Effects of Vertical Integration on Internet Service Providers' Zero-rating Choice

Saruta, Fuyuki

23 October 2021

Effects of Vertical Integration on Internet Service Providers' Zero-rating Choice[*†]

Fuyuki Saruta[‡]

October 23, 2021

Abstract

This study investigates the effects of vertical integration between an Internet service provider (ISP) and a content provider (CP) on the ISP's zero-rating choice and social welfare. We develop a simple model where a monopolistic ISP delivers content from two CPs to a representative consumer. The ISP can offer zero-rating contracts to one or two CPs, allowing the consumer to use zero-rated content without consuming monthly data usage. We investigate how the integration between the ISP and a CP impacts the ISP's zero-rating choice and social welfare. Our findings are as follows. First, the vertically integrated ISP may zero-rate the unaffiliated CP exclusively when the CPs' profitability is low and the ISP's operating cost is high. Second, the integration decreases the total surplus when the CP's profitability is sufficiently low; otherwise, it improves the total surplus. Our results indicate that a vertical integration and zero-rating could be both welfare-enhancing and reducing.

Keywords: Mobile Internet; Zero-rating; Sponsored data; Net neutrality; Vertical integration

JEL Classification: D21; L11; L96

[*]This work was partially supported by Grant-in-Aid for JSPS Fellows Grant Number 20J11411. The usual disclaimer applies.

[†]This paper develops a new model that is quite different from Saruta (2020). First, we generalize the consumer's utility function and the profit functions of the content providers (CPs) that are specified in Saruta (2020). Second, we allow the Internet service provider (ISP) to set the subscription fee and the data cap to consumers after it makes zero-rating contracts, whereas these are exogenously given in Saruta (2020). This model is simpler and more general than the previous version and we consider that it more clearly reveals the relationship between vertical integration, zero-rating, and the ISP's data plan.

[‡]Graduate School of Economics, Osaka University; 1-7 Machikaneyama, Toyonaka, Osaka, 560-0043, Japan; Email: saruta@iser.osaka-u.ac.jp, ORCID: 0000-0001-9998-0640.

1 Introduction

Zero-rating is a commercial tactic frequently observed in mobile Internet service markets.[1] In Internet plans for mobile phones, the Internet service providers (ISPs) often set monthly caps on subscribers' data consumption, which are the upper bounds of the total data use. Zero-rating plans [2] designate the data of particular CPs as free content; subscribers to the plan can use the zero-rated content as much as they want without additional payment. ISPs offer mobile Internet plans with zero-rating to collect zero-rating fees from CPs or to promote their own content.

The practice of zero-rating is controversial and there is a debate as to whether it violates the principle of "net neutrality." The term "net neutrality" is generally used to mean that ISPs do not favor certain content or charge CPs for delivering content. This principle is based on the idea that an open Internet is essential for technological innovation and economic growth. Moreover, it is pointed out that zero-rating may hinder fair competition among CPs. In particular, when ISPs zero-rate their content or their affiliated CPs content, the plans become subject to investigation and regulation.

Proponents of zero-rating, mostly ISPs, argue that (sponsored) zero-rating plans benefit consumers because they enjoy services for free. In addition, they argue that there is no violation of fair competition because all CPs have the opportunity to become zero-rated CPs. It may be the case that ISPs hold an unspoken belief that not only ISPs but also CPs should pay for consumers' data use because of the rapid growth in Internet usage. Conversely, opponents of zero-rating criticize it because consumers cannot choose the content included in zero-rating plans and have to pay a higher price if they want to enjoy content that is not zero-rated. They also point out that in the long run, the price of plans could increase and that zero-rating discourages the development of new content.

In some countries, such as Canada, Brazil, and India, zero-rating has been prohibited because it is considered to harm net neutrality, but there are some countries where the debate over its effects remains active. For example, in the US, despite the Open Internet Order that was intended to protect net neutrality, the Federal Communications Commission (FCC) stated in 2017 that it would end its investigation into zero-rating, effectively

[1] For a survey on zero-rating, see, e.g., Krämer and Peitz (2018) and Yoo (2017).

[2] A zero-rating plan is sometimes called a "sponsored data plan" when ISPs receive monetary transfers from zero-rated content providers (CPs). In this study, we focus on sponsored data plans, and do not deal with "nonsponsored" zero-rating plans.

allowing zero-rating plans.[3] In addition, the FCC has repealed the Open Internet Order and, jointly with the Federal Trade Commission, has adopted a stance of allowing ISPs more freedom.[4] In response, several consumer protection groups and US states that support net neutrality are actively fighting zero-rating. In particular, in California, a stringent net neutrality law was passed in 2018.[5] This law forced AT&T to discontinue its plan that zero-rates its video streaming service in 2021.[6] In the European Union, in 2021, the Court of Justice of the EU ruled that the zero-rating plans offered by Telecom Deutschland and Vodafone were in violation of EU law (Court of Justice of the European Union, 2021).

Although there has been much debate on whether zero-rating does violate net neutrality, there is no unified view on its actual impact on competition among CPs and social welfare. To fill this gap, we construct a simple monopolistic ISP model in which the ISP chooses the optimal zero-rating plan and then sets the data cap and subscription fee for consumers. Moreover, we examine whether the results vary depending on whether the ISP is integrated with a CP. We demonstrate that the vertical integration between the ISP and a CP may change the ISP's zero-rating choice and increase the total surplus.

To elaborate, we consider the situation where a monopolistic ISP delivers content from two CPs to a representative consumer and analyze the following two-stage game. First, the ISP makes zero-rating offers with zero-rating fees to one or both CPs if necessary. The CP or CPs that receive the offer decide whether to accept or decline it and the zero-rated CPs pay the zero-rating fee to the ISP. Second, the ISP sets the subscription fee and the data cap for the consumer, who chooses whether to join the plan. A consumer who subscribes to the plan determines his/her consumption amount of each type of content.

We derive the following results. First, the independent ISP implements open zero-rating (i.e., zero-rating with all CPs) or makes no zero-rating offers. Zero-rating increases the ISP's operating cost and the revenue from the consumer through subscription fees. Moreover, the ISP receives zero-rating fees from CPs. When the increase in cost outweighs the increase in revenue, the ISP implements open zero-rating; otherwise, it chooses net neutrality. This result may describe a situation where consumers are permitted to use data freely and their data use is too large for ISPs to bear alone, leading the ISPs to offer zero-rating plans so that CPs contribute to paying for the consumers' data use.

[3] https://www.fcc.gov/document/statement-chairman-pai-free-data-programs
[4] https://www.fcc.gov/document/fccftc-sign-mou-coordinate-online-consumer-protection-efforts
[5] https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB822
[6] https://www.attpublicpolicy.com/congress/impact-of-california-net-neutrality-law-on-free-data-services/

Second, if the ISP is integrated with a CP, the integrated ISP may exclusively zero-rate the unaffiliated CP. The ISP the ISP chooses exclusive zero-rating with the unaffiliated CP or no zero-rating when the CPs' advertising revenue per unit of consumption is lower than the ISP's marginal cost; otherwise. Note that the integrated ISP internalizes the revenue of the affiliated CPs. Therefore, when the ISP chooses exclusive zero-rating with the unaffiliated CP, it can collect a zero-rating fee from the CP while adjusting the data caps to ensure that the usage of the integrated CPs is at an optimal level. Conversely, when the ISP chooses net neutrality, it can control the consumption of both types of content to the second-best level.

Third, the vertical integration increases or decreases the total surplus depending on the CPs' advertising revenue and the ISP's operating cost per unit of content. When the CPs earn little or no revenue from advertising relative to the ISP's cost, the integration changes the selected plan from a net neutrality plan to an exclusive zero-rating plan with the unaffiliated CP, which increases the total consumption of content. This increase is inefficient when the advertising revenue is sufficiently low and efficient when it is not so low. When the advertising revenue becomes large, the integration changes the selected plan from open zero-rating to net neutrality, decreasing total consumption. In this case, the change is efficient for the total surplus. Because the integrated ISP internalizes the revenue of its affiliated CP, the ISP does not need to implement excessive zero-rating to collect zero-rating fees.

The remainder of the paper is as follows. Section 1.1 surveys the related literature. Section 2 explains the detail of our model. Section 3 analyzes the independent ISP case, and Section 4 studies the vertically integrated ISP case. Section 5 investigates the effect of the vertical integration on social welfare. Section 6 provides concluding remarks.

1.1 Related literature

We contribute to the literature on net neutrality (e.g., Bourreau and Lestage, 2019; Choi et al., 2015, 2018; Greenstein et al., 2016). The related literature discusses the impact on market outcomes of discrimination by ISPs in terms of transmission speed, transmission quality, or termination fees on content. Zero-rating is one means by which ISPs discriminate in their treatment of content on the Internet.

Several papers analyze zero-rating, and some model zero-rating as discrimination in terms of the termination fees at which ISPs transfer content. These papers assume that

ISPs charge termination fees to consumers per unit of consumption and discount those for zero-rated content (or make them free). Moreover, Gautier and Somogyi (2020) explore the difference between zero-rating and prioritization (differentiating in speed), and Lorenzon (2021) examines the CPs' investment in their content quality and the ISP's investment in its network capacity. Vyavahare and Manjunath (2018) studies zero-rating in the presence of competition between ISPs. Jeitschko et al. (2020) is the closest in spirit to our paper; they investigate the relationship between the ISP's vertical integration and zero-rating practice. Jeitschko et al. (2020), as well as the present paper, analyze the situation where an ISP intermediates the transactions between consumers and two CPs. They show that vertical integration is welfare-enhancing; however, it is detrimental to the unaffiliated CP. We complement Jeitschko et al. (2020) by assuming the ISP's operating cost and demonstrating that the vertical integration may be either welfare-enhancing or welfare-reducing depending on the ISP's marginal cost and CPs' advertising revenue.

Some papers model zero-rating as the exemption of content from data caps, and we follow this approach. Somogyi (2017) analyzes the ISP's zero-rating choice taking the subscription fee and the data cap for consumers as given. The ISP implements zero-rating to adjust the consumption of each type of content and collects zero-rating fees from CPs. We complement Somogyi (2017) by allowing the ISP to set the subscription fee and the data cap after making zero-rating contracts with CPs. Hoernig and Monteiro (2020) also endogenize the subscription fee and the data cap. They analyze the ISP's incentive to implement nonsponsored zero-rating when content has network externalities. Inceoglu and Liu (2019) and Schnurr and Wiewiorra (2018) assume that there is heterogeneity among consumers, and Jullien and Sand-Zantman (2018) assume heterogeneity among CPs. They analyze zero-rating as second-degree price discrimination and demonstrate that the ISP can screen consumers or CPs by offering the zero-rating option.

At last, our paper is also related to the literature on ISPs' strategic use of data caps (e.g., Chillemi et al., 2020; Dai and Jordan, 2013a,b; Economides and Hermalin, 2015; Hermalin and Katz, 2007). In the literature, ISPs set data caps for various purposes (for a survey, see Jordan, 2017). We contribute to the literature by incorporating zero-rating with strategic use of a data cap. In our model, the ISP sets a data cap to control consumption of content that is not zero-rated and to avoid the unnecessary operating cost.

2 Model

We analyze the situation where a monopolistic ISP delivers content from two CPs, CP1 and CP2, to a representative consumer. This ISP offers a single data plan $\{P, D\}$ to the consumer, where P is the subscription fee, and D is the data cap. When the consumer subscribes to this plan by paying the subscription fee P, he/she can enjoy contents 1 and 2, which are provided by CP1 and CP2, respectively, within the data cap D. Moreover, the ISP specifies which CPs it will zero-rate. Consumption of zero-rated CPs' content is not counted toward D; i.e., the consumer can consume zero-rated content as much as he/she wants beyond D and consume content that is not zero-rated within D.

2.1 Internet service provider

The monopolistic ISP collects a subscription fee, P, from a consumer. In addition to this, the ISP can charge a zero-rating fee, S_i, to CP i $(= \{1, 2\})$ as a return for zero-rating content i. The ISP can zero-rate both CPs (*open zero-rating*) or zero-rate only one of them (*exclusive zero-rating*). When it does not implement any zero-rating, we refer to the situation as *net neutrality*. The ISP delivers content from CPs to the consumer at a constant marginal cost c (> 0). Then, its profit is:

$$\pi_{ISP} = P + \sum_{i \in \{1,2\}} S_i \cdot \mathbb{1}_i - \sum_{i \in \{1,2\}} c \cdot x_i, \tag{1}$$

where $\mathbb{1}_i$ is the indicator function, which takes a value of 1 when CPi is zero-rated and 0 otherwise, and x_i denotes the consumption of content i.

2.2 Content providers

Each CP, CPi, provides content i. We assume that the content is provided to the consumer for free, and that CPs earn revenue through advertising. The two CPs are homogeneous in their revenue-generating ability. When the consumption for content i is x_i, CPi's profit is $\pi_{CP}(x_i)$, where $\pi'_{CP}(x_i) > 0$ and $\pi''_{CP}(x_i) \leq 0$.

2.3 Consumer

The representative consumer subscribes to the data plan offered by the ISP to enjoy the content provided by the two CPs. We assume that this consumer perceives the two contents

as noncompeting goods and visits all CPs. Furthermore, the contents are homogeneous in their impacts on the consumer's utility. The consumer subscribing to the data plan determines a level of consumption, (x_1, x_2), to maximize his/her utility subject to the data budget constraint. The consumer solves the following maximization problem:

$$\text{maximize} \quad U(x_1, x_2) = u(x_1) + u(x_2) \tag{2}$$

$$\text{subject to} \quad x_1 \cdot (1 - \mathbb{1}_1) + x_2 \cdot (1 - \mathbb{1}_2) \leq D, \tag{3}$$

where $u(x_i)$ is the utility when consuming x_i units of content i. We assume this is strictly concave on $[0, \bar{x}]$ and ensures that the ISP can make its money back from the consumer's subscription fee alone; i.e., $u'(0) > c$ and $u'(\bar{x}) = 0$. The consumer faces data capacity constraints; however, when content i is zero-rated, the usage of content i will not be counted toward the data cap.

2.4 Timing

To summarize, we consider the following two-stage game.

Stage 1. The ISP makes zero-rating offers to one or both CPs, setting a zero-rating fee S_i. It can choose not to make any zero-rating offers and receive no zero-rating fees. The CPs that receive a zero-rating offer decide simultaneously whether to accept or decline it.

Stage 2. The ISP determines the subscription fee and the data cap, $\{P, D\}$, of its data plan. The consumer decides whether to subscribe to the data plan. When he/she subscribes to it, the consumer chooses his/her consumption level, (x_1, x_2).

We solve this game by backward induction. First, we analyze the case when the ISP is independent. Next, we deal with the case when the ISP is vertically integrated with one of the two CPs. Then, we examine the effect of the vertical integration on social welfare.

3 No-integration case

3.1 Stage 2 in the no-integration case

In Stage 2, the consumer subscribes to the data plan whenever $U(x_1, x_2) \geq P$. He/she chooses the consumption level, (x_1, x_2), to maximize utility, U. The optimal consump-

tion level depends on the size of the data cap, D, and what kind of zero-rating the ISP implements: net neutrality, open zero-rating, or exclusive zero-rating. In each scheme, anticipating the consumer's consumption level, the ISP sets P and D to maximize its profit.

Net neutrality Under net neutrality, because of the symmetry between the two contents expressed in (2), the consumer finds it optimal to consume the same amount of contents 1 and 2 up to half of the data cap D, or $\bar{x}$, the point at which his/her marginal utility is zero. Therefore, the consumer's consumption level is:

$$\begin{cases} (x_1, x_2) = (\frac{D}{2}, \frac{D}{2}) & \text{if } \frac{D}{2} < \bar{x}, \\ (x_1, x_2) = (\bar{x}, \bar{x}) & \text{if } \frac{D}{2} \geq \bar{x}. \end{cases} \tag{4}$$

Expecting these cases, the ISP sets P such that it extracts all of the consumer's surplus, that is:

$$\begin{cases} P = 2u(\frac{D}{2}) & \text{if } \frac{D}{2} < \bar{x} \\ P = 2u(\bar{x}) & \text{if } \frac{D}{2} \geq \bar{x}. \end{cases} \tag{5}$$

Here, we let x_c denote the amount for which $u'(x_c) = c$. Note that because $u'(x)$ is decreasing in x, $x_c < \bar{x}$. To make its marginal revenue equal to its marginal cost, the ISP optimally sets $D = 2x_c$ and $P = 2u(x_c)$ under net neutrality.

Open zero-rating Under open zero-rating, the consumer enjoys the CPs' contents as much as he/she desires. The optimal consumption level is:

$$(x_1, x_2) = (\bar{x}, \bar{x}). \tag{6}$$

Therefore, the ISP sets $P = 2u(\bar{x})$ to extract the consumer's surplus. This subscription fee for the open zero-rating plan does not depend on D. In other words, the size of the data cap does not matter when considering the price on the consumer's side under open zero-rating. However, an excessively large data cap undermines the CPs' incentives to accept zero-rating offers and pay zero-rating fees. Thus, we assume that under open zero-rating, the ISP sets $D \leq x_c$, which is small enough to make CPs accept zero-rating offers. However, this data cap is practically meaningless for the consumer under open zero-rating.

	$\{P, D\}$	(x_1, x_2)
NN	$\{2u(x_c), 2x_c\}$	(x_c, x_c)
Open	$\{2u(\bar{x}), D(\leq x_c)\}$	$(\bar{x}, \bar{x})$
Exclusive	$\{u(\bar{x}) + u(x_c), x_c\}$	$(\bar{x}, x_c)$

Table 1: Subscription fees, data caps of data plans, and the corresponding consumption levels in the no-integration case.

Exclusive zero-rating Suppose that CP1 is zero-rated exclusively. Now, the consumer can only devote D to the use of content 2 from CP2. Therefore, the consumer consumes as much of content 1 as he/she wants but only consumes content 2 up to D or $\bar{x}$. The optimal consumption level is:

$$\begin{cases} (x_1, x_2) = (\bar{x}, D) & \text{if } D < \bar{x}, \\ (x_1, x_2) = (\bar{x}, \bar{x}) & \text{if } D \geq \bar{x}. \end{cases} \tag{7}$$

In the same way as in the case of net neutrality, the ISP tries to extract all of the consumer's surplus through P. Therefore:

$$\begin{cases} P = u(\bar{x}) + u(D) & \text{if } D < \bar{x}, \\ P = 2u(\bar{x}) & \text{if } D \geq \bar{x}. \end{cases} \tag{8}$$

Now, the ISP can control the consumption of content 2. It wants its marginal revenue from content 2 to at least match its marginal cost, so it sets $D = x_c$ and $P = u(\bar{x}) + u(x_c)$.

The above results are summarized in Table 1.

3.2 Stage 1 in the no-integration case

In Stage 1, the ISP that wants to implement zero-rating plans offers acceptable zero-rating fees to the CP(s). The CPs earn $\bar{x}$ consumption and $\pi_{CP}(\bar{x})$ advertising revenue when their contents are zero-rated, regardless of whether the zero-rating is exclusive or open. Conversely, they earn x_c consumption and $\pi_{CP}(x_c)$ revenue when they are not zero-rated. Note that the ISP does not zero-rate content if it is unable to obtain compensation from the CPs because its marginal cost exceeds its marginal revenue from the consumer under any zero-rating plans. Therefore, when implementing open zero-rating, the ISP charges both CPs $S = \pi_{CP}(\bar{x}) - \pi_{CP}(x_c)$, and when implementing exclusive zero-rating, it charges

CP1 the same S. The ISP chooses the most profitable of the following three plans:

$$\pi_{ISP}^{NN} = 2u(x_c) - 2cx_c, \tag{9}$$

$$\pi_{ISP}^{Open} = 2u(\bar{x}) - 2c\bar{x} + 2(\pi_{CP}(\bar{x}) - \pi_{CP}(x_c)), \tag{10}$$

$$\pi_{ISP}^{Ex} = u(\bar{x}) + u(x_c) - c(\bar{x} + x_c) + \pi_{CP}(\bar{x}) - \pi_{CP}(x_c), \tag{11}$$

where the superscripts NN, $Open$, and Ex denote net neutrality, open zero-rating, and exclusive zero-rating, respectively. Comparing the profits of the three plans, we confirm that the ISP chooses open zero-rating or net neutrality depending on the inequality below:

$$\begin{cases} \pi_{ISP}^{Open} > \pi_{ISP}^{Ex} > \pi_{ISP}^{NN} & \text{if } u(\bar{x}) - u(x_c) - c(\bar{x} - x_c) + \pi_{CP}(\bar{x}) - \pi_{CP}(x_c) > 0, \\ \pi_{ISP}^{Open} < \pi_{ISP}^{Ex} < \pi_{ISP}^{NN} & \text{otherwise.} \end{cases} \tag{12}$$

The results so far are summarized as the following proposition.

Proposition 1

When $u(\bar{x}) - u(x_c) - c(\bar{x} - x_c) + \pi_{CP}(\bar{x}) - \pi_{CP}(x_c) > 0$, the ISP implements open zero-rating by setting the zero-rating fee as $S = \pi_{CP}(\bar{x}) - \pi_{CP}(x_c)$ for the two CPs, and offers a data plan such that $\{P, D\} = \{2u(\bar{x}), x_c\}$ to the consumer. Otherwise, the ISP does not implement any zero-rating and sets $\{P, D\} = \{2u(x_c), 2x_c\}$.

This proposition states that the ISP implements open zero-rating when the increase in the CPs' advertising revenue compensates for overuse of the Internet by the consumer, who is heedless of the ISP's cost. This may describe the situation observed in the real world where ISPs have introduced zero-rating plans, claiming that the revenue from the consumer side was not sufficient to cover their operating costs. They implement zero-rating policies to ensure CPs pay for consumers' data use.

4 Vertical integration case

In this section, we analyze the equilibrium when the ISP is vertically integrated with one of the two CPs. Now, we assume that the integrated CP is CP1. Therefore, the ISP makes a zero-rating decision to maximize the joint profit as follows:

$$\Pi = P + \pi_{CP1} + S_2 \cdot \mathbb{1}_2 - \sum_{i \in \{1,2\}} c \cdot x_i. \tag{13}$$

In contrast to the independent ISP case, the ISP takes CP1's profit into account and does not collect a zero-rating fee from CP1. In addition, because the two CPs are no longer symmetric from the ISP's viewpoint, we must distinguish between the case of exclusive zero-rating with CP1 and exclusive zero-rating with CP2. Focusing on these points, we again derive the equilibrium results.

4.1 Stage 2 in the vertical integration case

The consumer's decision about subscribing to a data plan and consuming content in Stage 2 does not depend on whether the ISP integrates with CPs. Furthermore, the ISP behaves in the same manner as in the no-integration case under open zero-rating and exclusive zero-rating with CP1. It sets $D = x_c$ and $P = 2u(\bar{x})$ under open zero-rating, and it sets $D = x_c$ and $P = u(\bar{x}) + u(x_c)$ under exclusive zero-rating with CP1. As in the independent case, the integrated ISP cannot control the consumption level under open zero-rating, and it restricts the consumption of the unaffiliated CP's content under exclusive zero-rating with CP1. Differences arise when the affiliated CP's content (content 1) is not zero-rated, that is, under net neutrality or an exclusive zero-rating with CP2.

Net neutrality Under net neutrality, the ISP sets P to extract all of the consumer's surplus as in the no-integration case. It sets P according to (5). However, the integrated ISP sets D to maximize its joint profit, which is:

$$\begin{cases} 2u(\frac{D}{2}) + \pi_{CP}(\frac{D}{2}) - cD & \text{if } \frac{D}{2} < \bar{x} \\ 2u(\bar{x}) + \pi_{CP}(\bar{x}) - 2c\bar{x} & \text{if } \frac{D}{2} \geq \bar{x}. \end{cases} \tag{14}$$

The ISP's first-order condition for $\frac{D}{2} < \bar{x}$ is:

$$u'\left(\frac{D}{2}\right) + \frac{1}{2}\pi'_{CP}\left(\frac{D}{2}\right) - c = 0. \tag{15}$$

We have assumed that $u'(x) > 0$ for $x \in [0, \bar{x})$, $u'(0) > c$, and $\pi'_{CP} > 0$ and $\pi''_{CP}(x) \leq 0$ for $x > 0$. Therefore, there is a solution to the first-order condition if and only if $\frac{1}{2}\pi'(\bar{x}) < c$. We let $\tilde{x}$ be the amount that satisfies $u'(\tilde{x}) + \frac{1}{2}\pi'_{CP}(\tilde{x}) - c = 0$. The ISP sets the data cap so that its marginal revenue equals its marginal cost ($D = 2\tilde{x}$), or until the consumer becomes satisfied ($D = 2\bar{x}$). Comparing the joint profits, we derive the ISP's optimal

choice as follows:

$$\begin{cases} D = 2\tilde{x} & \text{if } 2u(\tilde{x}) + \pi_{CP}(\tilde{x}) - 2c\tilde{x} > 2u(\bar{x}) + \pi_{CP}(\bar{x}) - 2c\bar{x} \\ & \& \ \frac{1}{2}\pi'_{CP}(\bar{x}) < c, \qquad (\textit{Condition A}) \\ D = 2\bar{x} & \text{otherwise.} \end{cases} \tag{16}$$

The ISP compares the increase in the subscription fee minus its operating cost (negative) and the increase in the revenue of its affiliated CP. If the latter exceeds the former, then the ISP increases D up to the level at which the consumer is satisfied. Otherwise, the supplier sets $D = 2\tilde{x}$ to make the marginal revenue equal to the marginal cost. Note that $x_c < \tilde{x} < \bar{x}$ when $\frac{1}{2}\pi'_{CP}(\bar{x}) < c$.

Exclusive zero-rating with CP2 The ISP sets P according to (8) and sets D to maximize its joint profit wit CP2, which is:

$$\begin{cases} u(D) + u(\bar{x}) + \pi_{CP}(D) - c(D + \bar{x}) + S_2 & \text{if } D < \bar{x} \\ 2u(\bar{x}) + \pi_{CP}(\bar{x}) - 2c\bar{x} + S_2 & \text{if } D \geq \bar{x} \end{cases} \tag{17}$$

The ISP's first-order condition for $D < \bar{x}$ is:

$$u'(D) + \pi'_{CP}(D) - c = 0. \tag{18}$$

There is a solution to this equation if and only if $\pi'_{CP}(\bar{x}) < c$. We denote the value that satisfies $u'(\hat{x}) + \pi'_{CP}(\hat{x}) - c = 0$ by $\hat{x}$. The optimal data cap, D, under exclusive zero-rating with CP2 is:

$$\begin{cases} D = \hat{x} & \text{if } u(\hat{x}) + \pi_{CP}(\hat{x}) - c\hat{x} > u(\bar{x}) + \pi_{CP}(\bar{x}) - c\bar{x} \\ & \& \ \pi'_{CP}(\bar{x}) < c, \qquad (\textit{Condition B}) \\ D = \bar{x} & \text{otherwise.} \end{cases} \tag{19}$$

In contrast to net neutrality, the consumption level of content 2 is fixed at $\bar{x}$. The ISP directly controls the consumption level of content 1 when it sets D. The exclusive zero-rating with CP2 with $D = \bar{x}$ is virtually the same as under open zero-rating. Therefore, if *Condition B* holds, exclusive zero-rating with CP2 with $D = \hat{x}$ is preferable to open zero-rating for the integrated ISP. Note that $x_c < \tilde{x} < \hat{x} < \bar{x}$ when $\pi'_{CP}(\hat{x}) < c$. The subscription fees, data caps, corresponding consumption levels, and the ISP's profits under

	$\{P, D\}$	(x_1, x_2)	Π	Conditions
NN	$\{2u(\tilde{x}), 2\tilde{x}\}$	$(\tilde{x}, \tilde{x})$	$2u(\tilde{x}) + \pi_{CP}(\tilde{x}) - 2c\tilde{x}$	*Condition A*
	$\{2u(\bar{x}), 2\bar{x}\}$	$(\bar{x}, \bar{x})$	$2u(\bar{x}) + \pi_{CP}(\bar{x}) - 2c\bar{x}$	otherwise
Open	$\{2u(\bar{x}), D\}$	$(\bar{x}, \bar{x})$	$2u(\bar{x}) + \pi_{CP}(\bar{x}) - 2c\bar{x} + S_2^{Open}$	
Ex ZR1	$\{u(\bar{x}) + u(x_c), x_c\}$	$(\bar{x}, x_c)$	$u(\bar{x}) + u(x_c) + \pi_{CP}(\bar{x}) - c(\bar{x} + x_c)$	
Ex ZR2	$\{u(\hat{x}) + u(\bar{x}), \hat{x}\}$	$(\hat{x}, \bar{x})$	$u(\hat{x}) + u(\bar{x}) + \pi_{CP}(\hat{x}) - c(\hat{x} + \bar{x}) + S_2^{Ex2}$	*Condition B*
	$\{2u(\bar{x}), \bar{x}\}$	$(\bar{x}, \bar{x})$	$2u(\bar{x}) + \pi_{CP}(\bar{x}) - 2c\bar{x} + S_2^{Ex2}$	otherwise

Table 2: Subscription fees, data caps, corresponding consumption levels, and the ISP's profits in the integrated case. Under net neutrality (exclusive contract with CP2), there are two possibilities of the consumption level depending on whether *Condition A* (*Condition B*) holds or not.

each scheme are shown in Table 2.

4.2 Stage 1 in the vertical integration case

In Stage 1, CP2 decides whether to accept or reject the ISP's zero-rating offer when it receives it. Then, CP2 anticipates what will happen when it declines the zero-rating offer.[7] We assume that the ISP can exclusively zero-rate CP1 when its offer to CP2 is declined.

First, we know that an ISP that makes an offer that is declined by CP2 does not choose net neutrality with $D = 2\bar{x}$, open zero-rating, or exclusive zero-rating with CP2. Under these plans without S_2, the ISP's marginal cost significantly exceeds its marginal revenue. Therefore, these strategies are dominated by the exclusive zero-rating with CP1. Second, the ISP with the declined offer potentially chooses both net neutrality with $D = 2\tilde{x}$ and exclusive zero-rating with CP1. Comparing the ISP's profits under the two schemes, we know that it chooses net neutrality with $D = 2\tilde{x}$ when:

$$\Pi^{NN}(D = 2\tilde{x}) > \Pi^{Ex1}(D = x_c) \Leftrightarrow$$
$$2u(\tilde{x}) + \pi_{CP}(\tilde{x}) - 2c\tilde{x} > u(\bar{x}) + u(x_c) + \pi_{CP}(\bar{x}) - c(\bar{x} + x_c), \qquad (\textit{Condition C})$$

and that otherwise it implements exclusive zero-rating with CP1. To summarize, when CP2 declines the ISP's zero-rating offer, then the ISP selects net neutrality with $D = 2\tilde{x}$ when *Condition C* holds; otherwise the ISP implements exclusive zero-rating with CP1 with $D = x_c$. In the former case, CP2 earns $\pi_{CP}(\tilde{x})$; in the latter case, it earns $\pi_{CP}(x_c)$.

When CP2 is zero-rated, the consumption of its content is $\bar{x}$, and CP2's revenue is $\pi_{CP}(\bar{x})$ under any plans. Therefore, for both open and exclusive zero-rating with CP2,

[7] In the no-integration case, CP2 does not have to consider this problem because the consumption of content 2 is always x_c when it rejects the zero-rating offer.

the ISP sets the zero-rating fee as follows:

$$S_2 = S_2^{Open} = S_2^{Ex2} = \begin{cases} \pi_{CP}(\bar{x}) - \pi_{CP}(\tilde{x}) & \text{when } \textit{Condition } C \text{ holds,} \\ \pi_{CP}(\bar{x}) - \pi_{CP}(x_c) & \text{otherwise.} \end{cases} \tag{20}$$

Given such zero-rating fees, we compare the ISP's profits under each plan and characterize the ISP's zero-rating choice in the equilibrium. Because S_2 is common to open zero-rating and the exclusive zero-rating with CP2, the joint profits under these plans are the same. Moreover, net neutrality, under which the ISP sets $D = 2\bar{x}$, is dominated by exclusive zero-rating with CP1. Therefore, we can narrow down the zero-rating plans that could be implemented to the following four options: (i) net neutrality where the ISP sets $D = 2\tilde{x}$, (ii) open zero-rating, (iii) exclusive zero-rating with CP1, and (iv) exclusive zero-rating with CP2 where the ISP sets $D = \hat{n}$.

Hereafter, we assume that $\pi_{CP}(x) = ax$ in characterizing the ISP's equilibrium choice.[8] The joint profits under each plan are:

$$\Pi^{NN}(D = 2\tilde{x}) = 2u(\tilde{x}) + a\tilde{x} - 2c\tilde{x}, \tag{21}$$

$$\Pi^{Open}(D = 2\bar{x}) = 2u(\bar{x}) + a\bar{x} - 2c\bar{x} + S_2, \tag{22}$$

$$\Pi^{Ex1}(D = x_c) = u(\bar{x}) + u(x_c) + a\bar{x} - c(\bar{x} + x_c), \tag{23}$$

$$\Pi^{Ex2}(D = \hat{x}) = u(\hat{x}) + u(\bar{x}) + a\hat{x} - c(\hat{x} + \bar{x}) + S_2, \tag{24}$$

where superscripts $Ex1$ and $Ex2$ denote exclusive zero-rating with CP1 and CP2, respectively. First, we suppose that $a \geq c$ and, next, that $a < c$.[9]

When $a \geq c$, the integrated ISP chooses open zero-rating. Under open zero-rating, the consumer uses the two contents as much as he/she wants beyond x_c. However, for content 1, the ISP can monetize the consumption through CP1's advertising revenue. Regarding content 2, because $a \geq c$ implies that *Condition C* does not hold and $S_2 = a(\bar{x} - x_c)$, the ISP can extract all of CP2's gain from being zero-rated. As a result, the integrated ISP implements open zero-rating when the CPs' advertising revenue per unit of content exceeds the ISP's marginal cost. This result is the same as in the no-integration case.

[8] We assume this linear advertising function following, e.g., Economides and Tåg (2012), Gautier and Somogyi (2020), and Jullien and Sand-Zantman (2018).

[9] Jullien and Sand-Zantman (2018) assume that high (low) quality CPs generate more (less) advertising revenue than the ISP's marginal cost per unit of content. If we focus on CPs that do not have high profitability, $a < c$ may be a reasonable setting.

Next, suppose that $a < c$. It is instructive to assume that open zero-rating does not occur in this case; $a < c$ is a sufficient condition for *Condition B*, which says that open zero-rating is dominated by an exclusive zero-rating with CP2. The zero-rating fee is $S_2 = a(\bar{x} - x_c)$ or $S_2 = a(\bar{x} - \tilde{x})$ depending on *Condition C*. If *Condition C* does not hold and the ISP can set the former zero-rating fee, then the ISP implements exclusive zero-rating with CP2, in which case $D = \hat{x}$, which leads to $(x_1, x_2) = (\hat{x}, \bar{x})$. Although a larger consumption of content 2 than $\hat{x}$ is not optimal for the ISP, zero-rating content 2 exclusively allows the ISP to control the consumption of content 1 by adjusting the data cap. At the same time, the ISP can easily extract CP2's gain through $S_2 = a(\bar{x} - x_c)$. On the whole, it is profitable for the ISP to implement this exclusive zero-rating with CP2.

Finally, suppose that $a < c$ and *Condition C* holds. The condition implies that $\Pi^{NN}(D = 2\tilde{x}) > \Pi^{Ex1}(D = x_c)$. Furthermore, as mentioned above, $\Pi^{Ex2}(D = \hat{x}) > \Pi^{Open}(D = 2\bar{x})$ when $a < c$. The remaining candidates are net neutrality with $D = 2\tilde{x}$ and exclusive zero-rating with CP2 with $D = \hat{x}$. Comparing these profits, we derive the following inequality:

$$\Pi^{NN}(D = 2\tilde{x}) > \Pi^{Ex2}(D = \hat{x}) \Leftrightarrow$$
$$2u(\tilde{x}) + a\tilde{x} - 2c\tilde{x} > u(\hat{x}) + u(\bar{x}) + a\hat{x} - c(\hat{x} + \bar{x}) + a(\bar{x} - \tilde{x}). \qquad (\textit{Condition D})$$

When $a < c$ and *Condition C* holds, *Condition D* may or may not hold; whether the integrated ISP chooses net neutrality or exclusive zero-rating with CP2 depends on the parameters a and c, and the function $u(\cdot)$. We summarize the results so far in the following proposition.

Proposition 2

If the advertising revenue per unit of content is larger than the ISP's cost, $a \geq c$, the integrated ISP implements open zero-rating. Otherwise, when $a < c$, the ISP implements exclusive zero-rating with CP2 with $D = \hat{x}$ or chooses net neutrality with $D = 2\tilde{x}$ depending on whether Condition D holds or not.

Note that the integrated ISP internalizes the revenue of the affiliated CPs. The impact of internalization is apparent in several respects. First, the integrated ISP may implement exclusive zero-rating with CP2. This is because the ISP can collect a zero-rating fee from the unaffiliated CP while adjusting the data caps to ensure the usage of the integrated CP is at an optimal level. Second, the data cap under net neutrality becomes large when

the ISP is integrated with a CP. The integrated ISP has an incentive to increase the consumption of its affiliated content; in contrast, it does not want to increase that of the unaffiliated content. Under net neutrality, even though the ISP can not receive a zero-rating fee from CP2, it can control the consumption of both contents to a certain extent.

To characterize the ISP's equilibrium choice more accurately, we suppose that $u(x) = -\frac{\alpha}{2}x^2 + \beta x + \gamma$, where $\alpha > 0$, $\beta > c$, and $\gamma > 0$. Then, we derive the following corollary.

Corollary 1

When we suppose $u(x) = -\frac{\alpha}{2}x^2 + \beta x + \gamma$, the integrated ISP chooses:

$$\begin{cases} \textit{exclusive zero-rating with CP2 with } D = \hat{x}, & \textit{if } 0 < a < (2-\sqrt{2})c, \\ \textit{net neutrality with } D = 2\tilde{x}, & \textit{if } (2-\sqrt{2})c \leq a < c, \\ \textit{open zero-rating,} & \textit{if } c \leq a. \end{cases} \tag{25}$$

The total consumption under the exclusive zero-rating with CP2, $\hat{x}+\bar{x}$, is larger than that under net neutrality, $2\tilde{x}$. Thus, interestingly, Corollary 1 says that the ISP chooses a heavier traffic plan when a becomes lower than $(2-\sqrt{2})c$. When the CP's advertising revenue decreases, the ISP places more weight on the revenue from the consumer. Consequently, the ISP implements exclusive zero-rating, which results in higher total consumption.

5 Effects of vertical integration

We analyze the welfare impact of the integration between the ISP and a CP. As in the previous section, we assume that $u(x) = -\frac{\alpha}{2}x^2 + \beta x + \gamma$. First, to explore the impact on the ISP's choice, we rewrite the condition (12) that characterizes the ISP's equilibrium choice in no-integration case with $u(x) = -\frac{\alpha}{2}x^2 + \beta x + \gamma$ as:

$$\begin{cases} \pi_{ISP}^{Open} > \pi_{ISP}^{Ex} > \pi_{ISP}^{NN} & \text{if } a > \dfrac{c}{2}, \\ \pi_{ISP}^{Open} < \pi_{ISP}^{Ex} < \pi_{ISP}^{NN} & \textit{otherwise.} \end{cases} \tag{26}$$

As long as $a \geq c$, the ISP chooses open zero-rating independently of the vertical integration. Therefore, we focus on the case when $a < c$. The ISP's choices with and without integration are summarized in Table 3. When $0 < a < c/2$, the ISP chooses net neutrality without integration; however, it chooses exclusive zero-rating with CP2 with vertical inte-

	No-integration case	Integration case
$0 < a < c/2$	Net neutrality ($D = x_c$)	Exclusive zero-rating with CP2 ($D = \hat{x}$)
$c/2 < a < (2-\sqrt{2})c$	Open zero-rating	Net neutrality ($D = 2\tilde{x}$)
$(2-\sqrt{2})c < a$	Open zero-rating	Open zero-rating

Table 3: The ISP's choice under the no-integration and integration cases.

gration. When $c/2 < a < (2-\sqrt{2})c$, the ISP chooses open zero-rating without integration; however, it chooses net neutrality with integration. When $(2-\sqrt{2})c < a$, the ISP chooses open zero-rating regardless of whether integration exists.

Because the consumer's surplus is fully extracted by the ISP through its subscription fee, the consumer surplus is always zero. However, it is straightforward that consumption increases in the case of vertical integration when $0 < a < c/2$ and decreases when $c/2 < a < (2-\sqrt{2})c$. In the former case, the consumer can enjoy more of both contents 1 and 2 after the integration. Conversely, in the latter case, after the integration, he/she cannot consume as much content as before the integration.

Next, we define the total surplus, TS, as:

$$TS = U(x_1, x_2) + (a - c)(x_1 + x_2). \tag{27}$$

From the first-order derivative of TS with respect to x_i, $\partial TS/\partial x_i = u'(x_i) + a - c$, we know that $x_1 = x_2 = \hat{x}$ is the most efficient consumption for TS. Comparing the TS under each plan, we derive the following proposition.

Proposition 3

When $0 < a < (\sqrt{2}-1)c$, the vertical integration decreases the TS; conversely, when $(\sqrt{2}-1)c < a < (2-\sqrt{2})c$, it increases the TS. When $a > (2-\sqrt{2})c$, the vertical integration does not have any effect on the ISP's zero-rating choice and the social welfare.

Total surplus under each scheme are described in Figure 1. When $0 < a < (\sqrt{2}-1)c$, the CPs' advertising revenue is much lower than the ISP's cost. Therefore, the exclusive zero-rating plan that is chosen under integration generates an excessively large consumption and is detrimental to the total surplus. Conversely, when $(\sqrt{2}-1)c < a < c/2$, the exclusive zero-rating plan becomes efficient, and the vertical integration improves the TS. When $c/2 < a < (2-\sqrt{2})c$, the integration changes the selected plan from open zero-rating to net neutrality. The total consumption decreases from $2\bar{x}$ to $2\tilde{x}$; however, it is efficient for the TS. The vertical integration allows the ISP to internalize the revenue of CP1 and

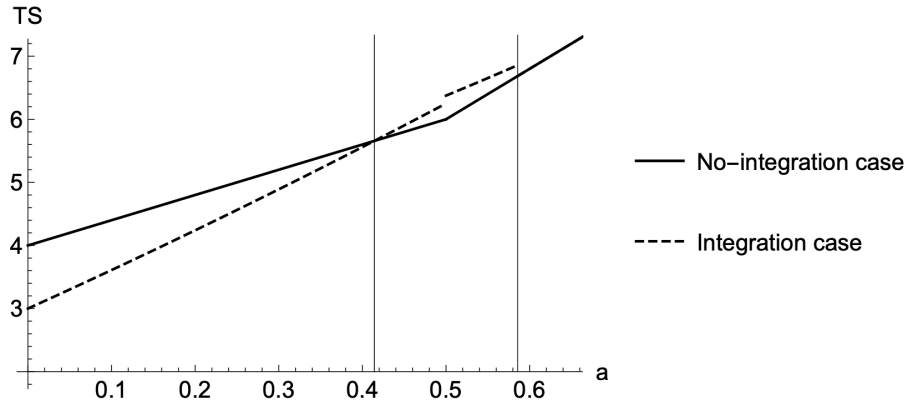

Figure 1: Total surplus under no-integration case and integration case when $\alpha = 1/2$, $\beta = 2$, $\gamma = 1$, and $c = 1$.

therefore the integrated ISP does not need to implement the excessive zero-rating plan to collect zero-rating fees.

6 Conclusion

This study has considered the effect of vertical integration between an ISP and a CP on the ISP's zero-rating decision and on social welfare. In a simple and tractable setting, we show that vertical integration may change the ISP's zero-rating choice and improve social welfare. The CPs' profitability and the ISP's operating cost are the critical determinants of the welfare effect. We demonstrate that when the ISP's cost is relatively high, vertical integration changes the implemented plan from open zero-rating to exclusive zero-rating with the unaffiliated CP. This change reduces the total consumption of content; however, it is welfare-enhancing. In contrast, when the cost is very low, the integration increases the consumption excessively and is detrimental to social welfare. By internalizing its affiliated CP's profit, the integrated ISP implements or aborts excessive zero rating from the perspective of the total surplus.

We assumed that the ISP sets the consumer's subscription fee and the data cap after its zero-rating decision. Therefore, our findings indicate the long-term effect of the zero-rating choice. In reality, vertically integrated ISPs often zero-rate their own content, which is not implemented in the equilibrium in our integrated case. Zero-rating for own content may be implemented when the ISP cannot reconfigure data caps and subscription fees, when it cannot collect zero-rating fees from the nonintegrated CP, or when there is heterogeneity between CPs. Incorporating these modifications is a task for future research.

We consider that our model can be extended in many different directions, and that analyzing the relationship between vertical integration and zero-rating in a more general context is essential for discussing applicable regulations. For example, we assumed a monopolistic ISP and a representative consumer. In mobile network markets, consumers usually join one ISP. Therefore, when we introduce competition between ISPs, the competition for consumers is intense, and zero-rating will be a more powerful means of attracting customers. At the same time, we can expect competition to arise in relation to making zero-rating contracts with CPs. In future, investigating the combined effects of the competition for zero-rated contracts with CPs and the competition for consumers would make our contribution to the literature on two-sided markets even greater.

References

Bourreau, Marc and Romain Lestage (2019) "Net neutrality and asymmetric platform competition," *Journal of Regulatory Economics*, Vol. 55, No. 2, pp. 140–171.

Chillemi, Ottorino, Stefano Galavotti, and Benedetto Gui (2020) "The impact of data caps on mobile broadband Internet access: A welfare analysis," *Information Economics and Policy*, Vol. 50, p. 100843.

Choi, Jay Pil, Doh-Shin Jeon, and Byung-Cheol Kim (2015) "Net Neutrality, Business Models, and Internet Interconnection," *American Economic Journal: Microeconomics*, Vol. 7, No. 3, pp. 104–141.

——— (2018) "Net Neutrality, Network Capacity, and Innovation at the Edges," *The Journal of Industrial Economics*, Vol. 66, No. 1, pp. 172–204.

Court of Justice of the European Union (2021) "Press Release No 145/21," Retrieved October 13, 2021, from https://curia.europa.eu/jcms/upload/docs/application/pdf/2021-09/cp210145en.pdf.

Dai, Wei and Scott Jordan (2013a) "Design and impact of data caps," in *2013 IEEE Global Communications Conference (GLOBECOM)*, pp. 1650–1656, DOI: 10.1109/GLOCOM.2013.6831310.

——— (2013b) "How Do ISP Data Caps Affect Subscribers?" in *TPRC 41: The 41st Research Conference on Communication, Information and Internet Policy 2013, Available at SSRN: https://ssrn.com/abstract=2240424*.

Economides, Nicholas and Benjamin E Hermalin (2015) "The strategic use of download limits by a monopoly platform," *The RAND Journal of Economics*, Vol. 46, No. 2, pp. 297–327.

Economides, Nicholas and Joacim Tåg (2012) "Network neutrality on the Internet: A two-sided market analysis," *Information Economics and Policy*, Vol. 24, No. 2, pp. 91–104.

Gautier, Axel and Robert Somogyi (2020) "Prioritization vs zero-rating: Discrimination on the internet," *International Journal of Industrial Organization*, Vol. 73, p. 102662.

Greenstein, Shane, Martin Peitz, and Tommaso Valletti (2016) "Net Neutrality: A Fast Lane to Understanding the Trade-Offs," *Journal of Economic Perspectives*, Vol. 30, No. 2, pp. 127–150.

Hermalin, Benjamin E. and Michael L. Katz (2007) "The economics of product-line restrictions with an application to the network neutrality debate," *Information Economics and Policy*, Vol. 19, No. 2, pp. 215–248.

Hoernig, Steffen and Francisco Monteiro (2020) "Zero-rating and network effects," *Economics Letters*, Vol. 186, p. 108813.

Inceoglu, Firat and Xingyi Liu (2019) "Multiproduct price discrimination with quantity limits: An application to zero-rating," *Economics Letters*, Vol. 180, pp. 41–45.

Jeitschko, Thomas D, Soo Jin Kim, and Aleksandr Yankelevich (2020) "Zero-rating and Vertical Content Foreclosure," *Information Economics and Policy*, p. 100899.

Jordan, Scott (2017) "A critical survey of the literature on broadband data caps," *Telecommunications Policy*, Vol. 41, No. 9, pp. 813–837.

Jullien, Bruno and Wilfried Sand-Zantman (2018) "Internet regulation, two-sided pricing, and sponsored data," *International Journal of Industrial Organization*, Vol. 58, pp. 31–62.

Krämer, Jan and Martin Peitz (2018) "A fresh look at zero-rating," *Telecommunications Policy*, Vol. 42, No. 7, pp. 501–513.

Lorenzon, Emmanuel (2021) "Zero rating, Content Quality and Network Capacity," *Available at SSRN: https://ssrn.com/abstract=3825813*.

Saruta, Fuyuki (2020) "Effects of Content Providers' Heterogeneity on Internet Service Providers' Zero-rating Choice," MPRA Paper 107505, University Library of Munich, Germany, URL: https://mpra.ub.uni-muenchen.de/107505/.

Schnurr, Daniel and Lukas Wiewiorra (2018) "Bit-by-Bit Towards Unlimited: An Analysis of Zero Rating and Sponsored Data Practices of Internet Service Providers," in *29th European Regional Conference of the International Telecommunications Society (ITS)*: Trento: International Telecommunications Society (ITS).

Somogyi, Robert (2017) "Zero-Rating and Net Neutrality," CORE Discussion Papers 2016047, Université catholique de Louvain, Center for Operations Research and Econometrics (CORE).

Vyavahare, Pooja and D. Manjunath (2018) "Sponsored data : On the Effect of ISP Competition on Pricing Dynamics and Content Provider Market Structures."

Yoo, C.S. (2017) "Avoiding the Pitfalls of Net Uniformity: Zero Rating and Nondiscrimination," *Review of Industrial Organization*, Vol. 50, No. 4, pp. 509–536.