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.

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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 for a preset amount of data and an overage charge for each additional data beyond the preset amount of data.[1] 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.[2]

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.[3] Similarly, 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.[4] 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.

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

[2] 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/.

[3] 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/.

[4] 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,[5] 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).[6] Recently, California plans to make a tougher proposal which specifically attacks ISPs' zero-rating practices by prohibiting ISPs from implementing zero-rating practices.[7] 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.[8] 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

[5]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.

[6]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.

[7]Refer to SB 822: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB822

[8]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.

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 ISP incentives to offer sponsored data options?

To address the questions above, we consider a model in which a monopolistic ISP offers consumers a two-part tariff consisting of a hookup fee H and a linear data overage charge τ, and where two asymmetric CPs sell content to consumers. Since we focus on how the existence of overage charge affects content market competition and consumers, we consider a two-part tariff rather than a three-part tariff with a data cap for simplicity.[9] CPs are asymmetric in terms of the content quality that they provide, but their content is substitutable to a 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 when 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' contents are 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 refer to as full zero-rating in the paper. If content is sufficiently differentiated, both CPs always pay a positive fee for zero-rating, which

[9] Put differently, we assume that data cap is set as zero. The suitable real case example is a pay-as-you-go plan. Vodafone Pass in Germany which provides free data toward certain online services at a fixed cost can be one example of zero-rating practice with a two-part tariff.

increases the ISP's incentive to lead to full zero-rating. As both CPs' contents become 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, the 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, vertical integration does not exclude full zero-rating. Still, the low quality CP can be worse off under vertical integration, because it deprives it 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 the 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, the relevant literature is discussed. Section 3 provides the basic model setup. Sections 4 and 5 solve the game for no vertical integration and vertical integration, respectively. In Section 6 and 7, welfare implications and policy implications are drawn. The conclusion follows in Section 8.

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.[10] 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 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.[11] 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.[12] Somogyi finds that zero-rating is an optimal ISP strategy when CP revenue per click is relatively large, whereas the ISP subscription fee is

[10] 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.

[11] Additionally, Koning and Yankelevich (2017) briefly analyze zero-rating using a standard model of vertically integrated firms who supply their rivals.

[12] 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.

relatively small.[13] 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), who view content as non-rival and Somogyi (2017), who views it as perfectly substitutable,[14] 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.[15]

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, Jeitschkor and Tremblay 2017), 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

[13]Both the revenue per click and subscription fee are exogenous in the most recent version of the working paper.

[14]More accurately, in Somogyi (2017), the content of CPs who can be zero-rated is perfectly substitutable.

[15]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.

(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).[16]

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 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). 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 γ. Assuming that there is a unit mass of consumer, the utility for each consumer is defined by a variation of typical quadratic utility function.

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

where α_n denotes content quality provided by CP_n, x_n is the amount of content provided by CP_n, γ is the degree of content substitutability, H is a hookup fee charged by the ISP, p_n is a content n's subscription fee, τ is a per unit overage charge set by the ISP, and $\mathbb{1}_n$ is an indicator taking the value one if CP_n is no zero-rated and 0 if it is zero-rated.[17]

The ISP chooses a hookup fee H and an overage charge τ. With this two-part tariff pricing

[16] Moreover, a number of authors have explored the welfare "neutrality" of net neutrality (Gans 2015; Gans and Katz 2016; Greenstein, Peitz, and Valletti 2016).

[17] As mentioned in Section 1, we consider a two-part tariff rather than a three-part tariff with a data cap for simplicity, which means that data cap is set as zero.

scheme, an overage charge is only applied to any positive excess usage. Given that consumers use some positive data, the pricing scheme which is a typical two-part tariff, so τ 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 the ISP's zero-rating offer if any is provided. If it accepts the offer, the overage charge τ 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.

For simplicity, we normalize α_2 to one and denote α_1 as α for the rest of paper. Also, we further assume that $1 \leq \alpha \leq 2$. 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 show on what grounds the ISP wants to make a deal with either one of the CPs.

On top of that, there is a restriction on γ which guarantees the interior solutions for both CPs to have positive market shares. For the interior solution assumption, we need an assumption that γ is smaller than a certain threshold, which guarantees the existence of interior solution in all cases.

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 all consumer surplus.

The timing of the game is as follows. The ISP first announces its policies regarding to which CP(s) it offers a zero-rating deal. 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 consume from 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, the equilibrium for no zero-rating case is derived using 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.

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

Given this, each CP solves its profit maximization problem to obtain the following equilibrium prices.

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

This leads to the equilibrium market share for each CP of

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

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

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

The profit for ISP is given by

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

The optimal τ is obtained by solving the profit maximization problem with respect to τ, yielding

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

Since $\alpha \geq 1$ is assumed, the demand for content is weighted towards CP_1 from a certain level of γ. As γ increases, which means that content becomes more substitutable, consumers choose only one of the types of content. So, there is a threshold of γ 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 given by

$$
x_2 > 0 \Longleftrightarrow \gamma < \frac{\alpha-\sqrt{2\alpha^2-8\alpha+15}}{\alpha-3} \equiv \tilde{\gamma}, \tag{8}
$$

where the subscript NZ denotes no zero-rating case. This interior solution condition on γ is assumed to be satisfied throughout the paper.[18]

4.2 Zero rated content without monetary transfer

4.2.1 Partial zero-rated content

Now 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

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

[18] Assuming that $\alpha = 2$, $\tilde{\gamma} \approx 0.645751$. This condition sufficiently guarantees the existence of interior solution in all different scenarios.

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

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

The equilibrium is given by

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

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

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

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 obtain the following optimal price.

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

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

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

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.

Consider 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.

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

Although there is no closed form solution to γ which satisfies the above inequality, there is a condition on γ 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 γ 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

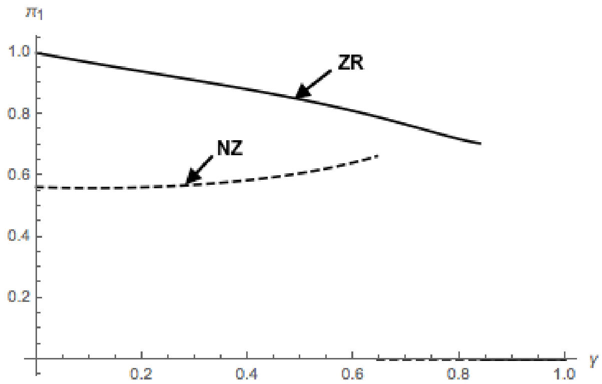

Figure 1: CP_1's profits as a function of γ under $\alpha = 2$

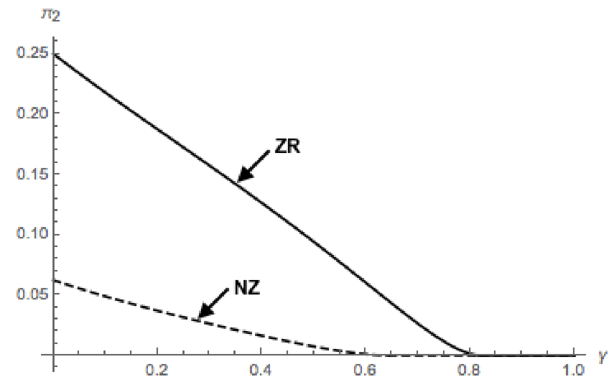

Figure 2: CP_2's profits as a function of γ under $\alpha = 2$

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, it remains to be shown to which CP that the ISP offers zero-rating.

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

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

Last, given that the ISP offers a deal with CP_2 and CP_2 accepts it, i.e., γ 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 γ is sufficiently small whereas $\pi_{ISP}^{ZR_2} > \pi_{ISP}^{NZ}$ if γ is large enough. Thus, the ISP offers a zero-rating deal only when content is sufficiently substitutable. Proposition 1 summarizes this finding.[19]

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 γ, $\gamma < \tilde{\gamma}$. Thus, zero-rating with low quality CP_2 occurs for $\gamma \in (\gamma_I, \tilde{\gamma})$.*

Here is the intuition for this finding. Given that the ISP zero-rates CP_2's content, the ISP's

[19] Under the same numerical example of $\alpha = 2$, the relevant thresholds on γ which constitutes Proposition 1 are as follows: $\gamma_I = 0.237235$ and $\tilde{\gamma} = 0.645751$.

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, τx_2, is large in this range of γ, 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.

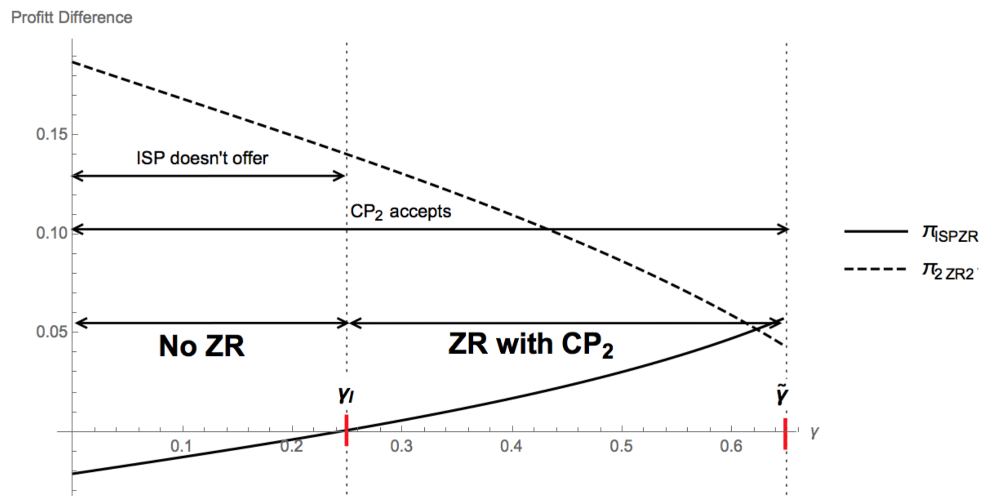

Figure 3: Solid line is $\pi_{ISP}^{ZR_2} - \pi_{ISP}^{NZ}$ and dashed line is $\pi_2^{ZR_2} - \pi_2^{NZ}$ when α=2

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

Here, 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 γ 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.

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

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 γ ($\gamma < \tilde{\gamma}$) is satisfied. Assuming that CPs accept the offer, it remains to be shown to which CP the ISP makes the offer. To check this, compare ISP's profit under zero-rating with CP_1 to that under zero-rating with CP_2. For notational convenience, we denote $\widehat{\pi}$ for profits with monetary transfer.

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

We find that $\widehat{\pi}_{ISP}^{ZR_1} - \widehat{\pi}_{ISP}^{ZR_2}$ is greater than zero if γ 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 γ but does the same thing to CP_2 for a different level of γ. 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 γ, denoted as γ_{PZ} such that if $\gamma < \gamma_{PZ}$, the ISP offers a deal to CP_1 but offers to CP_2 if $\gamma > \gamma_{PZ}$. Proposition 2 summarizes the findings.[20]

Proposition 2. *There are thresholds on γ, γ_{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 $0 < \gamma < \gamma_{PZ}$, 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 $\gamma_{PZ} < \gamma < \tilde{\gamma}$.*

The intuition behind choosing low quality CP_2 for large γ 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 γ is sufficiently large.

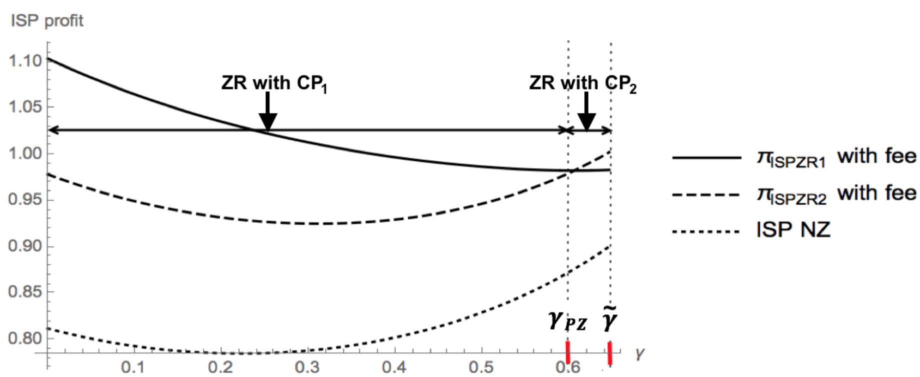

Figure 4: Partial Zero-rating Equilibrium if $\alpha = 2$

[20] γ_{PZ} is the γ satisfying $\widehat{\pi}_{ISP}^{ZR_1} - \widehat{\pi}_{ISP}^{ZR_2} = 0$. Note that $\gamma_{PZ} < \tilde{\gamma}$ is guaranteed under our assumption on α.

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.

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

By similar logic to the partial zero-rating case, under the interior solution assumption, it can be shown that r_1^{FZ} is always positive whereas r_2^{FZ} can be negative if γ 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 $\gamma > \gamma_{Subsidy}$,[21] 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 γ, 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*

[21] $\gamma_{Subsidy} = \frac{1}{2}\left(\sqrt{2\left(\sqrt{\alpha^2-1}+\alpha\right)\alpha+7} - \sqrt{\alpha^2-1} - \alpha\right)$

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.

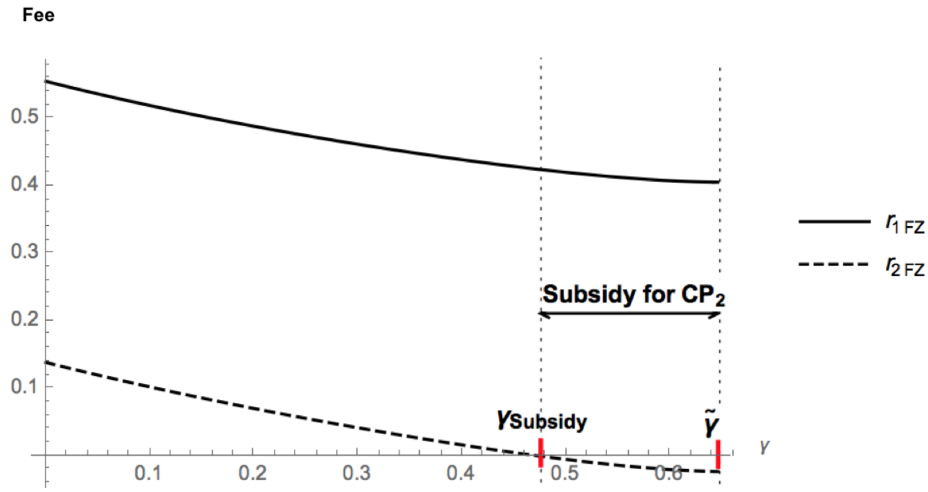

Figure 5: Fixed fee comparison

4.3.3 Equilibrium

Consider how the ISP makes its decision. Under full zero-rating, ISP's total profit is given as follows.

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

By comparing $\hat{\pi}^{FZ}_{ISP}$ to $\hat{\pi}^{ZR_1}_{ISP}$ and $\hat{\pi}^{ZR_2}_{ISP}$, it can be shown that $\hat{\pi}^{FZ}_{ISP}$ 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 γ 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.*

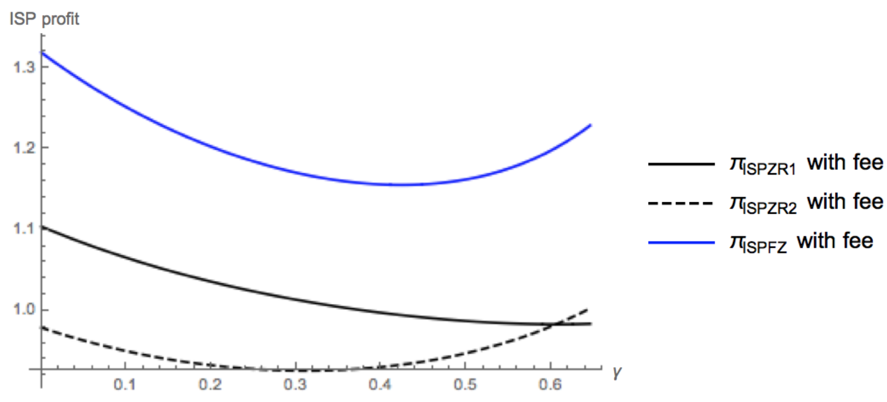

Figure 6: ISP profit comparison

4.4 Comparison – with and without monetary transfer

From Proposition 1 and Proposition 3, we have shown that under monetary transfer case, the ISP fully zero-rates both CPs' content whereas low quality CP can be the only one providing zero-rated content under no monetary transfer case. By comparing the relevant profit levels, it is easy to conclude that low quality CP becomes worse off when a monetary transfer for zero-rating is allowed. As low quality CP, it can partly overcome its quality disadvantage by using zero-rated service. However, since the ISP wants full zero-rating if it can take fees from CPs, low quality CP loses its advantageous position — if both high and low quality contents become zero-rated, more consumers would choose better quality content. Therefore, low quality CP loses its market share and profit when both contents are zero-rated with monetary transfer. The following Corollary summarizes this finding.

Corollary 1. *Allowing monetary transfer for zero-rating which induces full zero-rating makes low quality content provider worse off in terms of market share and profit.*

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.

As in the no vertical integration game, we need the interior solution assumption here: $\gamma < \tilde{\gamma}_{VI}$ guarantees the existence of interior solution under the vertical integration game.[22]

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.

$$
\begin{aligned}
\tau^R_{VICP_1} &= \frac{\gamma^2\left(\alpha\gamma\left(2\gamma^2-5\right)+7\right)-4}{3\left(\gamma^4+3\gamma^2-4\right)}\\
H^R_{VICP_1} &= \frac{\alpha^2\left(8\gamma^8+52\gamma^6-36\gamma^4-99\gamma^2+108\right)-2\alpha\left(8\gamma^4-11\gamma^2+36\right)\gamma+9\gamma^4+8\gamma^2+16}{18\left(\gamma^4+3\gamma^2-4\right)^2}\\
\pi^R_{VICP_1} &= \frac{\alpha^2\left(4\gamma^6-18\gamma^2+15\right)+2\alpha\gamma\left(5\gamma^2-6\right)-3\gamma^2+4}{6\left(\gamma^2-1\right)^2\left(\gamma^2+4\right)}\\
p^R_{VICP_1} &= \frac{\gamma^3-\alpha\left(\gamma^4-2\gamma^2+2\right)}{\gamma^4+3\gamma^2-4}; \quad p^R_2 = \frac{1}{3}\left(\frac{13\alpha\gamma-8}{\gamma^2+4}-4\alpha\gamma+3\right)\\
x^R_{VICP_1} &= \frac{2\left(\alpha\left(\gamma^4-3\right)+2\gamma\right)}{3\left(\gamma^4+3\gamma^2-4\right)}; \quad x^R_2 = \frac{\alpha\left(4\gamma^2+3\right)\gamma-3\gamma^2-4}{3\left(\gamma^4+3\gamma^2-4\right)}.
\end{aligned}
\tag{22}
$$

Note that the subscript $VICP_1$ denotes vertical integrated with CP_1. Let's now see the

[22] Under $\alpha = 2$, $\tilde{\gamma}_{VI} \approx 0.577$.

equilibrium for zero τ (full zero-rating) for the case in which CP_2 accepts the offer.

$$\begin{aligned} H^A_{VICP_1} &= \frac{\alpha^2 \left(3-2\gamma^2\right) - 2\alpha\gamma + 1}{2\left(\gamma^4 - 5\gamma^2 + 4\right)} \\ \pi^A_{VICP_1} &= \frac{\alpha^2 \left(-4\gamma^4 + 19\gamma^2 - 20\right) + 2\alpha\gamma\left(8 - 3\gamma^2\right) - \gamma^2 - 4}{2\left(\gamma^2 - 4\right)^2 \left(\gamma^2 - 1\right)} \\ p^A_{VICP_1} &= \frac{\alpha\left(\gamma^2 - 2\right) + \gamma}{\gamma^2 - 4}; \quad p^A_2 = \frac{\alpha\gamma + \gamma^2 - 2}{\gamma^2 - 4} \\ x^A_{VICP_1} &= -\frac{\alpha\left(\gamma^2 - 2\right) + \gamma}{\gamma^4 - 5\gamma^2 + 4}; \quad x^A_2 = \frac{2 - \gamma(\alpha + \gamma)}{\gamma^4 - 5\gamma^2 + 4}. \end{aligned} \tag{23}$$

To see whether CP_2 accepts or rejects the offer, we need to compare π^A_2 to π^R_2 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*) under the interior solution assumption.

Let's now see the integrated firm makes an offer in the first place. It is easy to see that $\pi^A_{VICP_1} - \pi^R_{VICP_1} = -\frac{\left(\gamma^2\left(\alpha\gamma\left(2\gamma^2-5\right)+7\right)-4\right)^2}{6\left(\gamma^2+4\right)\left(\gamma^4-5\gamma^2+4\right)^2} < 0$ 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 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.

$$\tau^R_{VICP_2} = \frac{7\alpha\gamma^2 - 4\alpha + 2\gamma^5 - 5\gamma^3}{3(\gamma^4 + 3\gamma^2 - 4)}$$
$$H^R_{VICP_2} = \frac{\alpha^2(9\gamma^4 + 8\gamma^2 + 16) - 2\alpha(8\gamma^4 - 11\gamma^2 + 36)\gamma + 8\gamma^8 + 52\gamma^6 - 36\gamma^4 - 99\gamma^2 + 108}{18(\gamma^4 + 3\gamma^2 - 4)^2}$$
$$\pi^R_{VICP_2} = \frac{-3(\alpha^2 + 6)\gamma^2 + 4\alpha^2 + 10\alpha\gamma^3 - 12\alpha\gamma + 4\gamma^6 + 15}{6(\gamma^2 - 1)^2(\gamma^2 + 4)}$$
$$p^R_{VICP_2} = \frac{\gamma^2(\gamma(\alpha - \gamma) + 2) - 2}{\gamma^4 + 3\gamma^2 - 4}; \quad p^R_1 = \frac{13\gamma - 8\alpha}{3(\gamma^2 + 4)} + \alpha - \frac{4\gamma}{3}$$
$$x^R_{VICP_2} = \frac{2(2\alpha\gamma + \gamma^4 - 3)}{3(\gamma^4 + 3\gamma^2 - 4)}; \quad x^R_1 = \frac{-3\alpha\gamma^2 - 4\alpha + 4\gamma^3 + 3\gamma}{3(\gamma^4 + 3\gamma^2 - 4)}. \tag{24}$$

Let's now characterize the equilibrium in which CP_1 accepts the offer.

$$H^A_{VICP_2} = \frac{\alpha^2 - 2\alpha\gamma - 2\gamma^2 + 3}{2\gamma^4 - 10\gamma^2 + 8}$$
$$\pi^A_{VICP_2} = -\frac{\alpha^2(\gamma^2 + 4) + 2\alpha(3\gamma^2 - 8)\gamma + 4\gamma^4 - 19\gamma^2 + 20}{2(\gamma^2 - 4)^2(\gamma^2 - 1)}$$
$$p^A_{VICP_2} = \frac{\gamma(\alpha + \gamma) - 2}{\gamma^2 - 4}; \quad p^A_1 = \frac{\alpha(\gamma^2 - 2) + \gamma}{\gamma^2 - 4}$$
$$x^A_{VICP_2} = \frac{2 - \gamma(\alpha + \gamma)}{\gamma^4 - 5\gamma^2 + 4}; \quad x^A_1 = -\frac{\alpha(\gamma^2 - 2) + \gamma}{\gamma^4 - 5\gamma^2 + 4}. \tag{25}$$

Comparing π^A_1 to π^R_1 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 for the integrated firm to offer zero-rating to unaffiliated CP_1 because $\pi^A_{VICP_2} - \pi^R_{VICP_2} = -\frac{(-7\alpha\gamma^2+4\alpha-2\gamma^5+5\gamma^3)^2}{6(\gamma^2+4)(\gamma^4-5\gamma^2+4)^2} < 0$ 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 $\pi^R_{VICP_1} - \pi^R_{VICP_2} = \frac{(\alpha^2-1)(4(\gamma^4+\gamma^2)-11)}{6(\gamma^4+3\gamma^2-4)} > 0$ 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.[23]

Corollary 2. *When there is no monetary transfer, vertical integration between ISP and high quality CP makes low quality CP worse off because it deprives low quality CP of the chance to be the only one zero-rated CP.*

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 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

First, the fee r_2^{VI} is determined at $\pi_2^A - \pi_2^R$, which means r_2^{VI} is positive under the interior solution assumption. Also, the integrated firm's profit from full zero-rating with r_2^{VI} (which means *A*ccept) is always greater than that from no zero-rating (which means *R*eject) if content

[23] 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.

is sufficiently independent. That is, there exists a threshold on γ, γ_{VICP_1}, below which $\widehat{\pi}^A_{VICP_1} - \pi^R_{VICP_1} > 0$ is guaranteed where $\widehat{\pi}$ denotes the profit with monetary transfer.[24] Thus, when there is a monetary transfer, full zero-rating occurs in vertical integration equilibrium if $\gamma < \gamma_{VICP_1}$ and for the range of $\gamma > \gamma_{VICP_1}$, the integrated firm refuses to zero-rate its rival's content. It is also easy to show that a fee that CP_2 wants to pay for zero-rating is always positive, which implies that even if the unaffiliated low quality CP, CP_2, is willing to pay a positive fee to be zero-rated, the integrated firm does not want to zero-rate its rival's content.

5.2.2 Integrated with CP_2 who provides lower quality of content

We can show that $\widehat{\pi}^A_{VICP_2} - \pi^R_{VICP_2} > 0$ 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 $\max\{\widehat{\pi}^A_{VICP_1}, \pi^R_{VICP_1}\} > \widehat{\pi}^A_{VICP_2}$. 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 γ, 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 ($\gamma < \gamma_{VICP_1}$), the integrated firm wants to zero-rate its unaffiliated CP in exchange for a positive fee. If content is sufficiently substitutable ($\gamma > \gamma_{VICP_1}$), no zero-rating deal is made.*

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 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

[24] γ_{VICP_1} is the solution to $\widehat{\pi}^A_{VICP_1} - \pi^R_{VICP_1} = 0$. Under $\alpha = 2$, $\gamma_{VICP_1} \approx 0.4775$.

to pay for zero-rating becomes smaller as γ becomes larger. More importantly, the unaffiliated low quality CP's content is not zero-rated though it always wants to zero-rate at a positive fee.

In other words, unlike in the no vertical integration game, the integrated firm does not want to pay a subsidy since it is less willing to have 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. The following Proposition 6 summarizes this finding.

Proposition 6. *When there is monetary transfer for zero-rating, vertical integration between the ISP and high quality CP might keep the unaffiliated low quality CP from being zero-rated even if it wants to pay a positive fee for zero-rating. Thus, full zero-rating case is less likely to emerge in equilibrium due to the vertical integration.*

5.3 Comparison – with and without monetary transfer

We have shown that no monetary transfer situation takes low quality CP's opportunity to be zero-rated due to vertical integration between the ISP and high quality CP and the resulting content foreclosure. Allowing monetary transfer, however, lets low quality CP's customers enjoy zero-rating service for some range of γ, which makes low quality CP gain more market share. The following Corollary summarizes this finding.

Corollary 3. *Under the vertical integration game, monetary transfer for zero-rating can make the unaffiliated low quality CP better off in terms of market share.*

6 Welfare Analysis

In this section, we 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.

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, we compare total social welfare levels under those two scenarios.

$$SW^R_{VICP_1} - SW_{ZR_2} = \underbrace{[\pi^R_{VICP_1} - \pi^{ZR_2}_{ISP} - \pi^{ZR_2}_1]}_{(+)} + \underbrace{[\pi^R_2 - \pi^{ZR_2}_2]}_{(-)} > 0 \tag{26}$$

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 under the no vertical integration game, 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 the fee for zero-rating is much higher under the vertical integration game than the other. Proposition 7 summarizes the finding.

Proposition 7. *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 low quality CP suffers from a lower profit under the integration due to higher fee for zero-rating.*

7 Policy Implications

As shown so far, the impacts of zero-rating on low quality CP and the society as a whole depend on the market structure. One of the controversial issues regarding zero-rating is whether sponsored data plan for zero-rating should be allowed. First of all, allowing sponsored data plan can be socially desirable since it induces full zero-rating which attains the greatest social welfare level.

However, more important issue is whether vertical affiliation between the ISP and CP combined with zero-rating poses any anticompetitive effect — if so, the lack of content market competition would make consumers worse off in the long run. As we showed before, low quality CP is the one suffering from lower profit and market share if monetary transfer for zero-rating and vertical integration are allowed. Given that entrant CPs are more likely to provide low quality content due to their limited resources, such market behaviors in conjunction with zero-rating can harm those entrants, which generates anticompetitive threats. Thus, focusing on a situation where vertically integrated firm tries to charge a positive fee for zero-rating, we draw context-specific policy remedies which induce full zero-rating equilibrium (which is welfare-enhancing) but do not disproportionately harm low quality market entrant CP.

7.1 Imposing a cap on fees for zero-rating

Comparing the equilibrium fee that CP_2 pays for zero-rating under the no vertical integration game, denoted as r_2^{FZ}, to that under the vertical integration game, denoted as r_2^{VI}, it is easy to show that $r_2^{FZ} < r_2^{VI}$. This implies that the unaffiliated low quality CP is harmed due to the vertical integration because it needs to pay much higher fee for the same zero-rating service. A policy remedy which imposes a cap on fees for zero-rating can be implemented to protect the unaffiliated low quality CP while attaining full zero-rating equilibrium. For example, policy makers can require the integrated firm not to charge any higher fee for zero-rating than the fee which it would charge without the integration as one of the merger conditions. By doing so, we can guarantee that the unaffiliated CP would not pay excessive amount of money to be zero-rated.

7.2 Government subsidies

As shown in Subsection 4.3.2, if there is no vertical affiliation and content is sufficiently substitutable, the ISP is willing to pay a positive subsidy to low quality CP to attain full zero-rating. However, if the ISP and high quality CP form a vertical integration, the integrated firm is less likely to have full zero-rating, which leads to less socially desirable situation.

If this is the case, government may want to pay a subsidy to the integrated firm, which induces it to have full zero-rating even after it takes the aggregate competitive effects into consideration. By doing so, consumers are more likely to benefit from full zero-rating.

8 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 a 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 for zero-rating. If the integrated firm can receive a fee for zero-rating, the integrated firm wants to zero-rate its rival's content as long as both CPs' content is sufficiently independent – vertical integration may not vertically foreclose its rival's content as long as there is a monetary transfer for zero-rating. From the welfare analysis, we also found that sponsored data plan which induces full zero-rating is welfare-enhancing. In addition, from total social welfare's perspective, vertical integration is the most socially desirable but it comes at the expense of the unaffiliated content provider which loses its market share and profit due to the integration.

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.[25]

[25] 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.

$$\pi_1^{ZR_1} - \pi_1^{NZ} = \frac{\frac{\left(\alpha\left(5-3\gamma^2\right)+(\gamma-2)\gamma-1\right)^2}{(2\gamma^2+\gamma-6)^2} - \frac{4\left(\gamma^2-2\right)^2\left(\alpha\left(2\gamma^2-3\right)+\gamma\right)^2}{(2\gamma^4-9\gamma^2+12)^2}}{4\left(\gamma^2-1\right)}$$
$$\pi_2^{ZR_2} - \pi_2^{NZ} = \frac{\frac{\left(-\alpha(\gamma-2)\gamma+\alpha+3\gamma^2-5\right)^2}{(2\gamma^2+\gamma-6)^2} - \frac{4\left(\gamma^2-2\right)^2(\gamma(\alpha+2\gamma)-3)^2}{(2\gamma^4-9\gamma^2+12)^2}}{4\left(\gamma^2-1\right)} \tag{27}$$

Both equations above are positive for $1 \leq \alpha \leq 2$ and $0 < \gamma < \tilde{\gamma}$, 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 π_{ISP}^{NZ} and π_{ISP}^{FZ}. First,

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

which is always positive. Second,

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

From Equation (29), we can see that $\pi_{ISP}^{ZR_2} < \pi_{ISP}^{NZ}$ if γ is sufficiently small whereas $\pi_{ISP}^{ZR_2} > \pi_{ISP}^{NZ}$ if γ is large enough. The threshold, which is denoted as γ_I, can be implicitly obtained as the solution satisfying $\pi_{ISP}^{ZR_2} - \pi_{ISP}^{NZ} = 0$. Lastly, we need to show that γ_I is always smaller than $\tilde{\gamma}$. By comparing the left-hand side of Equation $\pi_{ISP}^{ZR_2} - \pi_{ISP}^{NZ} = 0$ to that of $x_2^{NZ} = 0$, it is easy to see that the fixed point on γ satisfying $\pi_{ISP}^{ZR_2} - \pi_{ISP}^{NZ} = 0$ is smaller than that satisfying $x_2^{NZ} = 0$, which implies that $\gamma_I < \tilde{\gamma}$. □

Proof of Proposition 2. First, Equation (18) shows the equilibrium fee for each CP. Next, as in Equation (19), $\widehat{\pi}_{ISP}^{ZR_1} - \widehat{\pi}_{ISP}^{ZR_2}$ is greater than zero if $\gamma < \gamma_{PZ}$ where γ_{PZ} is the γ satisfying $\widehat{\pi}_{ISP}^{ZR_1} - \widehat{\pi}_{ISP}^{ZR_2} = 0$. It remains to show $\gamma_{PZ} < \tilde{\gamma}$ under our assumptions on α and γ. Note that

$\tilde{\gamma}$ is the solution satisfying $x_2^{NZ} = \frac{\alpha\left(\gamma^2-2\gamma-1\right)-3\gamma^2+5}{2(2\gamma^4+\gamma^3-8\gamma^2-\gamma+6)} = 0$. By comparing the left-hand side of Equation $\widehat{\pi}_{ISP}^{ZR_1} - \widehat{\pi}_{ISP}^{ZR_2} = 0$ to that of $x_2^{NZ} = 0$, it is easy to see that the fixed point on γ satisfying $\widehat{\pi}_{ISP}^{ZR_1} - \widehat{\pi}_{ISP}^{ZR_2} = 0$ is smaller than that satisfying $x_2^{NZ} = 0$, which implies that $\gamma_{PZ} < \tilde{\gamma}$.

□

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 $\gamma < \gamma_{Subsidy} = \frac{1}{2}\left(-\sqrt{\alpha^2-1}+\sqrt{2\alpha\left(\sqrt{\alpha^2-1}+\alpha\right)+7}-\alpha\right)$, $r_2^{FZ} > 0$. 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 γ satisfying $r_2^{FZ} = \frac{\frac{\left(\left(\gamma^2-2\right)^2-\alpha\gamma\right)^2}{\left(2\gamma^4-9\gamma^2+12\right)^2}-\frac{(\gamma(\alpha+\gamma)-2)^2}{\left(\gamma^2-4\right)^2}}{\gamma^2-1} = 0$. Also, $\tilde{\gamma} - \gamma_{Subsidy} = \frac{1}{2}\left(\sqrt{\alpha^2-1}-\sqrt{2\alpha\left(\sqrt{\alpha^2-1}+\alpha\right)+7}+\alpha\right)+\frac{\alpha-\sqrt{2(\alpha-4)\alpha+15}}{\alpha-3}$, which can be shown as positive.

□

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.

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

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. □

Proof of Corollary 1. First, we compare CP_2's profit levels and demand under monetary transfer scenario which leads to full zero-rating to those under no monetary transfer case which leads to zero-rating with CP_2.

$$\begin{aligned} \pi_2^{FZ} - \pi_2^{ZR_2} &= \frac{\frac{\left(\gamma^2-2\right)^2(\gamma(\alpha+2\gamma)-3)^2}{(2\gamma^4-9\gamma^2+12)^2} - \frac{(\gamma(\alpha+\gamma)-2)^2}{(\gamma^2-4)^2}}{\gamma^2-1} \\ x_2^{FZ} - x_2^{ZR_2} &= -\frac{\gamma\left(\alpha\left(\gamma^4-3\gamma^2+4\right)+2\gamma\left(\gamma^2-2\right)\right)}{2\gamma^8-19\gamma^6+65\gamma^4-96\gamma^2+48} \end{aligned} \tag{31}$$

After some algebra, it is easy to show that both equations above are negative for the interior solution assumption on γ. This implies that CP_2 suffers from lower market share and profit when monetary transfer is allowed. □

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 $\pi_2^A - \pi_2^R = \frac{\frac{\left(-\alpha\left(4\gamma^2+3\right)\gamma+3\gamma^2+4\right)^2}{(\gamma^2+4)^2} - \frac{9(\gamma(\alpha+\gamma)-2)^2}{(\gamma^2-4)^2}}{9(\gamma^2-1)} > 0$ 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 $\pi_1^A - \pi_1^R = \frac{\left(\alpha\left(\gamma^2-2\right)+\gamma\right)^2}{(\gamma^4-5\gamma^2+4)^2} + \frac{\left(3\alpha\gamma^2+4\alpha-4\gamma^3-3\gamma\right)^2}{9(\gamma^2-1)(\gamma^2+4)^2} > 0$. 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, $\pi_{VICP_1}^R - \pi_{VICP_2}^R = \frac{\left(\alpha^2-1\right)\left(4\left(\gamma^4+\gamma^2\right)-11\right)}{6(\gamma^4+3\gamma^2-4)} > 0$. □

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

□

Proof of Proposition 6. First, we need to show when r_2^{VI}, a fee that CP_2 pays to the integrated firm to be zero-rated, is positive, which means that CP_2 is willing to pay a positive fee for zero-rating.

$$r_2^{VI} = \pi^A - \pi^R = \frac{\frac{\left(-\alpha\left(4\gamma^2+3\right)\gamma+3\gamma^2+4\right)^2}{(\gamma^2+4)^2} - \frac{9(\gamma(\alpha+\gamma)-2)^2}{(\gamma^2-4)^2}}{9\left(\gamma^2-1\right)} \tag{32}$$

There exists a threshold on γ, denoted as $\gamma_{Subsidy}^{VI}$ above which r_2^{VI} is negative where $\gamma_{Subsidy}^{VI} =$

$\frac{\sqrt[3]{5\alpha^2+\sqrt{\alpha^4(2\alpha^2+25)}}}{2^{2/3}\alpha} - \frac{\alpha}{\sqrt[3]{2}\sqrt[3]{5\alpha^2+\sqrt{\alpha^4(2\alpha^2+25)}}}$ is the solution to $\pi^A - \pi^R = 0$.

To show that the integrated firm forecloses the unaffiliated CP's content by not zero-rating its content even if the unaffiliated CP is willing to pay for zero-rating, we need to prove that $\gamma_{VICP_1} < \gamma^{VI}_{Subsidy}$. Given that γ_{VICP_1} is determined at $\widehat{\pi}^A_{VICP_1} - \pi^R_{VICP_1} = 0$, it is sufficient to show that $\pi^A - \pi^R > \widehat{\pi}^A_{VICP_1} - \pi^R_{VICP_1}$. It is trivial to see that $(\pi^A - \pi^R) - (\widehat{\pi}^A_{VICP_1} - \pi^R_{VICP_1}) = \frac{\left(\gamma^2\left(\alpha\gamma\left(2\gamma^2-5\right)+7\right)-4\right)^2}{6(\gamma^2+4)(\gamma^4-5\gamma^2+4)^2}$ is always positive, which completes the proof. □

Proof of Corollary 3. Under the vertical integration game, the unaffiliated low quality CP (CP_2) is either not zero-rated (with no monetary transfer) or zero-rated (with monetary transfer). Comparing demand for CP_2 in each case, $x_2^A - x_2^R = \frac{8-2\gamma^2\left(\alpha\gamma\left(2\gamma^2-5\right)+7\right)}{3(\gamma^6-\gamma^4-16\gamma^2+16)}$, which is always positive for $\gamma \in (0,1)$. □

Proof of Proposition 7. 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.

$$\begin{aligned}
SW^R_{VICP_1} =& \frac{1}{18\left(\gamma^4+3\gamma^2-4\right)^2}\Big(3\left(\gamma^2+4\right)\left(\alpha^2\left(4\gamma^6-18\gamma^2+15\right)+2\alpha\gamma\left(5\gamma^2-6\right)-3\gamma^2+4\right) \\
&- 2\left(\gamma^2-1\right)\left(-\alpha\left(4\gamma^2+3\right)\gamma+3\gamma^2+4\right)^2\Big) \\
SW_{ZR_2} =& \frac{-1}{2\left(\gamma^2-1\right)\left(2\gamma^4-9\gamma^2+12\right)^2}\Big(\alpha^2\left(\gamma^2-2\right)^2\left(4\gamma^4-15\gamma^2+20\right) \\
&+ 2\alpha\left(4\gamma^6-26\gamma^4+57\gamma^2-44\right)\gamma+8\gamma^8-60\gamma^6+170\gamma^4-217\gamma^2+108\Big)
\end{aligned} \tag{33}$$

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).

$$SW^{A}_{VICP_1} - SW_{FZ} = -\frac{\left(\alpha\left(\gamma^2-2\right)+\gamma\right)^2}{\left(\gamma^2-4\right)^2\left(\gamma^2-1\right)}$$

$$SW^{R}_{VICP_1} - SW_{FZ} = \frac{1}{18\left(\gamma^4+3\gamma^2-4\right)^2}\Big(3\left(\gamma^2+4\right)\left(\alpha^2\left(4\gamma^6-18\gamma^2+15\right)+2\alpha\gamma\left(5\gamma^2-6\right)-3\gamma^2+4\right)$$
$$-2\left(\gamma^2-1\right)\left(-\alpha\left(4\gamma^2+3\right)\gamma+3\gamma^2+4\right)^2\Big)+\frac{9\left(2\left(\alpha^2+1\right)\gamma^4-9\left(\alpha^2+1\right)\gamma^2+12\left(\alpha^2+1\right)+6\alpha\gamma^3-16\alpha\gamma\right)}{\left(\gamma^2-4\right)^2\left(\gamma^2-1\right)} \tag{34}$$

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

Also, we need to show that the equilibrium fee that CP_2 pays for zero-rating under the vertical integration game, denoted as r_2^{VI}, is much higher thant that under the no vertical integration game, denoted as r_2^{FZ}. First, $r_2^{VI} - r_2^{FZ}$ can be simplified as follows.

$$r_2^{VI} - r_2^{FZ} = \frac{1}{9\left(\gamma^2-1\right)\left(-2\gamma^6+\gamma^4+24\gamma^2-48\right)^2}\Big[\gamma\left(2\alpha\left(4\gamma^6-15\gamma^4+9\gamma^2+12\right)-3\gamma^5+19\gamma^3-36\gamma\right)$$
$$\times\left(\gamma(\alpha(8\gamma^6-30\gamma^4+24\gamma^2+48)-9\gamma^5+19\gamma^3+36\gamma)-96\right)\Big] > 0 \quad \text{if} \quad \gamma \in (0, \tilde{\gamma}) \tag{35}$$

□