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# Zero-Rating and Vertical Content Foreclosure*

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July 2019

**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 an ISP zero-rates its own vertically integrated content, because the data limit and ensuing overage charges impose an additional cost on rival content. We find that zero-rating and vertical integration are complementary in improving social welfare, though potentially at the expense of lower profit to an unaffiliated content provider. Moreover, allowing content providers to pay for zero-rating via a sponsored data plan raises welfare by inducing the ISP to zero-rate more content.

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

**JEL Classification Numbers:** D43; L11; L42

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# 1 Introduction

Internet service providers (ISPs) offer subscribers a menu of service plans, many of which consist of a periodic fee and overage charges that apply when exceeding a predetermined limit or cap on data consumption (Nevo, Turner, Williams, 2016). 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 additional gigabytes of data beyond the preset amount.[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. T-Mobile's "Binge On" allows consumers to watch unlimited HBO, Hulu, Netflix, Sling, and other content without eating into their data allowances. To offer the service, T-Mobile reduces video quality to 480p+ for zero-rated content, though it does not charge content providers affiliated with this service.[3] In contrast, under the now defunct "Go90" sponsored data program, Verizon charged content providers to zero-rate their content.[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, 2018b ¶¶15-17).

[2] For example, Comcast 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] T-Mobile, Binge On. Available at https://www.t-mobile.com/offer/binge-on-streaming-video.html.

[4] Spangler, T. "Verizon is Shutting Down Go90, Its Ill-Fated Mobile Video Service." *Variety*. June 28, 2018. Available at https://variety.com/2018/digital/news/go90-shutting-down-verizon-1202860864/.

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] After the FCC abandoned net neutrality (FCC 2018a), California unveiled broad net neutrality legislation which, among other things, sought to ban zero-rating and sponsored data.[7] The California legislation is presently being challenged by the U.S. Justice Department.[8]

Regulations in various countries outside the U.S. have likewise curtailed zero-rating. In 2016, India prohibited data service providers from offering or charging different prices for data—even if offered for 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.[9] Similarly, regulators in Canada, Chile, Norway, the Netherlands, and Slovenia have made explicit state-

[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 (FCC, 2015), 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]See California SB-822. Available at https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB822. The California legislation goes further than the FCC's (2015) Open Internet Order, which did not explicitly prohibit zero-rating (Koning and Yankelevich, 2018).

[8]Kang C. "Justice Department Sues to Stop California Net Neutrality Law." The New York Times. September 30, 2018. Available at https://www.nytimes.com/2018/09/30/technology/net-neutrality-california.html.

[9]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. India went on to ban almost any form of discrimination or interference in data. Robertson, A. "India just approved net neutrality rules that ban "any form" of data discrimination." The Verge. July 11, 2018. Available at https://www.theverge.com/2018/7/11/17562108/india-department-of-telecommunications-trai-net-neutrality-proposal-approval.

ments 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.

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 content 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 access to content from two asymmetric CPs using a two-part tariff consisting of a hookup fee $H$ and a linear data overage charge $\tau$.[10] We view CPs as asymmetric in content quality, but also view their content as 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 between the ISP and CPs. We find that zero-rating leads to two opposing effects on an 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 the 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, in equilibrium, the ISP zero-rates the lower quality CP to take advantage of the higher overage charge that it can set for higher quality content. A zero-rating equilibrium only emerges under a sufficiently large level of substitutability. The intuition is that if the ISP zero-rates any content when content is highly differentiated (low level of substitutability), the loss to the ISP from an overage charge that could be charged on low quality content is relatively large: there are distinct demands for

[10] Ordinarily, consumers face a three-part tariff that stipulates a periodic fee, a marginal price of zero for usage below a cap, and a positive marginal cost for data consumption exceeding the cap (Nevo, Turner, Williams, 2016). Because consumers in our model are homogenous and our focus on zero-rating implies that we are distinctly interested in equilibria where consumers exceed the cap, as we show in the Appendix, our two-part tariff setup is without loss of generality. Put differently, we assume that the data cap is set to zero. Our setup also applies directly to pay-as-you-go plans. For instance, Vodafone Pass provides German subscribers free data toward certain online services at a fixed cost.

both CPs regardless of content quality. Consequently, the ISP chooses not to zero-rate to take advantage of consumers' relatively inelastic demand.

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 increases the ISP's incentive to lead to full zero-rating. As content becomes more substitutable, however, the low quality CP loses its incentive to pay a positive fee. When substitutability is sufficiently high, the ISP instead pays a subsidy to the low quality CP to induce full zero-rating, which softens content price competition, permitting the ISP to more than make up for the subsidy with a higher fee to the high quality CP.

In Section 5, we permit the ISP platform to integrate with one of the CPs. In general, the ISP optimizes by vertically integrating with the high quality CP and zero-rating its content to profit from revenue tied to the sale of content. Moreover, without a monetary transfer, the integrated firm only wants to zero-rate its affiliated content while optimally not zero-rating the rival's content in an attempt to vertically foreclose the 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. If full zero-rating does not emerge, the low quality CP is left worse off under vertical integration.

We also find that full zero-rating tends to lead to the highest level of social welfare. Zero-rating softens content competition, but ultimately leads consumers to pay less per unit of content (by reducing the overage charge to zero) and to consume more. 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. Additionally, vertical integration is welfare-enhancing due to elimination of double marginalization on content, but possibly at the expense of the unaffiliated CP, if it does not likewise receive a zero-rating offer.

## 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.[11] Using a variant of the model 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 lower content subscription fees. Zero-rating then allows the ISP to fine-tune how it wants different CPs to behave by adjusting its pricing to consumers. This allows the ISP to discriminate among different CPs without actually charging the CPs different prices for termination.

Our work is most closed related to the work of Jullien and Sand-Zantman (2018) and Somogyi (2017), who also use economic models of two-sided markets to analyze zero-rating.[12] Both Jullien and Sand-Zantman (2018) and Somogyi (2017) model an ISP that intermediates traffic between consumers and CPs who receive benefits proportional to consumer traffic, but do not charge for content. Jullien and Sand-Zantman (2018) 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.

Somogyi (2017) models zero-rating explicitly as a three-part tariff. 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.[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).

[11] 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.

[12] Additionally, Koning and Yankelevich (2018) briefly analyze zero-rating using a standard model of vertically integrated firms who supply their rivals.

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

Our model differs from both those of Jullien and Sand-Zantman (2018) and Somogyi (2017) along a number of important dimensions. First, in contrast to Jullien and Sand-Zantman (2018), 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, 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 by major ISPs like AT&T and Comcast, who are also substantial content owners, to vertical foreclose rival content.

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; Jeitschko and Tremblay, 2018), 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 and Choi and Kim (2010) and Cheng, Bandyopadhyay, and 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, and Valletti, 2015).[15]

As we have already pointed out, paid prioritization differs from zero-rating from both a

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

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

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 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

Our model consists of two content providers (CPs), one Internet service provider (ISP), and a unit mass of homogenous consumers. A consumer who has decided to connect to the platform chooses the amount of content to purchase from each CP. The content provided by the two CPs may be substitute or independent goods with degree of content substitutability $\gamma$. The utility for each consumer is defined by a variation of the typical quadratic utility function.

$$u = \left[\alpha_1 x_1 - \frac{1}{2}x_1^2 + \alpha_2 x_2 - \frac{1}{2}x_2^2 - \gamma x_1 x_2\right] - H - \sum_{n=1}^{2} p_n x_n - \tau \max\left\{0, \sum_{n=1}^{2} x_n \mathbb{1}_n\right\}, \tag{1}$$

where $\alpha_n$ denotes content quality provided by CP $n$ (henceforth $\text{CP}_n$), $x_n$ is the amount of content provided by $\text{CP}_n$, $H$ is a hookup fee charged by the ISP, $p_n$ is $\text{CP}_n$'s subscription fee, $\tau$ is a per unit "overage" charge set by the ISP, and $\mathbb{1}_n$ is an indicator that takes the value one if $\text{CP}_n$ is not zero-rated and 0 if it is zero-rated. This utility formulation simplifies the model of Economides and Hermalin (2015) along one dimension and complicates it along another. First, we abstract from the analysis of congestion externalities, which could, in principle, lead to second order effects from zero-rating. Second, unlike Economides and Hermalin (2015), we use $\gamma$ to permit content to be ex-ante substitutable, which we show has important implications for zero-rating.

At the outset of the game, the ISP chooses a hookup fee $H$, an overage charge $\tau$,[16] and zero-rating offers, if any.[17] Consumers do not face usage charges from zero-rated CPs. Additionally,

[16]As discussed in Section 1, we consider a two-part tariff rather than a three-part tariff with a data cap overages apply. As such, the overage charge might alternatively be referred to as a per unit data usage charge.

[17]As discussed in Section 1, we are interested in equilibria where consumers exceed the cap, so that the two-part tariff setup is without loss of generality. In the Appendix, we show that if we model a three-part tariff

we assume that ISPs don't charge CPs for content termination. This has been a prevailing norm under net neutrality regulation, which continues to be debated in the United States and enforced in various other nations.[18]

In the second stage of the game, each CP decides whether to accept the ISP's zero-rating offer, if any. If it accepts the offer, the overage charge $\tau$ is exempted for its content. Then, CPs set their profit maximizing content prices $p_n$. We assume that CPs face zero marginal costs for providing content.

To economize on notation, we normalize $\alpha_2$ to one and denote $\alpha_1$ as $\alpha$ throughout the remainder of paper. We further assume that $1 \leq \alpha \leq 2$. This condition implies that the quality of $CP_1$'s content is no lower and up to twice as high as that of $CP_2$'s content. By permitting asymmetric CPs, we are able to explore how relative content quality influences ISP zero-rating decisions.

In what follows, we restrict $\gamma$ to guarantee that both CPs have positive market shares in equilibrium (i.e., interior solutions). As we show, this requires $\gamma$ sufficiently low so that consumers continue to buy lower quality content. Thus, content is generally not perfectly substitutable.

# 4 No vertical integration

We first analyze the equilibrium without vertical integration. We consider three alternative scenarios: (1) no zero-rating, (2) zero-rating without monetary transfers, and (3) zero-rating with monetary transfers (sponsored data). 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. When permitted, the ISP first announces which CP(s) to zero-rate, if any. Then, it sets prices, the hookup fee, and the overage charge. Next, CPs decide whether to accept the ISP's zero-rating offer and announce per unit content subscription fees. Finally, consumers decide how much content to consume from each CP. We use backward

with a positive data cap, the equilibrium always leads to a zero overage charge $\tau$. In other words, a positive cap is only optimal if it does not bind.

[18] As Koning and Yankelevich (2018) explain, ISPs may alternatively charge CPs for interconnection. Whereas termination fees apply to delivery of content to the end user, interconnection pertains to CPs' ability to access the Internet. Because of our interest in the market to end users, we abstract from interconnection pricing, treating interconnection as a sunk cost incurred by CPs prior to the start of our game.

induction to solve for the subgame perfect Nash equilibrium (SPNE) of this game.[19]

### 4.1 No zero-rated content

In this section, we derive the equilibrium when the ISP chooses not to zero-rate. Given $H$, $\tau$, and CP prices $p_1$ and $p_2$, the consumer chooses $x_1$ and $x_2$ to maximize utility Expression (1). The resulting $x_n$ for each CP$_n$ are:

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

In Stage 2, given $H$, $\tau$, and consumer demand Equation (2), CP$_n$ maximizes $p_n x_n(p_1, p_2, \tau)$ to obtain equilibrium prices:

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

This leads to the following equilibrium market share for each CP as functions of $\tau$:

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

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

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

The ISP's profit, $\pi_{ISP}(\tau) = H(\tau) + \tau[x_1(\tau) + x_2(\tau)]$, equals

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

Maximizing $\pi_{ISP}$ with respect to $\tau$, yields the equilibrium outcome; where the superscript

[19] Note that the order of moves in the ISP's decision stage does not matter. That is, the same equilibria prevail in the game in which all ISP decisions are simultaneous.

$NZ$ denotes an equilibrium without zero-rating.

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

Because $\alpha \geq 1$ by assumption (i.e., $CP_1$ has higher quality), the demand for content is weighted towards $CP_1$ for $\gamma$ sufficiently high. As $\gamma$ increases, which means that content becomes more substitutable, consumers gravitate toward $CP_1$. Moreover, for $\gamma$ high enough, if $p_2$ is positive, there is a threshold level of $\gamma$ above which consumers will not choose $CP_2$'s content at all. To guarantee interior solutions (whereby $p_2^{NZ}$ and $x_2^{NZ}$ are positive), we suppose that $\gamma$ falls below the following threshold:

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

This interior solution condition on $\gamma$ is assumed to be satisfied throughout the paper.[20]

## 4.2 Zero-rated content without monetary transfers

### 4.2.1 Partial zero-rated content

Suppose that at the outset, the ISP instead 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 the consumer's utility maximization problem is given by

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

[20]For example, if $\alpha = 2$, $\tilde{\gamma} \approx 0.645751$. This condition is sufficient to guarantee existence of an interior solution in the remaining scenarios analyzed in Section 4. The Appendix contains a proof of this result.

which differs from Expression (2) in that $\tau$ now only enters demand for $\text{CP}_1$, namely $x_1$, indirectly through its effect on $\text{CP}_2$.

Working backward, maximizing CPs' profits with respect to content prices and then solving for the ISP's hookup fee and overage charge yields the following equilibrium outcome.

$$\begin{aligned}
&\tau^{ZR_1} = \frac{2\alpha\gamma(\gamma^2-2)+(4-3\gamma^2+\gamma^4)}{12-9\gamma^2+2\gamma^4};\\
&H^{ZR_1} = \frac{\alpha^2(-36+59\gamma-28\gamma^4+4\gamma^6)+2\alpha\gamma(-8+18\gamma^2-11\gamma^4+2\gamma^6)+(3\gamma^2-4)(\gamma^2-2)^2}{2(\gamma^2-1)(12-9\gamma^2+2\gamma^4)^2};\\
&\pi_{ISP}^{ZR_1} = \frac{\alpha^2(2\gamma^2-3)+2\alpha\gamma-(\gamma^2-2)^2}{2(\gamma^2-1)(12-9\gamma^2+2\gamma^4)};\\
&p_1^{ZR_1} = \frac{(\gamma^2-2)[\alpha(2\gamma^2-3)+\gamma]}{12-9\gamma^2+2\gamma^4};\quad p_2^{ZR_1} = \frac{-\alpha\gamma+(\gamma^2-2)^2}{12-9\gamma^2+2\gamma^4};\\
&x_1^{ZR_1} = \frac{(\gamma^2-2)[\alpha(2\gamma^2-3)+\gamma]}{(1-\gamma^2)(12-9\gamma^2+2\gamma^4)};\quad x_2^{ZR_1} = \frac{-\alpha\gamma+(\gamma^2-2)^2}{(1-\gamma^2)(12-9\gamma^2+2\gamma^4)}.
\end{aligned} \tag{10}$$

Similarly, the equilibrium outcome when the ISP makes a deal with $\text{CP}_2$ is given by:

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

where the superscripts $ZR_1$ and $ZR_2$ denote, respectively, zero-rating outcomes with respect to $\text{CP}_1$ and $\text{CP}_2$.

#### 4.2.2 Full zero-rated content

Next, consider a scenario with full zero-rating, meaning that the ISP zero-rates all content provided by both CPs. Under full zero-rating, the market share for each CP as a function of

CP prices, $p_1$ and $p_2$, reduces to

$$x_1(p_1,p_2) = \frac{\gamma - \alpha - \gamma p_2 + p_1}{\gamma^2 - 1}; \quad x_2(p_1,p_2) = \frac{\alpha\gamma - 1 - \gamma p_1 + p_2}{\gamma^2 - 1}, \tag{12}$$

because $\tau = 0$.

Proceeding as in the previous sections, the equilibrium outcome is:

$$\begin{aligned} H = \pi_{ISP}^{FZ} &= \frac{2\alpha\gamma^3 + (\alpha^2+1)(3\gamma^2-4)}{2(\gamma^2-4)^2(\gamma^2-1)}; \\ p_1^{FZ} &= \frac{\alpha(\gamma^2-2)+\gamma}{\gamma^2-4}; \quad p_2^{FZ} = \frac{(\gamma^2-2)+\alpha\gamma}{\gamma^2-4}; \\ x_1^{FZ} &= -\frac{\alpha(\gamma^2-2)+\gamma}{\gamma^4-5\gamma^2+4}; \quad x_2^{FZ} = -\frac{(\gamma^2-2)+\alpha\gamma}{\gamma^4-5\gamma^2+4}, \end{aligned} \tag{13}$$

where the superscript $FZ$ denotes full zero-rating.

### 4.2.3 Equilibrium

Before we characterize the equilibrium of the full game without transfers for zero-rating, we first note that a comparison of ISP profits under full zero-rating with no or partial zero-rating indicates that full zero-rating is strictly dominated and so will not be part of the SPNE outcome. Zero-rating permits content providers to raise prices, because as in Economides and Hermalin (2015), the overage charge, $\tau$, serves as an excise tax that is split between consumers and CPs. By not offering zero-rating, the ISP forces down content prices and benefits from the incremental consumption this generates through a combination of $\tau$ and hookup fee $H$.[21] As we next show, depending on the values of the underlying parameters, either partial zero-rating or no zero-rating emerges in equilibrium.

Suppose that the ISP offers to zero-rate $CP_1$. To see whether $CP_1$ accepts the zero-rating offer, it suffices to compare $CP_1$'s profits with partial and no zero-rating. $CP_1$ accepts if and only if

$$\pi_1^{NZ} = \frac{[\alpha(5-3\gamma^2)+(\gamma^2-2\gamma-1)]^2}{4(1-\gamma^2)(2\gamma^2+\gamma-6)^2} \leq \frac{(-2+\gamma^2)^2[\alpha(2\gamma^2-3)+\gamma]^2}{(1-\gamma^2)(12-9\gamma^2+2\gamma^4)^2} = \pi_1^{ZR_1}. \tag{14}$$

[21] We note that quantity demanded is greater under zero-rating because, although content prices are higher, consumers do not pay overage charge $\tau$.

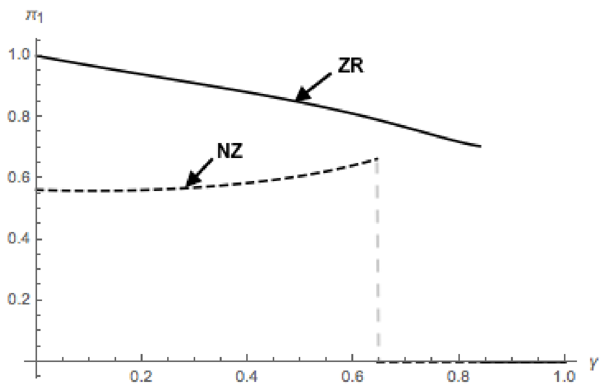


Figure 1: $CP_1$'s profit as a function of $\gamma$ when $\alpha = 2$

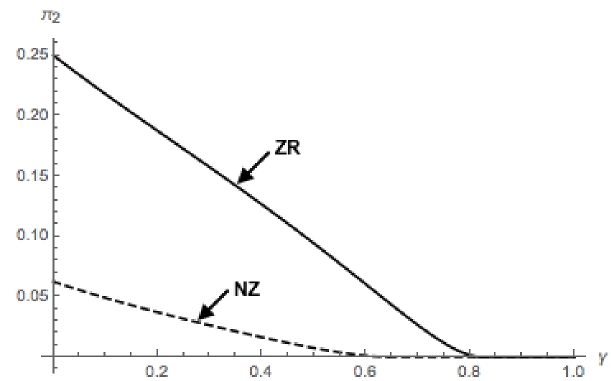


Figure 2: $CP_2$'s profit as a function of $\gamma$ when $\alpha = 2$

Although there is no closed form solution for $\gamma$ that 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 condition for an interior solution given by Expression (8) holds. Building on similar logic, Figure 2 shows that $CP_2$ always accepts a zero-rating offer when Expression (8) holds. In other words, CPs accept the ISP's zero-rating offer whenever their content is sufficiently independent compared to one another.

Given that CPs accept the offer, it remains to be shown which CP the ISP offers to zero-rate. This reduces to the following profit comparison:

$$\pi_{ISP}^{ZR_1} - \pi_{ISP}^{ZR_2} = \frac{(\alpha^2 - 1)(\gamma^2 - 1)}{24 - 18\gamma^2 + 4\gamma^4} < 0 \quad \forall \alpha \geq 1. \tag{15}$$

Thus, if the ISP chooses only one of the CPs to zero-rate without monetary transfers, it chooses $CP_2$ regardless of $\gamma$, taking advantage of the higher overage charge that consumers pay for $CP_1$'s content.

Lastly, given that the ISP offers a deal to $CP_2$ and $CP_2$ accepts, i.e., $\gamma$ is sufficiently small, it is necessary to determine whether the ISP has an incentive to make the offer in the first place by comparing its profit under no zero-rating to that under partial zero-rating of $CP_2$.

As shown in the proof of Proposition 1, $\pi_{ISP}^{ZR_2} < \pi_{ISP}^{NZ}$ 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 (proven in the Appendix) summarizes this finding.[22]

[22]Under the same numerical example of $\alpha = 2$, the relevant thresholds on $\gamma$ which constitute Proposition 1

**Proposition 1.** *When there is no monetary transfer for zero-rating, the ISP offers to zero-rate 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. Thus, zero-rating with low quality $CP_2$ occurs for $\gamma \in (\gamma_I, \tilde{\gamma})$.*

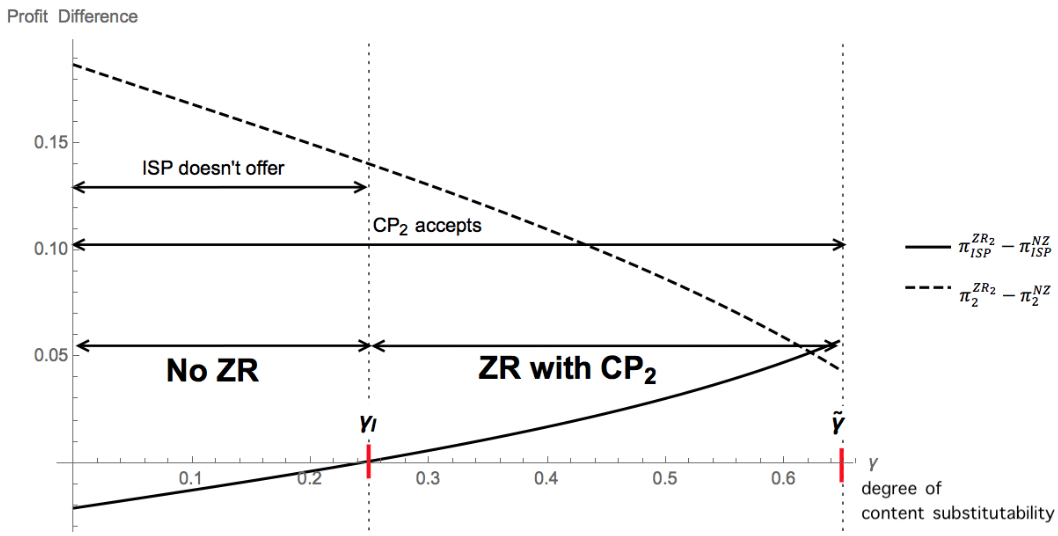


Figure 3: Solid upward sloping curve is the ISP's profit difference between zero-rating with $CP_2$ and no zero-rating and dashed downward sloping curve is $CP_2$'s profit difference between being zero-rated and not zero-rated when $\alpha$=2

The intuition for this finding is as follows. If the ISP zero-rates $CP_2$'s content, the ISP's total profit is the sum of the hookup fee, which depends on total content demand, $x_1 + x_2$, and the overage charge from consumers of $CP_1$ only. There is distinct demand for each type of content because content is sufficiently differentiated, so that even lower quality $CP_2$ has relatively large demand. In this case, the profit loss to the ISP from eliminating the overage charge that would be paid by $CP_2$'s subscribers, $\tau x_2$, is large enough to prevent the ISP from offering zero-rating in the first place. This is similar to the outcome in Economides and Hermalin (2015), where $\gamma$ is implicitly zero. Consequently, the ISP chooses not to zero-rate to take advantage of consumers' relatively inelastic demand when CPs' content is relatively independent. Conversely, when $\gamma > \gamma_I$, high quality content displaces low quality content to a large enough degree that lowering the cost to consumers of that content (through zero-rating) bolsters demand and permits the ISP to more than recoup lost profits through the hookup fee.

are $\gamma_I = 0.237235$ and $\tilde{\gamma} = 0.645751$.

## 4.3 Zero-rated content with monetary transfers (sponsored data)

Suppose now that monetary transfers between the ISP and CPs may accompany zero-rating. This is the case of sponsored data. Assume that the ISP can make a take-it-or-leave-it zero-rating offer to CPs. Table 1 represents each CP's profit, with the profit to the left(right) of each comma representing that of $CP_1$($CP_2$) and $r_1$ and $r_2$ representing transfers to the ISP (with superscripts following the convention in Section 4.2).

There are two different levels of equilibrium fees depending on the rival CPs' decision; that is, the fee in which the rival also accepts a zero-rating offer is different from that in which the rival rejects the offer. As such, we analyze partial and full zero-rating separately.

Table 1: CP's Equilibrium Profits Following Zero-Rating Offers

| | | $CP_2$ Accept | $CP_2$ Reject |
|---|---|---|---|
| $CP_1$ | Accept | $\frac{-[\alpha(\gamma^2-2)+\gamma]^2}{(\gamma^2-4)^2(\gamma^2-1)} - r_1^{FZ}, \frac{-[(\gamma^2-2)+\alpha\gamma]^2}{(\gamma^2-4)^2(\gamma^2-1)} - r_2^{FZ}$ | $\frac{-(\gamma^2-2)^2[\alpha(2\gamma^2-3)+\gamma]^2}{(\gamma^2-1)(2\gamma^4-9\gamma^2+12)^2} - r_1^{PZ_1}, -\frac{[\alpha\gamma-(\gamma^2-2)^2]^2}{(\gamma^2-1)(2\gamma^4-9\gamma^2+12)^2}$ |
| | Reject | $\frac{-[\alpha(\gamma^2-2)^2-\gamma]^2}{(\gamma^2-1)(2\gamma^4-9\gamma^2+12)^2}, \frac{-(\gamma^2-2)^2[(2\gamma^2-3)+\alpha\gamma]^2}{(\gamma^2-1)(2\gamma^4-9\gamma^2+12)^2} - r_2^{PZ_2}$ | $\frac{-\{\alpha(3\gamma^2-5)+[1-(\gamma-2)\gamma]\}}{4(\gamma^2-1)(2\gamma^2+\gamma-6)^2}, \frac{-\{(5-3\gamma^2)+\alpha[(\gamma-2)\gamma-1]\}^2}{4(\gamma^2-1)(2\gamma^2+\gamma-6)^2}$ |

### 4.3.1 Partial zero-rated content

If the ISP zero-rates only one of the CPs' content, the fixed fee charged to each CP must satisfy:

$$\begin{aligned} r_1^{PZ_1} &\leq \pi_1^{ZR_1} - \pi_1^{NZ} = -\frac{(\gamma^2-2)^2\left[\alpha\left(2\gamma^2-3\right)+\gamma\right]}{(\gamma^2-1)\left(2\gamma^4-9\gamma^2+12\right)^2} + \frac{\{\alpha\left(3\gamma^2-5\right)+[1-(\gamma-2)\gamma]\}}{4\left(\gamma^2-1\right)\left(2\gamma^2+\gamma-6\right)^2} \\ r_2^{PZ_2} &\leq \pi_2^{ZR_2} - \pi_2^{NZ} = -\frac{(\gamma^2-2)^2\left[(2\gamma^2-3)+\alpha\gamma\right]}{(\gamma^2-1)\left(2\gamma^4-9\gamma^2+12\right)^2} + \frac{\{(5-3\gamma^2)+\alpha[(\gamma-2)\gamma-1]\}}{4\left(\gamma^2-1\right)\left(2\gamma^2+\gamma-6\right)^2}. \end{aligned} \tag{16}$$

The reference point for each CP to decide whether or not to accept the offer is its profit from no zero-rating. Assuming that CPs accept the offer, it remains to be shown to which CP the ISP makes the offer. To check this, we compare the ISP's profit under zero-rating with $CP_1$ to that under zero-rating with $CP_2$. For notational convenience, we use $\widehat{\pi}$ to denote profits with monetary transfers.

$$\widehat{\pi}_{ISP}^{ZR_1} - \widehat{\pi}_{ISP}^{ZR_2} = -\frac{(\alpha^2-1)(\gamma-2)(\gamma+1)(2\gamma+3)\{\gamma\{[2\gamma(\gamma+1)-15]\gamma^2+\gamma+24\}-12\}}{2\left(2\gamma^2+\gamma-6\right)\left(2\gamma^4-9\gamma^2+12\right)^2}. \tag{17}$$

We find that $\widehat{\pi}_{ISP}^{ZR_1} - \widehat{\pi}_{ISP}^{ZR_2}$ is greater than zero if $\gamma$ is sufficiently small whereas the reverse holds otherwise. Thus, as content becomes more differentiated, the ISP has a greater incentive to make a deal with $CP_1$. In other words, unlike in the case with no monetary transfers for zero-rating, the ISP offers the deal to $CP_1$ over a certain range of $\gamma$ and to $CP_2$ over the remaining range below $\tilde{\gamma}$. Therefore, when there is a monetary transfer for zero-rating, one needs to compare the ISP's profit under no zero-rating to the ISP's profit under zero-rating with $CP_1$ and $CP_2$ over the relevant ranges for $\gamma$. As we can see from Figure 4, the ISP's profit under no zero-rating is lower than its profit under partial zero-rating with $CP_1$ or with $CP_2$ when data is sponsored. As Figure 4 indicates, there exists a threshold level of $\gamma$, $\gamma_{PZ}$, below which the ISP offers to zero-rate $CP_1$ and above which it offers to zero-rate $CP_2$. Lemma 1 summarizes these findings.[23]

**Lemma 1.** *The ISP always prefers partial zero-rating with monetary transfers to no zero-rating. The ISP makes an offer to the high quality $CP_1$ and $CP_1$ accepts it by paying $r_1^{PZ_1}$ to the ISP when $\gamma < \gamma_{PZ}$. The ISP makes an offer to low quality $CP_2$ and $CP_2$ accepts it by paying $r_2^{PZ_2}$ to the ISP when $\gamma > \gamma_{PZ}$.*

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

### 4.3.2 Full zero-rated content

Assuming that the ISP zero-rates both CPs' content, the fixed fees must satisfy:

$$\begin{aligned} r_1^{FZ} &\le \pi_1^{FZ} - \pi_1^{ZR_2} = \frac{[\alpha(\gamma^2-2)^2 - \gamma]^2}{(\gamma^2-1)(2\gamma^4 - 9\gamma^2+12)^2} - \frac{[\alpha(\gamma^2-2)+\gamma]^2}{(\gamma^2-4)^2(\gamma^2-1)} \\ r_2^{FZ} &\le \pi_2^{FZ} - \pi_2^{ZR_1} = \frac{[\alpha\gamma - (\gamma^2-2)^2]^2}{(\gamma^2-1)(2\gamma^4 - 9\gamma^2+12)^2} - \frac{[(\gamma^2-2)+\alpha\gamma]^2}{(\gamma^2-4)^2(\gamma^2-1)}. \end{aligned} \tag{18}$$

By similar logic to the partial zero-rating case, 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

[23] $\gamma_{PZ}$ is the $\gamma$ that satisfies $\widehat{\pi}_{ISP}^{ZR_1} - \widehat{\pi}_{ISP}^{ZR_2} = 0$. Note that $\gamma_{PZ} < \tilde{\gamma}$ is guaranteed under our assumption on $\alpha$.

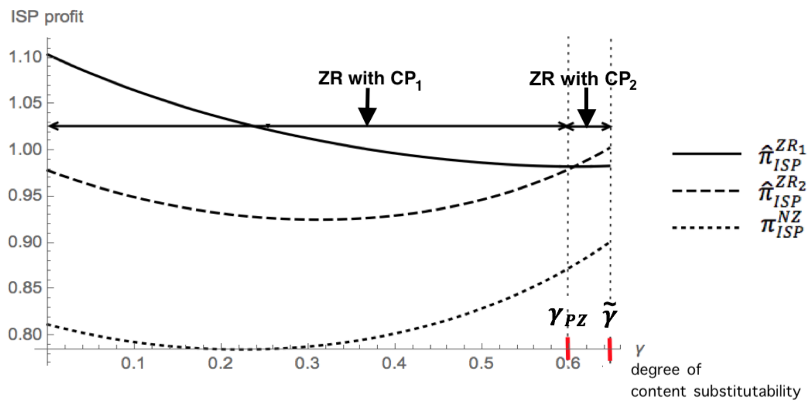


Figure 4: Partial Zero-rating Equilibrium when $\alpha = 2$

differentiated, more demand shifts toward high quality content. Thus, the high (low) quality CP charges a higher (lower) price for its content. Compared to partial zero-rating, full zero-rating leads to a higher price for the CP that is not zero-rated under partial zero-rating and a lower price for the one that is zero-rated under partial zero-rating. This implies that the low quality content price falls more in the full zero-rating case than when only $CP_1$ is zero-rated.

For sufficiently large levels of $\gamma$, the effect of a lower CP price on demand for low quality content is relatively small. Therefore, lowering the content price under full zero-rating leads to lower profit for the low quality CP. Consequently, as content becomes more substitutable, $r_2^{FZ}$ not only decreases, but can become negative. For the high quality CP, however, a lower content price induces increasingly higher demand, in turn, leading to greater profit, and increasing its willingness to pay for full zero-rating. Thus, if content is sufficiently substitutable, i.e., $\gamma > \gamma_{Subsidy}$,[24] 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. Because, as we will show, the ISP wants full zero-rating for sufficiently large $\gamma$, it finds it profitable to pay a subsidy to $CP_2$. Lemma 2 (proven in the Appendix) summarizes this finding. Figure 5 demonstrates how the sponsored data fees vary with $\gamma$ when $\alpha = 2$.

**Lemma 2.** *If content is sufficiently substitutable ($\gamma > \gamma_{Subsidy}$), the ISP must pay a positive subsidy to the low quality CP to attain full zero-rating.*

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

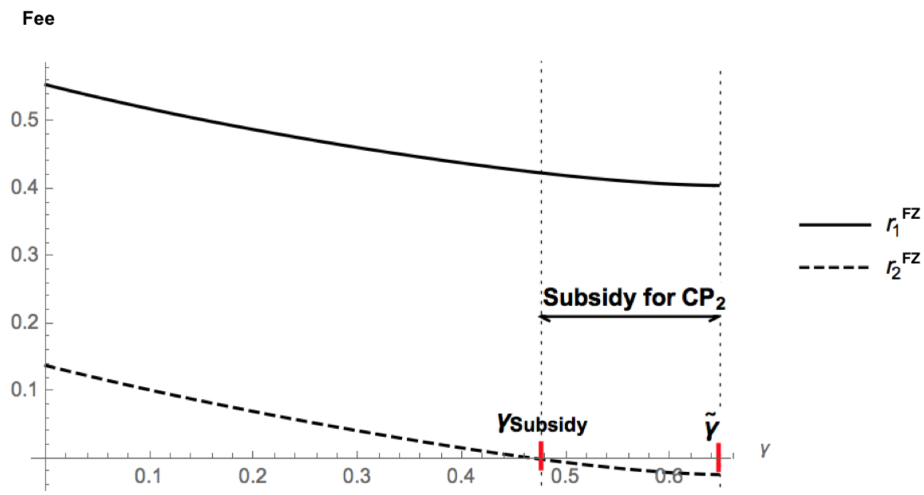


Figure 5: Fixed fee comparison when $\alpha = 2$

### 4.3.3 Equilibrium

We can now evaluate the ISP's zero-rating decision under sponsored data. Under full zero-rating, the ISP's total profit is given by:

$$\hat{\pi}_{ISP}^{FZ} = \frac{1}{2\left(\gamma^2-1\right)}\left\{\frac{3\left(\alpha^2+1\right)\gamma^2-4\left(\alpha^2+1\right)+2\alpha\gamma^3}{\left(\gamma^2-4\right)^2}\right.$$
$$\left.+2\left\{\frac{[\left(\gamma^2-2\right)^2-\alpha\gamma]^2}{\left(2\gamma^4-9\gamma^2+12\right)^2}-\frac{[\gamma(\alpha+\gamma)-2]^2}{\left(\gamma^2-4\right)^2}\right\}+2\left\{\frac{[\gamma-\alpha\left(\gamma^2-2\right)^2]^2}{\left(2\gamma^4-9\gamma^2+12\right)^2}-\frac{\left[\alpha\left(\gamma^2-2\right)+\gamma\right]^2}{\left(\gamma^2-4\right)^2}\right\}\right\} \tag{19}$$

Comparing $\hat{\pi}_{ISP}^{FZ}$ to $\hat{\pi}_{ISP}^{ZR_1}$ and $\hat{\pi}_{ISP}^{ZR_2}$, we find that $\hat{\pi}_{ISP}^{FZ}$ is always greater than profit in either partial zero-rating scenario. Unlike the result when monetary transfers are not permitted, when data can be sponsored, the ISP wants to fully zero-rate. Full zero-rating softens price competition between CPs relative to no zero-rating and, as discussed in Section 4.2, is dominated without monetary transfers. However, when the ISP can charge CPs to sponsor data, it finds doing so worthwhile because the ensuing demand when $\tau$ is effectively zero and prices are higher (equilibrium outcome with full zero-rating) is still higher than when $\tau$ is positive but CPs charge lower prices (equilibrium outcome without zero-rating). The intuition is similar when we compare full-zero-rating with either partial zero-rating scenario. Moreover, $r_1^{FZ}$ and $r_2^{FZ}$ give the ISP more flexibility than the overage charge $\tau$, which leaves consumers subject to the charge to face a double markup for content.

Figure 6 shows that ISP profits under full zero-rating are higher than profits in either partial zero-rating outcome when $\alpha = 2$. As can be seen, per Lemma 2, profits are higher under full zero-rating even when $\gamma$ is sufficiently large and the ISP pays a positive subsidy to $CP_2$ to achieve full zero-rating.

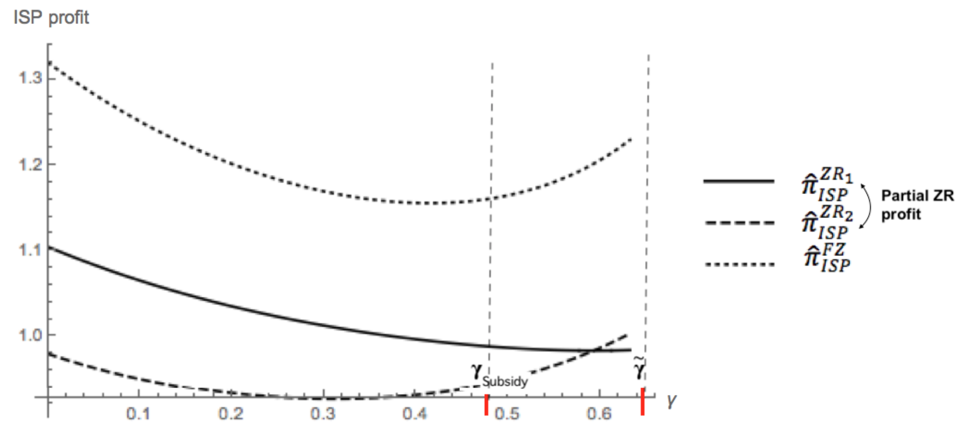


Figure 6: ISP profit comparison when $\alpha = 2$

**Proposition 2.** *If there is a monetary transfer for zero-rating, the ISP always fully zero-rates all content from both CPs. If content is sufficiently substitutable, the ISP pays a positive subsidy to the lower quality CP to attain full zero-rating.*

## 4.4 Comparison with and without monetary transfers

In Propositions 1 and 2, we have shown that when there are no monetary transfers the ISP zero-rates, at best, the low quality CP, whereas it optimally zero-rates both CPs when it can sponsor data for a fee (or subsidy). Clearly, the ISP is always better off when it can sponsor data because it can always choose to set the monetary transfer to zero. However, by comparing the relevant profit levels, it is easy to show that the low quality CP becomes worse off when a monetary transfer for zero-rating is permitted. As a low quality CP, it can partly overcome its quality disadvantage by using a zero-rated service. However, because the ISP engages in full zero-rating if it can collect fees from both CPs, the low quality CP loses its advantageous position—if both high and low quality content is zero-rated, consumers prefer more of the better quality content. Therefore, the low quality CP loses market share and profit when all content is zero-rated with a monetary transfer. The following Corollary summarizes this finding.

**Corollary 1.** *Allowing monetary transfers for zero-rating and inducing full zero-rating makes the lower quality content provider $CP_2$ worse off in terms of market share and profit.*

# 5 Vertical integration

In the previous section, we characterized zero-rating equilibrium outcomes with and without monetary transfers between the ISP and CPs. The latter arrangement—whereby the ISP charges CPs to zero-rate their content—is one example of a sponsored data arrangement. However, in reality, many ISPs zero-rate affiliated content for free, instead, charging only to zero-rate unaffiliated content. In this section, our focus is to see whether this behavior poses any anti-competitive threat (i.e., through vertical content foreclosure).

As in the game with no vertical integration, we continue to rely on an interior solution assumption, $\gamma < \tilde{\gamma}_{VI}$, which guarantees the existence of an interior solution in the game with vertical integration studied here.[25]

## 5.1 Zero-rated content without monetary transfers

### 5.1.1 Integration with high quality content provider, $\mathrm{CP}_1$

Suppose that in the game of Section 4, the ISP and $\mathrm{CP}_1$ are vertically integrated and the vertically integrated firm zero-rates its own affiliated content.[26] The timing of the game is as follows. The integrated firm decides whether to make a take-it-or-leave-it zero-rating offer to $\mathrm{CP}_2$ and sets the hookup fee and overage charge. Then, if an offer was extended, $\mathrm{CP}_2$ decides whether to accept the offer and both the integrated firm and $\mathrm{CP}_2$ set per unit content subscription fees. Finally, consumers decide how much content to purchase from each CP.

If $\mathrm{CP}_2$ rejects a zero-rating offer, the equilibrium outcome is as follows:

[25] When $\alpha = 2$, $\tilde{\gamma}_{VI} \approx 0.577$. See the Appendix for additional detail.

[26] Note that the integrated firm always zero-rates its own content because doing so is more profitable.

$$
\begin{aligned}
\tau_{VI_1}^R &= \frac{\gamma^2\left[\alpha\gamma\left(2\gamma^2-5\right)+7\right]-4}{3\left(\gamma^4+3\gamma^2-4\right)};\\
H_{VI_1}^R &= \frac{1}{18\left(\gamma^4+3\gamma^2-4\right)^2}\Big\{\alpha^2\left(8\gamma^8+52\gamma^6-36\gamma^4-99\gamma^2+108\right);\\
&\quad -2\alpha\left(8\gamma^4-11\gamma^2+36\right)\gamma+9\gamma^4+8\gamma^2+16\Big\};\\
\pi_{VI_1}^R &= \frac{\alpha^2\left(4\gamma^6-18\gamma^2+15\right)+2\alpha\gamma\left(5\gamma^2-6\right)-3\gamma^2+4}{6\left(\gamma^2-1\right)^2\left(\gamma^2+4\right)};\\
p_{VI_1}^R &= \frac{\gamma^3-\alpha\left(\gamma^4-2\gamma^2+2\right)}{\gamma^4+3\gamma^2-4};\quad p_2^R=\frac{1}{3}\left(\frac{13\alpha\gamma-8}{\gamma^2+4}-4\alpha\gamma+3\right);\\
x_{VI_1}^R &= \frac{2\left[\alpha\left(\gamma^4-3\right)+2\gamma\right]}{3\left(\gamma^4+3\gamma^2-4\right)};\quad x_2^R=\frac{\alpha\left(4\gamma^2+3\right)\gamma-3\gamma^2-4}{3\left(\gamma^4+3\gamma^2-4\right)}.
\end{aligned}
\tag{20}
$$

The subscript $VI_1$ denotes that the ISP is vertically integrated with $\text{CP}_1$ and superscript $R$ denotes that the zero-rating offer was rejected. Alternatively, if $\text{CP}_2$ accepts the zero-rating offer (and $\tau$ equals zero), the equilibrium outcome is:

$$
\begin{aligned}
H_{VI_1}^A &= \frac{\alpha^2\left(3-2\gamma^2\right)-2\alpha\gamma+1}{2\left(\gamma^4-5\gamma^2+4\right)};\\
\pi_{VI_1}^A &= \frac{\alpha^2\left(-4\gamma^4+19\gamma^2-20\right)+2\alpha\gamma\left(8-3\gamma^2\right)-\gamma^2-4}{2\left(\gamma^2-4\right)^2\left(\gamma^2-1\right)};\\
p_{VI_1}^A &= \frac{\alpha\left(\gamma^2-2\right)+\gamma}{\gamma^2-4};\quad p_2^A=\frac{\alpha\gamma+\gamma^2-2}{\gamma^2-4};\\
x_{VI_1}^A &= -\frac{\alpha\left(\gamma^2-2\right)+\gamma}{\gamma^4-5\gamma^2+4};\quad x_2^A=\frac{2-\gamma(\alpha+\gamma)}{\gamma^4-5\gamma^2+4}.
\end{aligned}
\tag{21}
$$

where superscript $A$ denotes that the offer was accepted.

Comparing $\pi_2^A$ with $\pi_2^R$ shows that $\text{CP}_1$'s profit under zero-rating (acceptance) is always greater than that under no zero-rating (rejection). Conversely, we find that $\pi_{VI_1}^A - \pi_{VI_1}^R = -\frac{\left\{\gamma^2\left[\alpha\gamma\left(2\gamma^2-5\right)+7\right]-4\right\}^2}{6\left(\gamma^2+4\right)\left(\gamma^4-5\gamma^2+4\right)^2} < 0$ for $\gamma \in (0,1)$. Thus, the integrated firm does not offer to zero-rate $\text{CP}_2$ to begin with. That is, contrary to the outcomes in Section 4.2, there is no zero-rating with $\text{CP}_2$ when the ISP is vertically integrated with $\text{CP}_1$. Although $\text{CP}_2$ would benefit from zero-rating, vertical integration precludes the zero-rating of unaffiliated content.

### 5.1.2 Integration with low quality content provider, $\text{CP}_2$

Suppose instead that the ISP and $\text{CP}_2$ are vertically integrated and the integrated firm zero-rates its affiliated content while potentially zero-rating unaffiliated $\text{CP}_1$. The timing of the game is analogous to that in Section 5.1.1. The equilibrium outcome when $\mathrm{CP}_1$ rejects the zero-rating offer is:

$$\begin{aligned}
\tau_{VI_2}^R &= \frac{7\alpha\gamma^2 - 4\alpha + 2\gamma^5 - 5\gamma^3}{3\left(\gamma^4 + 3\gamma^2 - 4\right)};\\
H_{VI_2}^R &= \frac{\alpha^2\left(9\gamma^4 + 8\gamma^2 + 16\right) - 2\alpha\left(8\gamma^4 - 11\gamma^2 + 36\right)\gamma + 8\gamma^8 + 52\gamma^6 - 36\gamma^4 - 99\gamma^2 + 108}{18\left(\gamma^4 + 3\gamma^2 - 4\right)^2};\\
\pi_{VI_2}^R &= \frac{-3\left(\alpha^2 + 6\right)\gamma^2 + 4\alpha^2 + 10\alpha\gamma^3 - 12\alpha\gamma + 4\gamma^6 + 15}{6\left(\gamma^2 - 1\right)^2\left(\gamma^2 + 4\right)};\\
p_{VI_2}^R &= \frac{\gamma^2(\gamma(\alpha - \gamma) + 2) - 2}{\gamma^4 + 3\gamma^2 - 4}; \quad p_1^R = \frac{13\gamma - 8\alpha}{3\left(\gamma^2 + 4\right)} + \alpha - \frac{4\gamma}{3};\\
x_{VI_2}^R &= \frac{2\left(2\alpha\gamma + \gamma^4 - 3\right)}{3\left(\gamma^4 + 3\gamma^2 - 4\right)}; \quad x_1^R = \frac{-3\alpha\gamma^2 - 4\alpha + 4\gamma^3 + 3\gamma}{3\left(\gamma^4 + 3\gamma^2 - 4\right)}.
\end{aligned} \tag{22}$$

Conversely, the equilibrium outcome when $\mathrm{CP}_1$ accepts the offer is:

$$\begin{aligned}
H_{VI_2}^A &= \frac{\alpha^2 - 2\alpha\gamma - 2\gamma^2 + 3}{2\gamma^4 - 10\gamma^2 + 8};\\
\pi_{VI_2}^A &= -\frac{\alpha^2\left(\gamma^2 + 4\right) + 2\alpha\left(3\gamma^2 - 8\right)\gamma + 4\gamma^4 - 19\gamma^2 + 20}{2\left(\gamma^2 - 4\right)^2\left(\gamma^2 - 1\right)};\\
p_{VI_2}^A &= \frac{\gamma(\alpha + \gamma) - 2}{\gamma^2 - 4}; \quad p_1^A = \frac{\alpha\left(\gamma^2 - 2\right) + \gamma}{\gamma^2 - 4};\\
x_{VI_2}^A &= \frac{2 - \gamma(\alpha + \gamma)}{\gamma^4 - 5\gamma^2 + 4}; \quad x_1^A = -\frac{\alpha\left(\gamma^2 - 2\right) + \gamma}{\gamma^4 - 5\gamma^2 + 4}.
\end{aligned} \tag{23}$$

Comparing $\pi_1^A$ to $\pi_1^R$ shows that $\mathrm{CP}_1$ always wants to be zero-rated. However, as in Section 5.1.1, there is no incentive for the integrated firm to offer zero-rating to unaffiliated $\mathrm{CP}_1$ because $\pi_{VI_2}^A - \pi_{VI_2}^R = -\frac{\left(-7\alpha\gamma^2+4\alpha-2\gamma^5+5\gamma^3\right)^2}{6\left(\gamma^2+4\right)\left(\gamma^4-5\gamma^2+4\right)^2} < 0$ for $\gamma \in (0,1)$.

### 5.1.3 Equilibrium

We have shown that an ISP that is integrated with a content provider, does not offer to zero-rate unaffiliated content. Moreover, comparison of the integrated firm's equilibrium profits in Sections 5.1.1 and 5.1.2 shows that the ISP prefers to integrate with $\mathrm{CP}_1$, the high quality content provider. Specifically, $\pi_{VI_1}^R - \pi_{VI_2}^R = \frac{\left(\alpha^2-1\right)\left[4\left(\gamma^4+\gamma^2\right)-11\right]}{6\left(\gamma^4+3\gamma^2-4\right)} > 0$ for $\gamma \in (0,1)$.[27]

[27]Note that we have confirmed that there is an incentive to vertically integrate. In other words, the joint profits of the affiliated CP and ISP under no integration are always less than the profits of the integrated firm.

**Proposition 3.** *When there is no monetary transfer for zero-rating, the ISP and high quality CP agree to integrate. The integrated firm chooses to zero-rate its affiliated content, but does not offer to zero-rate unaffiliated lower quality content even if the unaffiliated low quality CP would like to be zero-rated.*

In contrast to the game without vertical integration or monetary transfers, where the ISP zero-rates $CP_2$'s (low quality) content for intermediate levels of content substitutability, but not the content of $CP_1$, vertical integration leads to the opposite situation. Following vertical integration, the ISP and high quality $CP_1$ integrate and do not zero-rate $CP_2$'s content. As an integrated firm, the ISP directly derives profit from affiliated content via the content prices. Intuitively, high quality $CP_1$ can earn greater profit if zero-rated. If unaffiliated content is not zero-rated, the vertically integrated firm derives additional profit from an overage charge as long as content provided by both CPs is independent to some extent. Moreover, by refraining from zero-rating unaffiliated content, the vertically integrated firm not only derives a direct source of profit through the overage charge, but also raises the cost of unaffiliated content relative to its own, allowing it to sell even more affiliated content.[28]

This result has a direct counterpart in the literature on selling to rivals (e.g., Arya, Mittendorf, and Sappington 2008; Moresi and Schwartz 2017). In particular, Arya et al. (2008) show that a lower cost downstream retailer would outbid its otherwise symmetrically differentiated rival in an effort to integrate with an upstream input provider. Similarly, the ISP stands to gain more by integrating with a higher quality (alternatively put, lower cost per unit of quality) provider. A critical difference is that here, the vertically integrated firm impacts what consumers pay for a rival product directly, via $\tau$, instead of through its ability to control the cost of rival inputs.

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

In contrast to the equilibrium outcome of Section 5.1, as we show here, if the vertically integrated firm can charge a fee to zero-rate unaffiliated content, a full zero-rating outcome emerges. Thus, similarly to Section 4.3, we now assume that the vertically integrated firm makes a take-it-or-leave-it zero-rating offer to the unaffiliated CP.

[28] Although this effect is dampened somewhat by the fact that prices are strategic complements and decreasing in $\tau$ (the overage charge).

#### 5.2.1 Integration with high quality content provider, $\mathrm{CP}_1$

First, the fee $r_2^{VI}$ charged for zero-rating must be no greater than $\pi_2^A - \pi_2^R$, which implies that $r_2^{VI}$ is positive. Additionally, the integrated firm's profit from full zero-rating with $r_2^{VI}$ (which implies that the unaffiliated CP accepts) must be greater than that without zero-rating. This occurs when content is sufficiently independent. That is, there exists a threshold $\gamma_{VI_1}$ below which $\widehat{\pi}^A_{VI_1} - \pi^R_{VI_1} > 0$, where $\widehat{\pi}$ denotes profit with monetary transfers.[29] Thus, when there is a monetary transfer, full zero-rating occurs under vertical integration if $\gamma < \gamma_{VI_1}$, whereas, when $\gamma > \gamma_{VI_1}$, the vertically integrated firm refuses to zero-rate unaffiliated content. Although the ISP might be induced to zero-rate unaffiliated content at some fee sufficiently larger than $r_2^{VI} = \pi_2^A - \pi_2^R$, $\mathrm{CP}_2$ is unwilling to pay such a fee.

#### 5.2.2 Integration with low quality content provider, $\mathrm{CP}_2$

It can be readily shown that $\widehat{\pi}^A_{VI_2} - \pi^R_{VI_2} > 0$ for $\gamma \in (0, 1)$ when the vertically integrated firm charges a fee, $r_1^{VI} = \pi_1^A - \pi_1^R$ to the unaffiliated $\mathrm{CP}_1$. Thus, full zero-rating always emerges when the ISP integrates with $\mathrm{CP}_2$ and sponsors $\mathrm{CP}_1$ data.

#### 5.2.3 Equilibrium

As long as $\mathrm{CP}_1$'s content quality, $\alpha$, is sufficiently higher than that of $\mathrm{CP}_2$, it is easy to show that $\max\{\widehat{\pi}^A_{VI_1}, \pi^R_{VI_1}\} > \widehat{\pi}^A_{VI_2}$, meaning that the ISP prefers to integrate with the higher quality CP.[30] Additionally, in contrast to a scenario without monetary transfers, sponsored data sometimes makes it preferable for the integrated firm to zero-rate the unaffiliated CP's content. This happens when content is sufficiently independent. Proposition 4 summarizes these findings.

**Proposition 4.** *Suppose that the quality difference between the two CPs is sufficiently large ($\alpha > \tilde{\tilde{\alpha}}$ when $\gamma > \gamma_{VI_1}$ and $\alpha > \tilde{\alpha}$ when $\gamma < \gamma_{VI_1}$). Then, when there is a monetary transfer for zero-rating, the ISP and high quality CP vertically integrate. If content is sufficiently independent ($\gamma < \gamma_{VI_1}$), the integrated firm zero-rates the unaffiliated CP in exchange for a positive fee which the CP agrees to pay. If content is sufficiently substitutable ($\gamma > \gamma_{VI_1}$), unaffiliated content is not zero-rated.*

[29] $\gamma_{VI_1}$ is the solution to $\widehat{\pi}^A_{VI_1} - \pi^R_{VI_1} = 0$. When $\alpha = 2$, $\gamma_{VI_1} \approx 0.4775$.

[30] As we show in the Appendix, this occurs whenever $\alpha > \tilde{\tilde{\alpha}}$, where $\tilde{\tilde{\alpha}} \in (1, 2)$ is a threshold defined in the proof of Proposition 5.

Thus, allowing the integrated firm to charge a fee for zero-rating can alter the result relative to Section 5.1. If content is sufficiently independent, the integrated firm is able to charge a higher fee for zero-rating. This incentivizes it to fully zero-rate all content and profit through the fee that it charges on unaffiliated content rather than by limiting the quantity of such content through the overage charge. If content becomes sufficiently substitutable, the integrated firm again does not want to zero-rate its content rival because doing so will cut into profits for affiliated content more than the rival is willing to compensate via the zero-rating fee. Importantly, the unaffiliated low quality CP's content is not zero-rated even though the CP is willing to pay for zero-rating.

Unlike in the case without vertical integration, the integrated firm never wishes to pay a subsidy to zero-rate content because of the strategic complementarity between content prices. Zero-rating lowers the cost of unaffiliated content for consumers, allowing the rival CP to sell more at the expense of the affiliated CP. As such, the vertically integrated firm always demands to be compensated for this lost profit.

Above, we derived the equilibrium outcomes assuming that $\alpha$ is sufficiently high (above threshold $\tilde{\tilde{\alpha}}$). We next consider what happens when $\alpha < \tilde{\tilde{\alpha}}$. Let us define $\tilde{\alpha} \in (1, 2)$ (whose value will be made more precise in the Appendix), such that $\tilde{\alpha} < \tilde{\tilde{\alpha}}$.

**Proposition 5.** *If the quality difference between two CPs is sufficiently small ($\alpha < \tilde{\alpha}$ when $\gamma < \gamma_{VI_1}$ and $\alpha < \tilde{\tilde{\alpha}}$ when $\gamma > \gamma_{VI_1}$), then, when there is a monetary transfer for zero-rating, the ISP and low quality CP vertically integrate. The integrated firm always zero-rates the unaffiliated CP in exchange for a positive fee.*

If $\alpha$ is relatively small, meaning less differentiation along the vertical quality dimension, there is less incentive for the ISP to integrate with high quality $CP_1$ and engage in vertical content foreclosure. As shown in Section 4.3.2, low quality $CP_2$ is less willing to pay for full zero-rating. If the ISP instead integrates with $CP_2$ and offers to fully zero-rate unaffiliated $CP_1$'s content, $CP_1$'s willingness to pay for full zero-rating is relatively high. Thus, the ISP finds it more profitable to zero-rate $CP_1$ for a fee than to vertically integrate with $CP_1$ and either foreclose $CP_2$ or sponsor $CP_2$'s data for a substantially lower fee.

### 5.3 Comparison with and without monetary transfers

As we saw from Section 5.1, when there are no monetary transfers, in contrast to the result without vertical integration, low quality content is never zero-rated due to its demand shifting effect on the vertically integrated firm's profit from selling affiliated content. On the other hand, full zero-rating emerges for a range of $\gamma$ with or without vertical integration when an ISP can sponsor data. Under vertical integration this turns out to increase consumption of lower quality content.

**Corollary 2.** *Under vertical integration, monetary transfers for zero-rating can raise the market share of the unaffiliated, lower quality CP.*

# 6 Welfare Analysis

Consider now welfare under different zero-rating regimes. Our main interest is to assess whether the zero-rating equilibrium under vertical integration is welfare-enhancing or -reducing, compared to the equilibrium without vertical integration. Because we are particularly interested in the possibility of vertical foreclosure, going forward we assume that $\alpha > \tilde{\tilde{\alpha}}$. We treat aggregate social welfare as the sum of consumer surplus, CPs' profits, and the ISP's profit. Because the ISP can extract all rents from consumers through the hookup fee, consumer surplus is always zero. Thus, we need to compare CP and ISP profits only.

We first compare total social welfare levels without monetary transfers. Suppose that $\gamma_I < \gamma$. Per Proposition 1, this implies that zero-rating with $CP_2$ takes place in an equilibrium with no vertical integration. In contrast, under vertical integration, per Proposition 3, only the affiliated $CP_1$'s content is zero-rated. Comparing social welfare levels under those two scenarios we have:

$$SW^R_{VI_1} - SW^{ZR_2} = \underbrace{[\pi^R_{VI_1} - \pi^{ZR_2}_{ISP} - \pi^{ZR_2}_1]}_{(+)} + \underbrace{[\pi^R_2 - \pi^{ZR_2}_2]}_{(-)} > 0. \tag{24}$$

Equation (24) indicates that total surplus is higher under vertical integration when there are no monetary transfers. However, this welfare-enhancing result comes at the expense of unaffiliated $CP_2$, which loses market share and profit by having to compete with what customers perceive as a relatively lower cost (higher quality) rival. Conversely, when $\gamma < \gamma_I$, whereby the ISP does not zero-rate any content when it does not vertically integrate, we find that $SW^{NZ} < SW^{R}_{VI_1}$.

We next compare total social welfare levels under sponsored data. From Proposition 2, we know that full zero-rating emerges in an equilibrium without vertical integration. Under vertical integration, per Proposition 4, full zero-rating may or may not emerge depending on whether or not content is sufficiently independent. By the same logic as above, we find that vertical integration is welfare-enhancing. First, if the integrated firm does not zero-rate unaffiliated content, the profit increasing effect for the integrated firm dominates the profit decreasing effect for the unaffiliated $\text{CP}_2$. Even for the case in which the integrated firm zero-rates $\text{CP}_2$'s content, which leads to full zero-rating (as would happen without vertical integration), total social welfare under vertical integration is greater than that without vertical integration, because the vertically integrated firm charges a lower content price for its higher quality, affiliated content. $\text{CP}_2$ becomes worse off due to vertical integration because it pays a higher fee for zero-rating under vertical integration and faces a lower priced competitor. Proposition 6, proven in the Appendix, summarizes these findings.

**Proposition 6.** *Vertical integration between the ISP and high quality content provider is welfare-enhancing relative to no vertical integration because profit gains to the vertically integrated firm outweigh any losses to the unaffiliated CP. However, the unaffiliated low quality CP is worse off under vertical integration.*

Proposition 6 indicates that vertical integration can be welfare-enhancing in a platform setting with zero-rating due to elimination of double marginalization on content. However, broadly, we also want to know whether monetary transfers for zero-rating are welfare-enhancing in general, and whether zero-rating improves overall welfare.

Absent vertical integration, we previously found that allowing monetary transfers for zero-rating leads to the full zero-rating (Proposition 2), but leaves $\text{CP}_2$, which might have been the only zero-rated firm without monetary transfers (Proposition 1) worse off (Corollary 1). However, in spite of the harm to $\text{CP}_2$, the net social welfare effect of sponsored data is positive. In the game with vertical integration, sponsored data is welfare-enhancing as long as it induces full zero-rating in the equilibrium, i.e., if $\gamma < \gamma_{VI_1}$. Conversely, as Proposition 3 and Proposition 4 indicate, if $\gamma > \gamma_{VI_1}$, unaffiliated content is not zero-rated, so that allowing sponsored data does not alter the equilibrium welfare outcome. Proposition 7 summarizes these findings.

**Proposition 7.** *When sponsored data leads to full zero-rating in equilibrium, total welfare is higher than if monetary transfers for zero-rating were not permitted. Sponsored data never lowers total welfare.*

It is worth emphasizing that the finding above is based on a static model of competition. Thus, though sponsored data attains the greatest social welfare level, this does not imply that it would be socially desirable in the long run as well. For instance, in the game without vertical integration, allowing monetary transfers can make the low quality CP worse off and leaves it with lower market share. If this threatens the CPs long-run solvency and diminishes long-run content competition, welfare may decline, though such considerations are beyond the scope of our model.

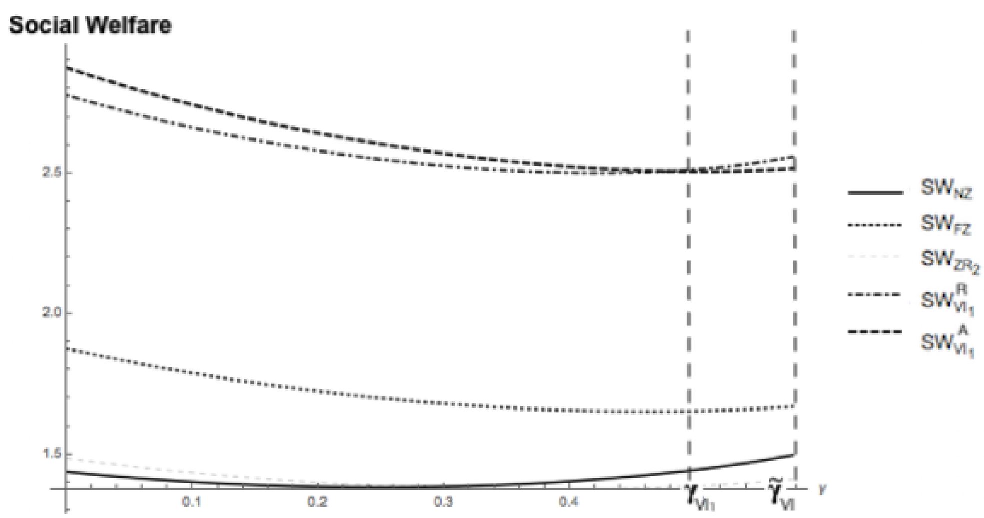


Figure 7: Total Social Welfare comparison when $\alpha = 2$

Lastly, we explore whether zero-rating with sponsored data is welfare-enhancing compared to no zero-rating. Comparing all possible social welfare levels in the game with vertical integration, we find that no zero-rating leads to lower social welfare than any other equilibrium outcome ($SW^{NZ} < \min\{SW^R_{VI_1}, SW^A_{VI_1}\}$). Compared to the full zero-rating equilibrium under no vertical integration, no zero-rating similarly leads to lower welfare ($SW^{NZ} < SW^{FZ}$). Figure 7 compares social welfare in the scenarios (full zero-rating in the game without vertical integration ($SW^{FZ}$), full zero-rating in the game with vertical integration ($SW^A_{VI_1}$), and foreclosing unaffiliated $\text{CP}_2$ ($SW^R_{VI_1}$)) that emerge in equilibrium when monetary transfers are allowed with social welfare without zero-rating to illustrate that social welfare is always higher under zero-rating with sponsored data. Proposition 8 summarizes these findings.

**Proposition 8.** *Zero-rating with sponsored data is welfare-enhancing relative to no zero-rating.*

# 7 Discussion

We explored alternative scenarios in which an ISP zero-rates content and the implications for social welfare. To recapitulate, when there are no monetary transfers for zero-rating, the ISP offers to zero-rate a lower quality CP, but only when content is sufficiently differentiated. In contrast, sponsored data always leads to full zero-rating in equilibrium. Alternatively, 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. On the other hand, if the integrated firm can charge to sponsor data it zero-rates both affiliated and unaffiliated content unless the difference between content quality is high and yet content is relatively substitutable. As such, zero-rating can serve as a de facto alternative to vertical foreclosure (via high overage fees for unaffiliated content). From a total welfare perspective, the alternative is welfare-enhancing. However, whereas vertical integration is socially desirable from a total welfare perspective, this may come at the expense of the unaffiliated content provider, which can lose market share and profit due to vertical integration.

The welfare analysis indicates that the impact of zero-rating on individual CPs and society as a whole depends on market structure. Notwithstanding integration between the ISP and $CP_1$, allowing sponsored data can be socially desirable because it induces full zero-rating, which leads to greater social welfare under our framework. Perhaps not surprisingly, content prices are higher under zero-rating, but consumers nevertheless consume more because they do not face overage charges, such that social welfare rises. We acknowledge that these results might necessitate additional nuance in a richer framework with, say, consumer heterogeneity without perfect price discrimination, but at minimum, our findings suggest that regulators should be wary of restricting sponsored data as a remedy against zero-rating.

Antitrust practitioners may be more interested to know if vertical integration between the ISP and a CP combined with zero-rating poses additional anticompetitive concerns over and above those following the integration of a platform and a seller on one side of a multisided market. As we showed previously, the low quality, unaffiliated CP may earn lower profit and loses market share if vertical integration forecloses it from being zero-rated. To the extent that entrant CPs are more likely to provide low quality content due to limited experience, such vertical integration in conjunction with zero-rating might in reality lead these CPs to become unprofitable. If, in a richer framework, zero-rating could, by reducing profit, serve to deter entry or induce exit, then social welfare can fall as well.

In the event that ISPs use sponsored data and antitrust agencies are concerned about foreclosure due to vertical integration, the fee charged to sponsor data can be used as a simple policy instrument. Comparing the equilibrium fee that $CP_2$ pays for zero-rating without vertical integration, denoted $r_2^{FZ}$, to that with vertical integration, denoted $r_2^{VI}$, it is easy to show that $r_2^{FZ} < r_2^{VI}$. That is, the higher fee to sponsor data presents one of the sources of merger harms to unaffiliated content providers. In this case, a price commitment barring the vertically integrated firm from raising the fees to sponsor data ameliorates some of the post-merger harm.

There are several potential extensions that we have left for future research. We suggest a few here. First, we have not modeled any congestion externalities as Economides and Hermalin (2015) had. We suspect that congestion diminishes the welfare improving implications of zero-rating, which induces consumers to consume more content. Second, as we had already suggested, the welfare implications might require more nuance in a framework with heterogeneous consumers. Specifically, in the present framework, the ISP appropriates all consumer surplus through the hookup fee. However, in the presence of consumer heterogeneity, the ISP's ability to appropriate welfare will depend on the extent of consumer heterogeneity and differences in elasticity of demand across different groups. If the ISP is unable to charge different hookup fees to different consumers, it may be less inclined to engage in zero-rating, which undermines its ability to use the overage charge to differentiate among consumers based on their ideal content consumption. Lastly, 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 explore how zero-rating can be used as a late entrant strategy by providing marketing collaboration to newer ISP entrants.[31]

[31] 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 Face-

# Appendix

**Three-part Tariff Setup.** In footnote 17 in Section 3, we suggested that a model with a three-part tariff (with a positive data cap) leads to the same equilibrium outcome as in our model with a two-part tariff (which implicitly sets the cap at zero) as long as consumers exceed the data cap in equilibrium. The utility function with a three-part tariff can be represented by:

$$u = \left[\alpha_1 x_1 - \frac{1}{2}x_1^2 + \alpha_2 x_2 - \frac{1}{2}x_2^2 - \gamma x_1 x_2\right] - H - \sum_{n=1}^{2} p_n x_n - \tau \max\{0, \sum_{n=1}^{2} x_n \mathbb{1}_n - L\}, \tag{25}$$

where $L$ is a positive data cap. Because our interest is the case in which consumers exceed the cap, suppose that $\sum_{n=1}^{2} x_n \mathbb{1}_n > L$. If content is zero-rated, then Equation (25) is equivalent to Equation (1) and neither $L$ nor $\tau$ are relevant in equilibrium. If content is not zero-rated, the utility function simplifies to:

$$u = \left[\alpha_1 x_1 - \frac{1}{2}x_1^2 + \alpha_2 x_2 - \frac{1}{2}x_2^2 - \gamma x_1 x_2\right] - H - \sum_{n=1}^{2} p_n x_n - \tau(\sum_{n=1}^{2} x_n - L). \tag{26}$$

It is readily seen that $L$ does not change the consumer's optimal consumption decision (because consumers take $L$ as given when solving the utility maximization problem), implying that the CPs' profit maximization problem is also the same as in our two-part tariff setup (e.g., see Section 4.1). Given Expressions (3) and (4), the ISP's hookup fee $H$ is given by:

$$\begin{aligned} H(\tau) =& \left[\alpha_1 x_1(\tau) - \frac{1}{2}x_1(\tau)^2 + \alpha_2 x_2(\tau) - \frac{1}{2}x_2(\tau)^2 - \gamma x_1(\tau) x_2(\tau)\right] - \sum_{n=1}^{2} p_n x_n(\tau) - \tau \sum_{n=1}^{2} x_n(\tau) \\ =& \frac{3\alpha^2\gamma^2 - 4\alpha^2 + 2\alpha\gamma^3 - 2(\alpha+1)(\gamma-1)(\gamma+2)^2\tau + 3\gamma^2 + 2(\gamma-1)(\gamma+2)^2\tau^2 - 4}{2\left(\gamma^2-4\right)^2\left(\gamma^2-1\right)}. \end{aligned} \tag{27}$$

Maximizing the ISP's profit ($\pi_{ISP}$=$H(\tau) + \tau[x_1(\tau) + x_2(\tau) - L]$) with respect to $\tau$, we find that the optimal value of $\tau$ equals:

$$\tau(L) = \frac{(\alpha+1)(\gamma-1) + (\gamma+1)(\gamma-2)^2 L}{4\gamma - 6}. \tag{28}$$

Substituting $\tau(L)$ into the ISP's profit function and maximizing it with respect to $L$, we obtain the optimal $L$ as follows:

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$$L = -\frac{(\alpha+1)(\gamma-1)}{(\gamma-2)^2(\gamma+1)}. \tag{29}$$

Finally, substituting $L$ into $\tau(L)$, we find that the optimal $\tau$ is equal to zero. In other words, if we assume that the data cap $L$ is positive, the equilibrium $\tau$ becomes zero. That is, the only time that it is optimal to set $L > 0$ is when it does not bind. Alternatively, if we maximize $\pi_{ISP}$ with respect to $L$ first, the optimal value of $L$ given $\tau > 0$ is zero, which brings us back to our two-part tariff setup.

**Proof of Interior Solution Conditions.** Here, we show that Expression (8) in Section 4 and the inequality $\gamma < \tilde{\gamma}_{VI}$ in Section 5 are sufficient conditions for an interior solution in, respectively, the games in Section 4 and Section 5. In Section 4, when the ISP partially zero-rates either one of the CPs or fully zero-rates with all CPs, the necessary interior solution conditions are:

$$\begin{aligned} x_2^{ZR_1} &= \frac{-\alpha\gamma + (\gamma^2-2)^2}{(1-\gamma^2)(12-9\gamma^2+2\gamma^4)} > 0 \Leftrightarrow \gamma < \tilde{\gamma}^{ZR_1}; \\ x_2^{ZR_2} &= \frac{(\gamma^2-2)[(2\gamma^2-3)+\alpha\gamma]}{(1-\gamma^2)(12-9\gamma^2+2\gamma^4)} > 0 \Leftrightarrow \gamma < \tilde{\gamma}^{ZR_2}; \\ x_2^{FZ} &= -\frac{(\gamma^2-2)+\alpha\gamma}{\gamma^4-5\gamma^2+4} > 0 \Leftrightarrow \gamma < \tilde{\gamma}^{FZ}. \end{aligned} \tag{30}$$

The corresponding thresholds are:

$$\begin{aligned} \tilde{\gamma}^{ZR_1} &= \frac{1}{6}\Bigg\{\sqrt{3}\sqrt{\sqrt[3]{\frac{27\alpha^2}{2} - \frac{3}{2}\sqrt{81\alpha^4+6144\alpha^2}+512} + \frac{64}{\sqrt[3]{\frac{27\alpha^2}{2} - \frac{3}{2}\sqrt{81\alpha^4+6144\alpha^2}+512}} + 8} \\ &\quad - 3\Bigg( -\frac{1}{3}\sqrt[3]{\frac{27\alpha^2}{2} - \frac{3}{2}\sqrt{81\alpha^4+6144\alpha^2}+512} - \frac{64}{3\sqrt[3]{\frac{27\alpha^2}{2} - \frac{3}{2}\sqrt{81\alpha^4+6144\alpha^2}+512}} \\ &\quad + \frac{2\sqrt{3}\alpha}{\sqrt{\sqrt[3]{\frac{27\alpha^2}{2} - \frac{3}{2}\sqrt{81\alpha^4+6144\alpha^2}+512} + \frac{64}{\sqrt[3]{\frac{27\alpha^2}{2} - \frac{3}{2}\sqrt{81\alpha^4+6144\alpha^2+512}}} + 8}} + \frac{16}{3}\Bigg)^{\frac{1}{2}}\Bigg\} \\ \tilde{\gamma}^{ZR_2} &= \frac{1}{4}\left(\sqrt{\alpha^2+24} - \alpha\right) \\ \tilde{\gamma}^{FZ} &= \frac{1}{2}\left(\sqrt{\alpha^2+8} - \alpha\right). \end{aligned} \tag{31}$$

Each of the expressions, $\tilde{\gamma} - \tilde{\gamma}^{ZR_1}$, $\tilde{\gamma} - \tilde{\gamma}^{ZR_2}$ and $\tilde{\gamma} - \tilde{\gamma}^{FZ}$, decreases in $\alpha$ where $\tilde{\gamma}$ is obtained from Expression (8). That is, each equation is maximized at $\alpha = 1$ given our assumption that

$\alpha \in [1, 2]$. Thus, all that remains to be shown is that the maximum value is non-positive in each instance. Following some algebraic manipulation, we find that each expression equals zero when $\alpha = 1$, which implies that $\tilde{\gamma}$ is sufficiently small to guarantee an interior solution regardless of the zero-rating outcome.

The proof for Section 5 that $\gamma < \tilde{\gamma}_{VI}$ is the sufficient condition for an interior solution follows similarly. When the unaffiliated CP accepts the zero-rating offer, it leads to full zero-rating. Thus, we only need to compare two different thresholds on $\gamma$ below which $x_2^R > 0$ (per Expression (20)) and $x_{VI_2}^R > 0$ (in Expression (22)) are guaranteed. Denoting $\tilde{\gamma}_{VI}$ and $\tilde{\gamma}_{VI_2}^R$ as the corresponding thresholds, we have:

$$\begin{aligned}
\tilde{\gamma}_{VI} &= \frac{9\sqrt[3]{26\alpha^2 + 2\sqrt{\alpha^2\left(16\alpha^4 + 157\alpha^2 + 16\right)} + 1} + \frac{9-36\alpha^2}{\sqrt[3]{26\alpha^2+2\sqrt{\alpha^2(16\alpha^4+157\alpha^2+16)}+1}} + 9}{36\alpha}; \\
\tilde{\gamma}_{VI_2}^R &= \frac{1}{2}\sqrt{-\sqrt[3]{2}\sqrt[3]{\sqrt{\alpha^4+16}+\alpha^2} + \frac{2^{5/3}}{\sqrt[3]{\sqrt{\alpha^4+16}+\alpha^2}} + \frac{4\alpha}{\sqrt{\sqrt[3]{2}\sqrt[3]{\sqrt{\alpha^4+16}+\alpha^2} - \frac{2^{5/3}}{\sqrt[3]{\sqrt{\alpha^4+16}+\alpha^2}}}}} \\
&\quad - \frac{1}{2}\sqrt{\sqrt[3]{2}\sqrt[3]{\sqrt{\alpha^4+16}+\alpha^2} - \frac{2^{5/3}}{\sqrt[3]{\sqrt{\alpha^4+16}+\alpha^2}}},
\end{aligned} \tag{32}$$

which leads to $\tilde{\gamma}_{VI} - \tilde{\gamma}_{VI_2}^R < 0$ for all $\alpha \in [1, 2]$. Thus, $\gamma < \tilde{\gamma}_{VI}$ is the sufficient condition for interior solution in the game with vertical integration. $\square$

**Proof of Proposition 1.** As discussed in Section 4.2.3, we need to show whether CPs have an incentive to accept any zero-rating offer without monetary transfers and whether the ISP would make such an offer. The profit difference for each CP equals:

$$\begin{aligned}
\pi_1^{ZR_1} - \pi_1^{NZ} &= \frac{\frac{\left[\alpha\left(5-3\gamma^2\right)+(\gamma-2)\gamma-1\right]^2}{(2\gamma^2+\gamma-6)^2} - \frac{4\left(\gamma^2-2\right)^2\left[\alpha\left(2\gamma^2-3\right)+\gamma\right]^2}{(2\gamma^4-9\gamma^2+12)^2}}{4\left(\gamma^2-1\right)} \\
\pi_2^{ZR_2} - \pi_2^{NZ} &= \frac{\frac{\left[-\alpha(\gamma-2)\gamma+\alpha+3\gamma^2-5\right]^2}{(2\gamma^2+\gamma-6)^2} - \frac{4\left(\gamma^2-2\right)^2[\gamma(\alpha+2\gamma)-3]^2}{(2\gamma^4-9\gamma^2+12)^2}}{4\left(\gamma^2-1\right)}.
\end{aligned} \tag{33}$$

Both equations in Expression (33) are positive for $1 \leq \alpha \leq 2$ and $0 < \gamma < \tilde{\gamma}$, which implies that each CP wants to be zero-rated. From Equation (15), we know that $\pi_{ISP}^{ZR_1} - \pi_{ISP}^{ZR_2} < 0$ for all $\alpha \geq 1$. Thus, the ISP always prefers the low quality $CP_2$ as a zero-rating partner. To complete the proof, we need to check if the ISP has an incentive to deviate to full or no zero-rating. To do so, we compare $\pi_{ISP}^{ZR_2}$ to $\pi_{ISP}^{NZ}$ and $\pi_{ISP}^{FZ}$. First,

$$\pi_{ISP}^{ZR_2} - \pi_{ISP}^{FZ} = -\frac{\left[\alpha\left(\gamma^4 - 3\gamma^2 + 4\right) + 2\gamma\left(\gamma^2 - 2\right)\right]^2}{2(\gamma-1)(\gamma+1)\left(\gamma^2-4\right)^2\left(2\gamma^4 - 9\gamma^2 + 12\right)}, \tag{34}$$

which is always positive. Second,

$$\begin{aligned}\pi_{ISP}^{ZR_2} - \pi_{ISP}^{NZ} = \frac{1}{4}\Bigg\{ & \frac{2\alpha^2\left(\gamma^2-2\right)^2 - 4\alpha\gamma - 4\gamma^2 + 6}{\left(\gamma^2-1\right)\left(2\gamma^4 - 9\gamma^2 + 12\right)} \\ & + \frac{\alpha^2\left[-(\gamma+5)\gamma^2 + \gamma + 7\right] - 2\alpha\left(\gamma^3 + \gamma^2 + \gamma - 1\right) - \gamma^2(\gamma+5) + \gamma + 7}{(\gamma-1)(\gamma+1)(\gamma+2)^2(2\gamma-3)}\Bigg\}.\end{aligned} \tag{35}$$

Equation (35) indicates 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 we denote $\gamma_I$, can be implicitly obtained as the solution to $\pi_{ISP}^{ZR_2} - \pi_{ISP}^{NZ} = 0$. It remains to show that $\gamma_I$ is always smaller than $\tilde{\gamma}$. Comparing the right-hand side of Equation (35) to that of $x_2^{NZ} = 0$ (see Equation (8)), we find that the value of $\gamma$ that satisfies $\pi_{ISP}^{ZR_2} - \pi_{ISP}^{NZ} = 0$ is smaller than that satisfying $x_2^{NZ} = 0$, which implies that $\gamma_I < \tilde{\gamma}$. □

**Proof of Lemma 1.** The equilibrium fee for each CP is given by Expression (16) when the left-hand side inequalities bind. From Equation (17), $\widehat{\pi}_{ISP}^{ZR_1} - \widehat{\pi}_{ISP}^{ZR_2}$ is greater than zero if $\gamma < \gamma_{PZ}$, where $\gamma_{PZ}$ is the value of $\gamma$ that satisfies $\widehat{\pi}_{ISP}^{ZR_1} - \widehat{\pi}_{ISP}^{ZR_2} = 0$. It remains to show $\gamma_{PZ} < \tilde{\gamma}$ under our assumptions on $\alpha$ and $\gamma$. Note that $\tilde{\gamma}$ is the solution to $x_2^{NZ} = \frac{\alpha\left(\gamma^2-2\gamma-1\right)-3\gamma^2+5}{2(2\gamma^4+\gamma^3-8\gamma^2-\gamma+6)} = 0$. By comparing the left-hand side of Equation $\widehat{\pi}_{ISP}^{ZR_1} - \widehat{\pi}_{ISP}^{ZR_2} = 0$ to $x_2^{NZ} = 0$, it is easy to see that the value of $\gamma$ satisfying $\widehat{\pi}_{ISP}^{ZR_1} - \widehat{\pi}_{ISP}^{ZR_2} = 0$ is smaller than that satisfying $x_2^{NZ} = 0$, implying that $\gamma_{PZ} < \tilde{\gamma}$. □

**Proof of Lemma 2.** The equilibrium fees, $r_1^{FZ}$ and $r_2^{FZ}$, are obtained by binding the inequalities in Expression (18). Following some algebraic manipulation, it is straightforward to show 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 to $\gamma$ satisfying $r_2^{FZ} = \frac{1}{(\gamma^2-1)}\left\{\frac{\left[\left(\gamma^2-2\right)^2-\alpha\gamma\right]^2}{(2\gamma^4-9\gamma^2+12)^2} - \frac{[\gamma(\alpha+\gamma)-2]^2}{(\gamma^2-4)^2}\right\} = 0$, which implies that $\gamma_{Subsidy} = \frac{1}{2}\left(-\sqrt{\alpha^2-1} + \sqrt{2\alpha\left(\sqrt{\alpha^2-1}+\alpha\right)+7} - \alpha\right)$. Additionally, $\tilde{\gamma} - \gamma_{Subsidy} =$

$\frac{1}{2}\left(\sqrt{\alpha^2-1}-\sqrt{2\alpha\left(\sqrt{\alpha^2-1}+\alpha\right)+7}+\alpha\right)+\frac{\alpha-\sqrt{2(\alpha-4)\alpha+15}}{\alpha-3}$, which is always positive. □

**Proof of Proposition 2.** The differences in ISP profits under full zero-rating and zero-rating with either $CP_1$ or $CP_2$ when monetary transfers are allowed are:

$$\begin{aligned}
\widehat{\pi}_{ISP}^{FZ}-\widehat{\pi}_{ISP}^{ZR_1} &= \frac{\alpha^2\left(3-2\gamma^2\right)-2\alpha\gamma+\left(\gamma^2-2\right)^2}{4\gamma^6-22\gamma^4+42\gamma^2-24}+\frac{1}{2\left(\gamma^2-1\right)}\Bigg\{\frac{3\left(\alpha^2+1\right)\gamma^2-4\left(\alpha^2+1\right)+2\alpha\gamma^3}{\left(\gamma^2-4\right)^2} \\
&+2\left\{\frac{\left[\left(\gamma^2-2\right)^2-\alpha\gamma\right]^2}{\left(2\gamma^4-9\gamma^2+12\right)^2}-\frac{\left[\gamma(\alpha+\gamma)-2\right]^2}{\left(\gamma^2-4\right)^2}\right\}+2\left\{\frac{\left[\gamma-\alpha\left(\gamma^2-2\right)^2\right]^2}{\left(2\gamma^4-9\gamma^2+12\right)^2}-\frac{\left[\alpha\left(\gamma^2-2\right)+\gamma\right]^2}{\left(\gamma^2-4\right)^2}\right\}\Bigg\} \\
&-\frac{1}{4\left(\gamma^2-1\right)}\left\{\frac{\left[\alpha\left(5-3\gamma^2\right)+(\gamma-2)\gamma-1\right]^2}{\left(2\gamma^2+\gamma-6\right)^2}-\frac{4\left(\gamma^2-2\right)^2\left[\alpha\left(2\gamma^2-3\right)+\gamma\right]^2}{\left(2\gamma^4-9\gamma^2+12\right)^2}\right\} \\
\widehat{\pi}_{ISP}^{FZ}-\widehat{\pi}_{ISP}^{ZR_2} &= \frac{1}{112\left(\gamma^2-1\right)}\Bigg\{\frac{14\left[\alpha^2\left(3\gamma^2-4\right)-32\alpha\gamma\left(\gamma^2-2\right)-47\gamma^2+116\right]}{\left(2\gamma^4-9\gamma^2+12\right)^2} \\
&+\frac{14\left(\alpha^2\left(10\gamma^2-21\right)+8\alpha\gamma\left(2\gamma^2-5\right)+28\gamma^2-83\right)}{2\gamma^4-9\gamma^2+12}-7\left(9\alpha^2-6\alpha+5\right) \\
&-\frac{56(\alpha-1)^2}{(\gamma+2)^2}+\frac{4(29\alpha-41)(\alpha-1)}{\gamma+2}-\frac{84(\alpha+1)^2}{\gamma-2}-\frac{28(\alpha+1)^2}{(\gamma-2)^2} \\
&+\frac{2(\alpha+1)(3\alpha-17)}{2\gamma-3}-\frac{7(\alpha+1)^2}{(3-2\gamma)^2}\Bigg\}.
\end{aligned} \tag{36}$$

Both equations in Expression (36) are positive for $1 \leq \alpha \leq 2$, which means that the ISP prefers full zero-rating if monetary transfers are allowed. □

**Proof of Corollary 1.** We compare $CP_2$'s profit levels and demand under sponsored data (and full zero-rating) to those under no monetary transfers (and zero-rating with $CP_2$ only).

$$\begin{aligned}
\widehat{\pi}_2^{FZ}-\pi_2^{ZR_2} &= \frac{\left[\gamma(\alpha+\gamma)-2\right]\left\{\gamma\left[\alpha\left(\gamma^2-3\right)+3\gamma^3-11\gamma\right]+10\right\}}{\left(2\gamma^4-9\gamma^2+12\right)^2} \\
x_2^{FZ}-x_2^{ZR_2} &= -\frac{\gamma\left[\alpha\left(\gamma^4-3\gamma^2+4\right)+2\gamma\left(\gamma^2-2\right)\right]}{2\gamma^8-19\gamma^6+65\gamma^4-96\gamma^2+48}
\end{aligned} \tag{37}$$

Following some algebraic manipulation, it is easy to show that both equations in Expression (37) are negative when $\gamma < \tilde{\gamma}$. This implies that $CP_2$ suffers from a lower market share and profit under sponsored data. □

**Proof of Proposition 3.** We begin by confirming whether either unaffiliated CP would accept a zero-rating offer from the integrated firm. Assuming that the ISP and $CP_1$ are integrated, the unaffiliated CP$_2$ accepts because $\pi_2^A - \pi_2^R = \frac{1}{9(\gamma^2-1)}\left\{\frac{\left[-\alpha\left(4\gamma^2+3\right)\gamma+3\gamma^2+4\right]^2}{\left(\gamma^2+4\right)^2} - \frac{9[\gamma(\alpha+\gamma)-2]^2}{\left(\gamma^2-4\right)^2}\right\} > 0$ for $1 \leq \alpha \leq 2$. Similarly, when the ISP and CP$_2$ integrate with each other, unaffiliated CP$_1$ also accepts because $\pi_1^A - \pi_1^R = \frac{\left[\alpha\left(\gamma^2-2\right)+\gamma\right]^2}{\left(\gamma^4-5\gamma^2+4\right)^2} + \frac{\left(3\alpha\gamma^2+4\alpha-4\gamma^3-3\gamma\right)^2}{9(\gamma^2-1)(\gamma^2+4)^2} > 0$. However, although either unaffiliated CP would consent to being zero-rated, because $\pi_{VI_n}^A - \pi_{VI_n}^R < 0$ for any CP $n$, the ISP does not extend the offer. Moreover, $\pi_{VI_1}^R - \pi_{VI_2}^R = \frac{\left(\alpha^2-1\right)\left(4\left(\gamma^4+\gamma^2\right)-11\right)}{6(\gamma^4+3\gamma^2-4)} > 0$, so that the ISP optimally integrates with CP$_1$. □

**Proof of Proposition 4.** This proof largely follows the procedure described in Section 5.2. Threshold $\gamma_{VI_1}$ in Section 5.2.1 is the value of $\gamma$ that satisfies $\widehat{\pi}_{VI_1}^A - \pi_{VI_1}^R = 0$ where

$$\widehat{\pi}_{VI_1}^A - \pi_{VI_1}^R = \frac{\left[\alpha\left(10\gamma^6 - 89\gamma^4 + 28\gamma^2 + 96\right)\gamma - 24\gamma^6 + 11\gamma^4 + 80\gamma^2 - 112\right]\left\{\gamma^2\left[\alpha\gamma\left(2\gamma^2-5\right)+7\right]-4\right\}}{18\left(\gamma^6 - \gamma^4 - 16\gamma^2 + 16\right)^2}. \quad (38)$$

It follows that as long as $\alpha > \tilde{\alpha}$ (where $\tilde{\alpha}$ is defined in the proof of Proposition 5), $\widehat{\pi}_{VI_1}^A > \pi_{VI_1}^R$ whenever $\gamma < \gamma_{VI_1}$, which implies that the vertically integrated firm zero-rates the low quality CP$_2$'s content for a fee.

We next show that $r_2^{VI}$, the fee that CP$_2$ pays to the integrated firm to be zero-rated, is positive.

$$r_2^{VI} = \pi_2^A - \pi_2^R = \frac{1}{9\left(\gamma^2-1\right)}\left\{\frac{\left[-\alpha\left(4\gamma^2+3\right)\gamma+3\gamma^2+4\right]^2}{\left(\gamma^2+4\right)^2} - \frac{9[\gamma(\alpha+\gamma)-2]^2}{\left(\gamma^2-4\right)^2}\right\}. \quad (39)$$

There exists a threshold on $\gamma$, $\gamma_{Subsidy}^{VI}$, above which $r_2^{VI}$ is negative. Specifically, $\gamma_{Subsidy}^{VI} = \frac{\sqrt[3]{5\alpha^2+\sqrt{\alpha^4(2\alpha^2+25)}}}{2^{2/3}\alpha} - \frac{\alpha}{\sqrt[3]{2}\sqrt[3]{5\alpha^2+\sqrt{\alpha^4(2\alpha^2+25)}}}$ is the solution to $\pi_2^A - \pi_2^R = 0$. To show that whenever CP$_2$ demands a subsidy the integrated firm refuses to zero-rate CP$_2$'s content it is sufficient to show that $\gamma_{VI_1} < \gamma_{Subsidy}^{VI}$. Given that $\gamma_{VI_1}$ is determined at $\widehat{\pi}_{VI_1}^A - \pi_{VI_1}^R = 0$, this is equivalent to showing that $\pi_2^A - \pi_2^R > \widehat{\pi}_{VI_1}^A - \pi_{VI_1}^R$. Because $(\pi_2^A - \pi_2^R) - (\widehat{\pi}_{VI_1}^A - \pi_{VI_1}^R) = \frac{\left\{\gamma^2\left[\alpha\gamma\left(2\gamma^2-5\right)+7\right]-4\right\}^2}{6(\gamma^2+4)(\gamma^4-5\gamma^2+4)^2}$ is always positive for $\alpha > \tilde{\alpha}$, this is indeed the case. □

**Proof of Proposition 5.** Suppose that monetary transfers for zero-rating are allowed. Proposition 4 states that when $\alpha > \tilde{\alpha}$, the ISP integrates with CP$_1$, and either full zero-rating (when $\gamma < \gamma_{VI_1}$) or content foreclosure (when $\gamma > \gamma_{VI_1}$) emerges in equilibrium. By comparison, from Section 5.2.2, recall that if the ISP were to integrate with CP$_2$ instead, full zero-rating emerges. This requires us to compare $\hat{\pi}_{VI_1}^A$ with $\hat{\pi}_{VI_2}^A$ when $\gamma < \gamma_{VI_1}$ and $\pi_{VI_1}^R$ with $\hat{\pi}_{VI_2}^A$ when $\gamma > \gamma_{VI_1}$.

Suppose that $\gamma < \gamma_{VI_1}$. The difference between $\hat{\pi}_{VI_1}^A$ and $\hat{\pi}_{VI_2}^A$ is:

$$\hat{\pi}^A_{VI_1} - \hat{\pi}^A_{VI_2} = \frac{1}{9\left(\gamma^6 - \gamma^4 - 16\gamma^2 + 16\right)^2}\Big[\alpha^2\left(16\gamma^{12} - 147\gamma^{10} + 180\gamma^8 + 538\gamma^6 + 84\gamma^4 - 1728\gamma^2 + 832\right) - 18\alpha\left(\gamma^6 + 6\gamma^4 - 32\right)\gamma^3 - 16\gamma^{12} + 138\gamma^{10} - 225\gamma^8 - 502\gamma^6 + 60\gamma^4 + 1152\gamma^2 - 832\Big]. \tag{40}$$

Following some algebraic manipulation, we find that there exists a threshold on $\alpha$, denoted $\tilde{\alpha}$, below which $\hat{\pi}^A_{VI_1} < \hat{\pi}^A_{VI_2}$. Specifically, $\tilde{\alpha}$, the solution to $\hat{\pi}^A_{VI_1} = \hat{\pi}^A_{VI_2}$, is:

$$\tilde{\alpha} = \frac{1}{16\gamma^{12} - 147\gamma^{10} + 180\gamma^8 + 538\gamma^6 + 84\gamma^4 - 1728\gamma^2 + 832}\Bigg[9\left(\gamma^9 + 6\gamma^7 - 32\gamma^3\right) + \sqrt{2}\sqrt{\left(\gamma^2 - 4\right)^2\left(\gamma^2 - 1\right)^3\left(8\gamma^6 - 21\gamma^4 - 90\gamma^2 - 104\right)\left(16\gamma^8 - 67\gamma^6 - 210\gamma^4 - 172\gamma^2 + 208\right)}\Bigg]. \tag{41}$$

Next, suppose that $\gamma > \gamma_{VI_1}$. Comparing $\pi^R_{VI_1}$ with $\hat{\pi}^A_{VI_2}$ yields:

$$\pi^R_{VI_1} - \hat{\pi}^A_{VI_2} = \frac{1}{18\left(\gamma^6 - \gamma^4 - 16\gamma^2 + 16\right)^2}\Big[4\left(3\alpha^2 - 8\right)\gamma^{12} + 6\left(46 - 11\alpha^2\right)\gamma^{10} - 141\left(\alpha^2 + 2\right)\gamma^8 + \left(1024\alpha^2 - 1177\right)\gamma^6 + 36\left(18\alpha^2 - 11\right)\gamma^4 + 48\left(71 - 72\alpha^2\right)\gamma^2 + 64\left(26\alpha^2 - 33\right) + 48\alpha\gamma^{11} - 248\alpha\gamma^9 + 342\alpha\gamma^7 + 72\alpha\gamma^5 + 32\alpha\gamma^3 + 384\alpha\gamma\Big]. \tag{42}$$

Following some algebraic manipulation, we find that there exists a threshold on $\alpha$, denoted $\tilde{\tilde{\alpha}}$, below which $\pi^R_{VI_1} < \hat{\pi}^A_{VI_2}$ holds. In this case, $\tilde{\tilde{\alpha}}$, which solves $\pi^R_{VI_1} = \hat{\pi}^A_{VI_2}$, is:

$$\tilde{\tilde{\alpha}} = \frac{1}{12\gamma^{12} - 66\gamma^{10} - 141\gamma^8 + 1024\gamma^6 + 648\gamma^4 - 3456\gamma^2 + 1664}\Big[2\sqrt{3}\sqrt{\left(\gamma^2 - 4\right)^2\left(\gamma^2 - 1\right)^3\left(\gamma^2 + 4\right)\left(32\gamma^{12} - 180\gamma^{10} - 300\gamma^8 + 2117\gamma^6 + 5286\gamma^4 + 1968\gamma^2 - 4576\right)} - \gamma\left(24\gamma^{10} - 124\gamma^8 + 171\gamma^6 + 36\gamma^4 + 16\gamma^2 + 192\right)\Big]. \tag{43}$$

We have confirmed that $\tilde{\alpha}$ and $\tilde{\tilde{\alpha}}$ are between 1 and 2 for all $\gamma \in (0, 1)$.[32] Under our interior solution condition, we can show that $\tilde{\alpha} < \tilde{\tilde{\alpha}}$, implying that $\alpha < \tilde{\alpha}$ is a sufficient condition for the ISP to integrate with $\text{CP}_2$ (and zero-rate $\text{CP}_1$). Moreover, if $\alpha \in (\tilde{\alpha}, \tilde{\tilde{\alpha}})$, the ISP integrates with $\text{CP}_1$ when $\gamma < \gamma_{VI_1}$ and $\text{CP}_2$ when $\gamma > \gamma_{VI_1}$. □

[32] Details available upon request.

**Proof of Corollary 2.** By Expressions in (20) and (21), the difference, $x_2^A - x_2^R$, is given by:

$$x_2^A - x_2^R = \frac{8 - 2\gamma^2 \left[\alpha\gamma \left(2\gamma^2 - 5\right) + 7\right]}{3\left(\gamma^6 - \gamma^4 - 16\gamma^2 + 16\right)}, \tag{44}$$

which can be readily shown to be positive. □

**Proof of Proposition 6.** Suppose that there are no monetary transfers. We compare total social welfare when the ISP vertically integrates with $\mathrm{CP}_1$ (and zero-rates affiliated content only) to welfare without vertical integration. In the latter case the ISP either zero-rates $\mathrm{CP}_2$ only ($\gamma > \gamma_I$) or does not zero-rate any content. Total social welfare level for each case is as follows:

$$\begin{aligned}
SW_{VI_1}^R &= \frac{1}{18\left(\gamma^4 + 3\gamma^2 - 4\right)^2}\Big\{3\left(\gamma^2+4\right)\left[\alpha^2\left(4\gamma^6 - 18\gamma^2 + 15\right) + 2\alpha\gamma\left(5\gamma^2 - 6\right) - 3\gamma^2 + 4\right] \\
&\quad - 2\left(\gamma^2 - 1\right)\left[-\alpha\left(4\gamma^2+3\right)\gamma + 3\gamma^2 + 4\right]^2\Big\} \\
SW^{ZR_2} &= \frac{-1}{2\left(\gamma^2-1\right)\left(2\gamma^4 - 9\gamma^2 + 12\right)^2}\Big[\alpha^2\left(\gamma^2-2\right)^2\left(4\gamma^4 - 15\gamma^2 + 20\right) \\
&\quad + 2\alpha\left(4\gamma^6 - 26\gamma^4 + 57\gamma^2 - 44\right)\gamma + 8\gamma^8 - 60\gamma^6 + 170\gamma^4 - 217\gamma^2 + 108\Big] \\
SW^{NZ} &= \frac{1}{4\left(\gamma^2-1\right)\left(2\gamma^2+\gamma-6\right)^2}\Big\{\alpha^2\left(\gamma\left(7 - 3\gamma\left(4\gamma^2+\gamma-15\right)\right) - 47\right) \\
&\quad + 2\alpha(4\gamma+1)(\gamma((\gamma-3)\gamma-3)+7) + \gamma\left(7 - 3\gamma\left(4\gamma^2+\gamma-15\right)\right) - 47\Big\}.
\end{aligned} \tag{45}$$

Following some algebraic manipulation, we find that $\max\{SW^{ZR_2}, SW^{NZ}\} < SW_{VI_1}^R$.

When there are monetary transfers for zero-rating, we need to compare the full zero-rating outcome without vertical integration to the alternative outcomes (full zero-rating and zero-rating affiliated content only) that can prevail under vertical integration.

$$\begin{aligned}
SW_{VI_1}^A - SW^{FZ} &= -\frac{\left[\alpha\left(\gamma^2-2\right)+\gamma\right]^2}{\left(\gamma^2-4\right)^2\left(\gamma^2-1\right)} \\
SW_{VI_1}^R - SW^{FZ} &= \frac{1}{18\left(\gamma^4+3\gamma^2-4\right)^2}\Big\{3\left(\gamma^2+4\right)\left[\alpha^2\left(4\gamma^6 - 18\gamma^2 + 15\right)\right. \\
&\quad \left. + 2\alpha\gamma\left(5\gamma^2-6\right) - 3\gamma^2 + 4\right] - 2\left(\gamma^2-1\right)\left[-\alpha\left(4\gamma^2+3\right)\gamma + 3\gamma^2 + 4\right]^2\Big\} \\
&\quad + \frac{9\left[2\left(\alpha^2+1\right)\gamma^4 - 9\left(\alpha^2+1\right)\gamma^2 + 12\left(\alpha^2+1\right) + 6\alpha\gamma^3 - 16\alpha\gamma\right]}{\left(\gamma^2-4\right)^2\left(\gamma^2-1\right)}
\end{aligned} \tag{46}$$

Following some algebraic manipulation, we find that $SW^{FZ} < \min\{SW_{VI_1}^R, SW_{VI_1}^A\}$.

We next show that $\text{CP}_2$'s market share and profit can be lower under vertical integration. Assuming that content is sufficiently substitutable ($\gamma_I < \gamma$), if monetary transfers are not allowed, the ISP zero-rates low quality $\text{CP}_2$'s content only. If this is the case, the profit difference (market share difference), $\pi_2^R - \pi_2^{ZR_2} = \frac{(\gamma^2-2)^2[\gamma(\alpha+2\gamma)-3]^2}{(2\gamma^4-9\gamma^2+12)^2(\gamma^2-1)} - \frac{[-\alpha(4\gamma^2+3)\gamma+3\gamma^2+4]^2}{9(\gamma^2+4)^2(\gamma^2-1)}$ ($x_2^R - x_2^{ZR_2} = \frac{\alpha(8\gamma^6-27\gamma^4+27\gamma^2+12)\gamma+22\gamma^4-66\gamma^2+24}{3(2\gamma^8-3\gamma^6-23\gamma^4+72\gamma^2-48)}$), can be shown to be negative, meaning that $\text{CP}_2$ has higher profit (and greater share) when it is zero-rated, which does not occur in the vertical integration regime when $\gamma_I < \gamma$.

If monetary transfers are allowed, we need to compare the full zero-rating case (no vertical integration) with either the case in which the integrated firm zero-rates the unaffiliated CP's content (full zero-rating under vertical integration) or the case in which the unaffiliated CP is not zero-rated (foreclosure under vertical integration). The profit difference (market share difference), $\pi_2^R - \pi_2^{FZ} = \frac{(\gamma(\alpha+\gamma)-2)^2}{(\gamma^2-4)^2(\gamma^2-1)} - \frac{[-\alpha(4\gamma^2+3)\gamma+3\gamma^2+4]^2}{9(\gamma^2+4)^2(\gamma^2-1)}$ ($x_2^R - x_2^{FZ} = \frac{2\{\gamma^2[\alpha\gamma(2\gamma^2-5)+7]-4\}}{3(\gamma^6-\gamma^4-16\gamma^2+16)}$), is always negative under our interior solution condition, meaning that $\text{CP}_2$ is worse off (and has lower share) under vertical integration.

Additionally, we compare the fees for zero-rating that $\text{CP}_2$ faces with and without vertical integration. The difference between the fee with vertical integration ($r_2^{VI}$) and that without integration ($r_2^{FZ}$) is given by:

$$r_2^{VI} - r_2^{FZ} = \frac{1}{9(\gamma^2-1)(-2\gamma^6+\gamma^4+24\gamma^2-48)^2}\Big\{\gamma\left[2\alpha\left(4\gamma^6-15\gamma^4+9\gamma^2+12\right)-3\gamma^5+19\gamma^3-36\gamma\right] \\ \times \left\{\gamma[\alpha(8\gamma^6-30\gamma^4+24\gamma^2+48)-9\gamma^5+19\gamma^3+36\gamma]-96\right\}\Big\} > 0 \quad \text{if} \quad \gamma \in (0, \tilde{\gamma}_{VI}), \tag{47}$$

which implies that the low quality $\text{CP}_2$ needs to pay more under vertical integration. □

**Proof of Proposition 7.** In the game without vertical integration, allowing monetary transfers for zero-rating always leads to full zero-rating equilibrium whereas either zero-rating with $\text{CP}_2$ or no zero-rating emerges without monetary transfers. In the game with vertical integration, the integrated firm offers to zero-rate the unaffiliated CP for a fee (which leads to full zero-rating) when $\gamma < \gamma_{VI}$. In order to see whether sponsored data (monetary transfers) is welfare-enhancing, we compare the welfare levels under full zero-rating to welfare under the partial zero-rating scenario that prevails without monetary transfers. This leads to the following set of comparisons:

$$
\begin{aligned}
SW^{FZ} - SW^{NZ} &= -\frac{(\alpha+1)^2(\gamma-1)^2(4\gamma-7)}{4(\gamma+1)\left(2\gamma^2-7\gamma+6\right)^2} \\
SW^{FZ} - SW^{ZR_2} &= -\frac{\left(4\gamma^4-21\gamma^2+28\right)\left[\alpha\left(\gamma^4-3\gamma^2+4\right)+2\gamma\left(\gamma^2-2\right)\right]^2}{2\left(\gamma^2-4\right)^2\left(\gamma^2-1\right)\left(2\gamma^4-9\gamma^2+12\right)^2} \\
SW^{A}_{VI_1} - SW^{R}_{VI_1} &= \frac{1}{18\left(\gamma^6-\gamma^4-16\gamma^2+16\right)^2}\Big\{\left[\alpha\left(10\gamma^6-89\gamma^4+28\gamma^2+96\right)\gamma\right. \\
&\quad \left.-24\gamma^6+11\gamma^4+80\gamma^2-112\right]\left\{\gamma^2\left[\alpha\gamma\left(2\gamma^2-5\right)+7\right]-4\right\}\Big\}.
\end{aligned} \tag{48}
$$

The first two equations are always positive whereas the last one is positive for $\gamma < \gamma_{VI_1}$. Thus, full zero-rating, which only prevails under sponsored data, is welfare-enhancing. □

**Proof of Proposition 8.** Suppose that monetary transfers for zero-rating are permitted. In the game without vertical integration, we compare $SW^{FZ}$ with $SW^{NZ}$. As discussed following Expression (48), $SW_{FZ} - SW_{NZ}$ is always positive. In the game with vertical integration, we compare $SW^{NZ}$ with either $SW^{A}_{VI_1}$ (when $\gamma < \gamma_{VI_1}$) or $SW^{R}_{VI_1}$ (when $\gamma > \gamma_{VI_1}$).

$$
\begin{aligned}
SW^{NZ} - SW^{A}_{VI_1} &= \frac{1}{4(3-2\gamma)^2(\gamma-2)^2(\gamma+2)^2\left(\gamma^2-1\right)} \\
&\quad \times \Big\{\alpha^2\{\gamma\{\gamma\{\gamma\{\gamma[\gamma(20\gamma-51)-55]+223\}-41\}-264\}+172\} \\
&\quad + 2\alpha\{\gamma\{\gamma\{\gamma[\gamma(\gamma-3)(4\gamma+25)+35]+135\}-144\}+28\} \\
&\quad + \gamma\{\gamma\{\gamma\{\gamma[\gamma(4\gamma-3)-11]-17\}+75\}-72\}+28\Big\} \\
SW^{NZ} - SW^{R}_{VI_1} &= \frac{1}{4\left(\gamma^2-1\right)\left(2\gamma^2+\gamma-6\right)^2}\Big\{\alpha^2\left\{\gamma\left[7-3\gamma\left(4\gamma^2+\gamma-15\right)\right]-47\right\} \\
&\quad + 2\alpha(4\gamma+1)\{\gamma[(\gamma-3)\gamma-3]+7\}+\gamma\left[7-3\gamma\left(4\gamma^2+\gamma-15\right)\right]-47\Big\} \\
&\quad - \frac{1}{18\left(\gamma^4+3\gamma^2-4\right)^2}\Big\{3\left(\gamma^2+4\right)\left[\alpha^2\left(4\gamma^6-18\gamma^2+15\right)+2\alpha\gamma\left(5\gamma^2-6\right)-3\gamma^2+4\right] \\
&\quad - 2\left(\gamma^2-1\right)\left[-\alpha\left(4\gamma^2+3\right)\gamma+3\gamma^2+4\right]^2\Big\}.
\end{aligned} \tag{49}
$$

We find that $SW_{NZ} < \min\{SW^{A}_{VI_1}, SW^{R}_{VI_2}\}$, which implies that zero-rating together with sponsored data leads to greater social welfare relative to no zero-rating. □

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