + \gamma^2 + \gamma - 1) - \gamma^2(\gamma + 5) + \gamma + 7}{(\gamma - 1)(\gamma + 1)(\gamma + 2)^2(2\gamma - 3)} \right).\end{aligned}\quad (29)$$

From Equation (29), we can see that  $\pi_{ISP}^{ZR_2} < \pi_{ISP}^{NZ}$  if  $\gamma$  is sufficiently small whereas  $\pi_{ISP}^{ZR_2} > \pi_{ISP}^{NZ}$  if  $\gamma$  is large enough. The threshold, which is denoted as  $\gamma_I$ , can be implicitly obtained as the solution satisfying  $\pi_{ISP}^{ZR_2} - \pi_{ISP}^{NZ} = 0$ .  $\square$

**Proof of Proposition 2.** First, Equation (18) shows the equilibrium fee for each CP. Next, as in Equation (19),  $\hat{\pi}_{ISP}^{ZR_1} - \hat{\pi}_{ISP}^{ZR_2}$  is greater than zero if  $\gamma < \tilde{\gamma}_{PZ}$  where  $\tilde{\gamma}_{PZ}$  is the  $\gamma$  satisfying  $\hat{\pi}_{ISP}^{ZR_1} - \hat{\pi}_{ISP}^{ZR_2} = 0$ . It remains to show  $\tilde{\gamma}_{PZ} < \tilde{\gamma}_{NZ}$  under our assumptions on  $\alpha$  and  $\gamma$ . Note that  $\tilde{\gamma}_{NZ}$  is the solution satisfying  $x_2^{NZ} = \frac{\alpha(\gamma^2-2\gamma-1)-3\gamma^2+5}{2(2\gamma^4+\gamma^3-8\gamma^2-\gamma+6)} = 0$ . By comparing the left-hand side of Equation (19) to that of  $x_2^{NZ}$ , it is easy to see that the fixed point on  $\gamma$  satisfying  $\hat{\pi}_{ISP}^{ZR_1} - \hat{\pi}_{ISP}^{ZR_2} = 0$  is smaller than that satisfying  $x_2^{NZ} = 0$ , which implies that  $\tilde{\gamma}_{PZ} < \tilde{\gamma}_{NZ}$ .  $\square$

**Proof of Lemma 1.** First,  $r_1^{FZ}$  and  $r_2^{FZ}$  can be obtained as in Equation (20). After some algebra, it is obvious that  $r_1^{FZ}$  is always positive. For  $r_2^{FZ}$ , it can be shown that if  $\gamma < \gamma_{Subsidy} = \frac{1}{2} \left( -\sqrt{\alpha^2 - 1} + \sqrt{2\alpha(\sqrt{\alpha^2 - 1} + \alpha) + 7 - \alpha} \right)$ ,  $r_2^{FZ} > 0$ . That is, if  $\gamma > \gamma_{Subsidy}$ ,  $r_2^{FZ} < 0$ , which implies a positive subsidy to  $CP_2$  for zero-rating. The threshold  $\gamma_{Subsidy}$  can be obtained as the solution  $\gamma$  satisfying  $r_2^{FZ} = \frac{\frac{((\gamma^2-2)^2 - \alpha\gamma)^2}{(2\gamma^4 - 9\gamma^2 + 12)^2} - \frac{(\gamma(\alpha+\gamma)-2)^2}{(\gamma^2-4)^2}}{\gamma^2-1} = 0$ .  $\square$

**Proof of Proposition 3.** First, the profit difference for the ISP between full zero-rating and zero-rating with either  $CP_1$  or  $CP_2$  when monetary transfers are allowed can be derived as follows.

$$\begin{aligned}
\widehat{\pi}_{ISP}^{FZ} - \widehat{\pi}_{ISP}^{ZR_1} &= \frac{\alpha^2(3 - 2\gamma^2) - 2\alpha\gamma + (\gamma^2 - 2)^2}{4\gamma^6 - 22\gamma^4 + 42\gamma^2 - 24} \\
&\quad + \frac{\frac{3(\alpha^2+1)\gamma^2 - 4(\alpha^2+1) + 2\alpha\gamma^3}{(\gamma^2-4)^2} + 2 \left( \frac{((\gamma^2-2)^2 - \alpha\gamma)^2}{(2\gamma^4 - 9\gamma^2 + 12)^2} - \frac{(\gamma(\alpha+\gamma)-2)^2}{(\gamma^2-4)^2} \right) + 2 \left( \frac{(\gamma - \alpha(\gamma^2-2))^2}{(2\gamma^4 - 9\gamma^2 + 12)^2} - \frac{(\alpha(\gamma^2-2) + \gamma)^2}{(\gamma^2-4)^2} \right)}{2(\gamma^2 - 1)} \\
&\quad - \frac{\frac{(\alpha(5-3\gamma^2) + (\gamma-2)\gamma-1)^2}{(2\gamma^2 + \gamma - 6)^2} - \frac{4(\gamma^2-2)^2(\alpha(2\gamma^2-3) + \gamma)^2}{(2\gamma^4 - 9\gamma^2 + 12)^2}}{4(\gamma^2 - 1)} \\
\widehat{\pi}_{ISP}^{FZ} - \widehat{\pi}_{ISP}^{ZR_2} &= \frac{1}{112(\gamma^2 - 1)} \left( \frac{14(\alpha^2(3\gamma^2 - 4) - 32\alpha\gamma(\gamma^2 - 2) - 47\gamma^2 + 116)}{(2\gamma^4 - 9\gamma^2 + 12)^2} \right. \\
&\quad + \frac{14(\alpha^2(10\gamma^2 - 21) + 8\alpha\gamma(2\gamma^2 - 5) + 28\gamma^2 - 83)}{2\gamma^4 - 9\gamma^2 + 12} - 7(9\alpha^2 - 6\alpha + 5) \\
&\quad - \frac{56(\alpha - 1)^2}{(\gamma + 2)^2} + \frac{4(29\alpha - 41)(\alpha - 1)}{\gamma + 2} - \frac{84(\alpha + 1)^2}{\gamma - 2} - \frac{28(\alpha + 1)^2}{(\gamma - 2)^2} \\
&\quad \left. + \frac{2(\alpha + 1)(3\alpha - 17)}{2\gamma - 3} - \frac{7(\alpha + 1)^2}{(3 - 2\gamma)^2} \right)
\end{aligned} \tag{30}$$

Both of equations are positive for  $1 \leq \alpha \leq 2$ , which means that the ISP always wants to have full zero-rating if monetary transfers are allowed.  $\square$

**Proof of Proposition 4.** First, we check whether each CP has an incentive to accept any zero-rating offer from the integrated firm. Assuming that the ISP and  $CP_1$  are integrated, the unaffiliated  $CP_2$  has an incentive to accept the offer because  $\pi_2^A - \pi_2^R = \frac{\frac{(-\alpha(4\gamma^2+3)\gamma+3\gamma^2+4)^2}{(\gamma^2+4)^2} - \frac{9(\gamma(\alpha+\gamma)-2)^2}{(\gamma^2-4)^2}}{9(\gamma^2-1)} > 0$  for  $1 \leq \alpha \leq 2$ . Similarly, for the case in which the ISP and  $CP_2$  integrate with each other, the unaffiliated  $CP_1$  also wants to be zero-rated because  $\pi_1^A - \pi_1^R = \frac{(\alpha(\gamma^2-2) + \gamma)^2}{(\gamma^4 - 5\gamma^2 + 4)^2} +$

$\frac{(3\alpha\gamma^2+4\alpha-4\gamma^3-3\gamma)^2}{9(\gamma^2-1)(\gamma^2+4)^2} > 0$ . Given that any CP accepts the offer, it remains to show with which CP the ISP wants to make an integration. As in the paper,  $\pi_{VICP_n}^A - \pi_{VICP_n}^R < 0$  for any CP  $n$ . On top of that,  $\pi_{VICP_1}^R - \pi_{VICP_2}^R = \frac{(\alpha^2-1)(4(\gamma^4+\gamma^2)-11)}{6(\gamma^4+3\gamma^2-4)} > 0$ .  $\square$

**Proof of Proposition 5.** Most steps are in the paper. Obviously,  $\gamma_I$  is the solution satisfying  $\hat{\pi}_{VICP_1}^A - \pi_{VICP_1}^R = 0$  where  $\hat{\pi}_{VICP_1}^A - \pi_{VICP_1}^R = \frac{(\alpha(10\gamma^6-89\gamma^4+28\gamma^2+96)\gamma-24\gamma^6+11\gamma^4+80\gamma^2-112)(\gamma^2(\alpha\gamma(2\gamma^2-5)+7)-4)}{18(\gamma^6-\gamma^4-16\gamma^2+16)^2}$ .  $\square$

**Proof of Proposition 6.** First, assuming that  $\gamma > \gamma_I$ , we need to compare total social welfare level under the case of zero-rating  $CP_2$ 's content only (in no vertical integration game without monetary transfer) to that of zero-rating  $CP_1$ 's content only (in vertical integration game without monetary transfer). Total social welfare level for each case can be derived as follows.

$$\begin{aligned}
SW_{VICP_1}^R &= \frac{1}{18(\gamma^4+3\gamma^2-4)^2} \left( 3(\gamma^2+4)(\alpha^2(4\gamma^6-18\gamma^2+15)+2\alpha\gamma(5\gamma^2-6)-3\gamma^2+4) \right. \\
&\quad \left. - 2(\gamma^2-1)(-\alpha(4\gamma^2+3)\gamma+3\gamma^2+4)^2 \right) \\
SW_{ZR_2} &= \frac{-1}{2(\gamma^2-1)(2\gamma^4-9\gamma^2+12)^2} \left( \alpha^2(\gamma^2-2)^2(4\gamma^4-15\gamma^2+20) \right. \\
&\quad \left. + 2\alpha(4\gamma^6-26\gamma^4+57\gamma^2-44)\gamma+8\gamma^8-60\gamma^6+170\gamma^4-217\gamma^2+108 \right)
\end{aligned} \tag{31}$$

When there are monetary transfers for zero-rating, we need to compare the case of full zero-rating (in no vertical integration game) to that of full zero rating or zero-rating  $CP_1$ 's content only (in vertical integration game).

$$\begin{aligned}
SW_{VICP_1}^A - SW_{FZ} &= -\frac{(\alpha(\gamma^2-2)+\gamma)^2}{(\gamma^2-4)^2(\gamma^2-1)} \\
SW_{VICP_1}^R - SW_{FZ} &= \frac{1}{18(\gamma^4+3\gamma^2-4)^2} \left( 3(\gamma^2+4)(\alpha^2(4\gamma^6-18\gamma^2+15)+2\alpha\gamma(5\gamma^2-6)-3\gamma^2+4) \right. \\
&\quad \left. - 2(\gamma^2-1)(-\alpha(4\gamma^2+3)\gamma+3\gamma^2+4)^2 \right) + \frac{9(2(\alpha^2+1)\gamma^4-9(\alpha^2+1)\gamma^2+12(\alpha^2+1)+6\alpha\gamma^3-16\alpha\gamma)}{(\gamma^2-4)^2(\gamma^2-1)}
\end{aligned} \tag{32}$$

After some algebra, it can be shown that  $SW_{VICP_1}^R > SW_{ZR_2}$ ,  $SW_{VICP_1}^R > SW_{FZ}$ , and  $SW_{VICP_1}^A > SW_{FZ}$ .  $\square$

**Proof of Proposition 7.** When there is no monetary transfer, either zero-rating with  $CP_2$  (in no vertical integration game) or zero-rating with  $CP_1$  (in vertical integration game) emerges in equilibrium. When there is monetary transfer, we can observe full zero-rating equilibrium both of the games with and without vertical integration. In order to see whether sponsored data plan (monetary transfer) is welfare-enhancing or not, we need to compare the welfare level under full zero-rating case to any welfare level under partial zero-rating case.

In no vertical integration, we focus on the equilibrium of zero-rating with  $CP_2$  only under no monetary transfer case and that of full zero-rating under monetary transfer case. In vertical integration, we need to compare the welfare level of zero-rating with  $CP_1$  only under no monetary transfer case to that of full zero-rating under monetary transfer case (i.e.  $\gamma < \gamma_{VI}$ ).

$$\begin{aligned}
SW_{FZ} - SW_{ZR_2} &= -\frac{(4\gamma^4 - 21\gamma^2 + 28)(\alpha(\gamma^4 - 3\gamma^2 + 4) + 2\gamma(\gamma^2 - 2))^2}{2(\gamma^2 - 4)^2(\gamma^2 - 1)(2\gamma^4 - 9\gamma^2 + 12)^2} \\
SW_{VICP_1}^A - SW_{VICP_1}^R &= \frac{1}{18(\gamma^6 - \gamma^4 - 16\gamma^2 + 16)^2} \left( (\alpha(10\gamma^6 - 89\gamma^4 + 28\gamma^2 + 96)\gamma \right. \\
&\quad \left. - 24\gamma^6 + 11\gamma^4 + 80\gamma^2 - 112)(\gamma^2(\alpha\gamma(2\gamma^2 - 5) + 7) - 4) \right) \quad (33)
\end{aligned}$$

The first equation is always positive while the second one is positive for  $\gamma < \gamma_{VI}$ . Given that the condition,  $\gamma < \gamma_{VI}$ , guarantees full zero-rating equilibrium in vertical integration game, we can say that full zero-rating attains the highest social welfare level. Also, given that full zero-rating equilibrium only emerges when there are monetary transfers, we can alternatively state that sponsored data leads to welfare-enhancing results.  $\square$