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The Effect of Zero-Rating on Mobile Broadband Demand: An Empirical Approach and Potential Implications

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Zero-rating, a popular practice in which certain services or applications are exempted from data charges, has motivated a debate within the broader topic of net neutrality. Advocates claim that it can be a driver of broadband adoption in less favored regions and population segments, and opponents argue that it entails socially undesirable outcomes. A growing body of literature supports these diverging positions, but empirical evidence and critical assessments are scarce. Therefore, this paper presents a regression model to provide empirical proof of the effect of zero-rating on the demanded quantity of mobile broadband. Results demonstrate that consumers are better off with zero-rating in terms of estimated consumer surplus. Because this evidence addresses only one side of an issue that should be analyzed in a multisided market framework, further theoretical implications are discussed. A key conclusion is that zero-rating can be associated with socially desirable outcomes, and, even though zero-rating also entails the potential for adverse consequences, the results advise caution regarding regulatory tools that might be too stringent.

Keywords: zero-rating, mobile broadband, net neutrality, consumer surplus, price discrimination

In the context of net neutrality, debate has emerged around the growing popularity of sponsored data plans under the practice known as zero-rating. On the one hand are those who advocate for its potential benefits as a driver of broadband adoption. On the other hand are those who oppose the practice because of its potential effects of favoring certain contents and applications. As a starting point, it is necessary to define this key concept. The practice of zero-rating involves exempting certain services or applications from mobile data charges so that the bandwidth used does not count toward a subscriber's Internet data allowance (TeleGeography, 2015).

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The relevance of zero-rating stems from a broad line of research that has identified broadband adoption as a key element in the path toward reducing socioeconomic and cultural disparities. With prevailing net-neutrality definitions, zero-rating practices are relevant in terms of rules that prohibit the prioritization of certain contents/applications over others. Other important aspects of this topic are regulatory provisions related to competition, innovation, and investment that can be found in national regulatory frameworks.

Although the growing body of literature on this topic has gradually formed a theoretical base to support diverging standpoints, it still deserves further discussion within the framework of multisided platforms that link different markets. Moreover, because the topic is very recent, it is lacking in terms of empirical evidence and critical discussions of its implications.

Bearing this in mind, the present article undertakes a first empirical approximation to address the need for evidence regarding the possible impact of zero-rating on the demanded quantity of mobile broadband. In particular, beyond the simple association of zero-rating with increased demand levels, this article formally tests whether such a relationship between the two variables is statistically significant. Specifically, a regression model is estimated in which a qualitative variable to account for zero-rating is introduced along with a set of variables from the relevant literature. With an exercise of this nature, it is possible to quantify the effect of zero-rating on mobile broadband demand levels. Because zero-rating could have impacts beyond its influence on demand, the article discusses potential implications in a multiplatform setting as well as regulation-relevant aspects in terms of the alleged link between zero-rating and market failures. The main arguments for and against zero-rating are presented and discussed, based on relevant bibliography and regulatory implications, considering the net-neutrality rules that have become standard in many countries.

The next section develops a literature review with basic concepts, an overview of the main points in the debate, and a description of the involved regulatory definitions and possibilities. Then I provide a detailed explanation of the variables, data, and methods employed. Finally, the results and a discussion and conclusions based on them are presented.

Literature Review

Plans or payment schemes that offer zero-rating belong to a category known as sponsored data plans. They are usually characterized by commercial agreements between Internet service providers (ISPs, a term that will also be used here to refer to mobile operators) and content providers and/or applications (COPs) (Soares-Ramos, 2014). The most popular cases have been based on what are called "over-the-top" agreements with COPs, which constitute separate actors with respect to ISPs (Unión Internacional de Telecomunicaciones, 2013). This is the case of Facebook Zero and Twitter Zero, which belong to the plans commonly referred to as "free social networks"; Google Free Zone, which is also a type of over-the-top agreement; and Wikipedia Zero (Openet Telecom, 2013; Soares-Ramos, 2014). Currently these plans are at the center of attention in the mobile context, whereas in countries such as the Netherlands and the United States, specific legal cases for fixed broadband have been documented. Another example that is important to mention is Internet.org (now Free Basics; see, e.g., Excélsior -

Notimex, 2015), which was founded by Facebook in coordination with key stakeholders, including Ericsson, Mediatek, Opera Software, Samsung, Facebook, Nokia, and Qualcomm. It is a global project that promotes initiatives and studies aimed at reducing the cost of accessing the Internet, improving efficiency in the use of data for mobile applications, and developing new business models to "bring more people online" (Facebook, 2016; West, 2015).

A fundamental aspect of the diffusion and popularity of zero-rating is based on the idea presented by its main proponents that the plans featuring it are drivers of broadband access. In addition, this type of plan has emerged as a response to the increase in costs and externalities from the demand for capacity that is associated with increasing traffic in the networks (Sen, Joe-Wong, Ha, & Chiang, 2013). Such behavior has been triggered by the broad adoption of mobile devices with powerful processors and high-quality features; by cloud-based services; by machine-to-machine applications; and, in general, by bandwidth-intensive applications, including those for file, music, and video downloads (Sen, Joe-Wong, Ha, & Chiang, 2012). In this sense, implementation of zero-rating has been justified by its role as a congestion management tool within the broader concept of congestion-based pricing. For example, in the United States, in the rules for an open Internet of 2010, it was suggested that broadband providers needed network management flexibility to be able to cope with congestion. In view of these considerations, beyond the flat tariffs that broadband users have traditionally paid, part of the cost of congestion has begun to be passed on to them through higher monthly prices. This has also translated into the implementation of usage monitoring and compression techniques by COPs to avoid reaching maximum data allowances (Sen et al., 2013).

In any case, the issue has arisen in the context of two-sided markets which belong to the more general framework of multisided markets in which a platform (in this case, the ISP) links final users and COPs. In such a setting, the key question has concerned who should pay the price of congestion. This, in turn, has oriented the debate toward one of the key questions in terms of net neutrality: the problem that arises if ISPs are able to engage in traffic management practices[2] and charge COPs so that the latter can deliver enhanced quality services (Renda, 2015). The different stakeholders have presented arguments on who would be more affected by the absorption of the costs, depending on whether the charges just described are allowed. From the COPs' perspective, it has been said that not having to incur additional payments to guarantee speed and quality in the access to broadband services has allowed great dynamism in terms of technological innovation on the Internet. From the ISPs' perspective, it has been pointed out that not being able to charge COPs beyond their broadband fees creates disincentives for the ISPs to invest in capacity to avoid congestion problems (Choi & Kim, 2008; Crowcroft, 2007; D'Annunzio & Russo, 2013; Ganley & Allgrove, 2006; Ma, 2014; van Schewick, 2014).

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[2] For instance, to control congestion and maintain quality-of-service standards, operators can change the timing of some application deliveries. They can charge end users premium prices for higher speeds and capacity, and they can disconnect high broadband end users by decreasing the revenue stream to application providers (Boliek, 2009).

Relevant Regulatory Framework

For regulatory purposes, zero-rating is usually assessed within the set of rules that promote net neutrality. The departure point for such rules is the technological feasibility of giving differential treatment to information that is transmitted through the networks based on its origin, content, and/or destination.[3] In other words, net-neutrality rules have focused on alleged incentives by broadband ISPs to act as Internet gatekeepers, disadvantaging certain Internet applications toward anticompetitive ends (Faulhaber, 2007). Through these rules, authorities seek to justify governmental intervention to prevent market failures and to promote consumer welfare (Brito & Ellig, 2007). The basic rules that can be identified at an international level are:

- No Blocking: broadband providers may not block access to legal content, applications, services, or non-harmful devices.

- No Throttling: broadband providers may not impair or degrade lawful Internet traffic on the basis of content, applications, services, or non-harmful devices

- No Paid Prioritization: broadband providers may not favor some lawful Internet traffic over other lawful traffic in exchange for consideration of any kind—in other words, no "fast lanes." This rule also bans ISPs from prioritizing content and services of their affiliates. (Federal Communications Commission, 2015, p. 6)

What these principles imply is that discrimination—both in prices and quality of service—should not be allowed (Arlandis & Baranes, 2011; Boliek, 2009; Krämer et al., 2013; Schuett, 2010). Based on this, it can be said that zero-rating would violate the third rule in the list. Moreover, if price discrimination happened in a situation in which the ISP favors its affiliate content through zero-rating, the applicable legal framework would be the one related to vertical integration.[4] As expressed by Cave and Crocioni (2007):

[3] As transmission pipes can handle increasingly larger amounts of information and servers and routers become more sophisticated due to increased and less costly processing power, inspecting packets becomes more feasible (Bauer, 2007). Under the current Internet protocol version 6, data packets can even be differentiated solely based on what type of data they are carrying, without the need for an explicit marking in the protocol header. This is possible by means of so-called deep packet inspection (Krämer, Wiewiorra, & Weinhardt, 2013).

[4] Consider a simplified setting where a production process consists of only two stages, A and B. In process B, raw materials are converted into an intermediate good that is an input into stage A. Process A involves transforming input B into output good A. Vertical integration means that producers of A integrate into the production of B. Instead of buying from a supplier of B, they produce B in-house. The transaction is organized and governed internally (Church & Ware, 2000).

> If net neutrality is about discriminatory behavior by network operators against unaffiliated ISPs and/or content and application providers, it is then nothing new but the name given to it. It is well known that when providers with market power discriminate against downstream rivals, there may be concerns about exclusionary behavior. This could be either aimed at favoring the downstream operators' arm or to fend off rivals who may threaten to integrate backward. (p. 671)

Regarding the traffic differentiation that takes place when zero-rating is present, it is important to consider that it would imply possible infringement of net-neutrality rules despite the potential of such practice as a way to charge the involved parts for the costs of congestion (based on the need for infrastructure investment). From a regulatory standpoint, this is crucial for countries where minimum quality-of-service standards and sustained investment in infrastructure are encouraged.

Zero-Rating and Broadband Diffusion

The main argument put forward by zero-rating advocates is that it constitutes a way to increase broadband penetration (i.e., the number of people who demand broadband services divided by a country's population). They also assert that it fosters innovation and competition on the Internet. This point has been stressed for those relatively disadvantaged regions where fewer people have access to broadband services, which is usually qualified as fundamental in triggering socioeconomic development (Atif, Endres, & Macdonald, 2012; Cardona, Kretschmer, & Strobel, 2013; Galperin, 2005). In other words, zero-rating has been said to have an important role in reducing the so-called digital divide.[5] Considering currently accepted development definitions, this is especially relevant in cases such as online social networks or a free encyclopedia. More specifically, allowing free access to these types of contents and applications can be a way to empower people through the expansion of their capabilities, a key concept in Amartya Sen's approach (e.g., Sen, 1982). Likewise, by contributing to increased connectivity, people benefit directly thanks to a service whose value increases as more people use it (Soares-Ramos, 2014).

In contrast to these ideas, the main criticism against zero-rating sustains that its implementation entails artificially favoring certain contents and applications, making them more appealing than others (van Schewick, 2015). This can happen because the "subsidized access" to certain contents/applications (Soares-Ramos, 2014) makes them relatively cheaper. This notion is based on the fact that even when the share of income that people have devoted to broadband consumption stays the same, the contents/applications that are included in their zero-rated plan do not involve an additional cost, while those that are not included still bear costs in terms of data consumption.

One related implication is that, to the extent that media diversity is considered a central pillar of a democratic society, having access to only certain specific contents would diminish people's capabilities. The underlying reasoning is that for lower segments of the population, Internet use would practically be

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[5] There is a gap in broadband access among geographic areas, at a national or regional level and between urban and rural areas, as well as among different socioeconomic sectors (Grubesic, 2003; Organisation for Economic Co-operation and Development, 2015).

equivalent to having access only to certain specific zero-rated applications/contents. This is a disadvantage with respect to people who have access to all the possibilities that become available through the Internet (Champion, 2015). Such a scenario runs counter to the main arguments set forth by zero-rating proponents, because it would represent forgone opportunities to foster the diffusion of digital services. This can be illustrated with the example given by West (2015), who asserts that in the early stages of desktop computing, having programs such as e-mail, word processing, and spreadsheet management encouraged people to use computers.

Price Discrimination

At this point, it is crucial to highlight the term *value*, because a central aspect of zero-rating is that with the possibility of consuming more of certain contents/applications for the same price, people obtain larger amounts of data for the same hired plan (West, 2015). This translates into more value for the same amount of money. Despite this, a decrease in the relative price of contents/applications does not necessarily translate into diminished broadband subscription fees, which still represents an obstacle to broadband adoption. If we add the fact that many regions of the world still lack infrastructure to bring broadband adoption into reality (Soares-Ramos, 2014), it is clear that there is a need to determine the impact on adoption that is attributable exclusively to the use of zero-rated plans.

The distinction between prices paid for a broadband plan and the relative value of specific contents/applications that are available with broadband access is also relevant in relation to proposed net-neutrality rules. Specifically, van Schewick (2015) asserts that zero-rating represents a form of price discrimination, which means that two "similar" products that have the same marginal cost to produce are sold by a firm at different prices (Armstrong, 2006b). In other words, there is a difference in prices that cannot be explained by differences in production costs (Weisman & Kulick, 2010). Strictly speaking, with zero-rating, discrimination would take place in terms of contents/applications whose specific value to final users is not determined by market prices and could instead be observed in terms of implicit (hedonic) prices of characteristics of the product or service under consideration (Rosen, 1974). Therefore, provided that the contents/applications are part of bundles to which customers have access when buying an Internet subscription with a price that does not vary, the situation would not fit the usual definition of price discrimination, which "involves selling the same good at different prices, adjusted for differences in costs" (Church & Ware, 2000, p. 157). Even so, if prices are expressed, for example, in terms of price per megabyte, under zero-rating, there would be a difference in prices between the zero-rated application and other similar applications. In this case, on the one hand, permitting price discrimination under zero-rating might open markets that would otherwise not be served at all (Armstrong, 2006b). On the other hand, there are reasons why competition policy may be concerned with price discrimination. One such reason is that a dominant firm may "exploit" final consumers with the result that total and consumer welfare are reduced (Armstrong, 2006b). However, it has been pointed out that, given the industry's characteristics, this might not be the case (Eisenach, 2015). Specifically, as one of the industries that are the hallmark of the "new economy," it is characterized by a cost pattern that entails sunk outlays that are large and must be incurred over and over again, but the marginal cost of serving an additional customer is virtually negligible. This is a special case of scale economies in which firms are forced to adopt prices that are discriminatory and exceed marginal costs if they operate in competitive markets. Firms cannot avoid these practices wherever such prices are feasible (i.e., because customers or sales can be divided up effectively without risk of arbitrage) (Baumol & Swanson, 2003). In fact, the authors sustain that competition, rather than its absence, may, in many cases, serve to impose discriminatory pricing. Also, according to Armstrong and Vickers (2001), freedom to engage in price discrimination tends to be desirable in sufficiently competitive conditions (the authors develop their conclusions in an oligopoly setting).

Other areas in which specificities of the industries under consideration are relevant are the need for investment due to increasing demand for capacity and the dynamism of competition. These entail large, nonrecoupable investments in research and development and physical infrastructure, which are largely invariant to the number of users. It is important to emphasize the issue of capacity constraints, because beyond the debate of trade-offs between innovation and investment (Boliek, 2009; Courcoubetis, Sdrolias, & Weber, 2014; Cheng, Bandyopadhyay, & Guo, 2011; Choi & Kim, 2008; Krämer & Wiewiorra, 2009; Njoroge, Ozdaglar, Stier-Moses, & Weintraub, 2010),[6] the investment to cope with network congestion affects all the actors in the ecosystem. Consequently, this issue entails the need to assess the magnitude of required investment and to decide who should pay for the costs of congestion. For this purpose, it should be kept in mind that congestion is an immediate problem, whereas investment decisions to cope with it are costly and take place over long time horizons (Faulhaber & Farber, 2010). It is important to note that setting prices equal to marginal cost will generally not recoup sufficient revenue to cover the fixed costs and the standard economic recommendation of "price at marginal cost" is not economically viable (Eisenach, 2015).

Competition Issues

Zero-rating understood as a form of price discrimination has been suggested as a concern in the sense that it can be used by a dominant firm to "'exclude' (or weaken) actual or potential rivals" (Armstrong, 2006b, p. 2). This can lead to market concentration and persistence of monopoly situations that result in disadvantages for new competitors. For instance, if an emerging company tries to compete with an established one whose services benefit from zero-rating, the entrant would have to face the fact that from the consumer's perspective, the service it offers requires a payment, while the one offered by the incumbent does not. As an alternative, the entrant could negotiate with the ISP to "pay the toll" and also have a distinctive treatment for its data traffic, a scenario that would increase barriers for start-up companies (Soares-Ramos, 2014). Such barriers could also act as obstacles for potential innovators (Renda, 2015), even though the Schumpeterian approach suggests that in some markets antitrust enforcement cannot rely on presumptions that increased concentration or market power will reduce innovation or harm consumer welfare. This, however, does not mean that concentration and market power promote innovation and consumer welfare, hence disregarding competition regulation (Katz & Shelanski, 2005). Likewise, Baumol and Swanson (2003) suggest that it is indefensible to claim that a firm should be

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[6] The net neutrality literature states that charging COPs beyond the tariffs they pay for broadband access subsidizes adoption because it allows ISPs to offer affordable plans to customers. This, in turn, translates into COPs being able to reach larger audiences. On the other hand, the opposite position sustains that when the charges are not allowed, innovation "at the edge" is encouraged, because many projects can be developed regardless of their uncertainty or expected returns (Bauer, 2007).

presumed to possess market power simply because it offers discriminatory prices, yet the authors note that consumers often suffer when firms are granted extra freedom to extract surplus.[7]

For the case under analysis, it has to be noted that ISPs cannot be said to directly price-discriminate to harm their competition: the ISP is not damaging its competitors unless it signs exclusive zero-rating agreements with COPs, which so far has not been common as applications have been partnering with different operators within the same market. Instead, it is the COP that could benefit from price discrimination. If COPs are the ones sponsoring data plans, then it is they who induce price discrimination that allows the ISP to serve a larger market but at the expense of potentially undermining competition in the COPs' market. If a situation of this nature happens between an ISP and an affiliated COP, this could be considered a vertical practice that should be subject to the corresponding legislation.

It also must be pointed out that the relevant actors are linked in a two-sided market setting. The ISP (or mobile operator) is a platform that links final Internet users with COPs that also buy access from the ISP, the latter being different in the sense that they use Internet to offer their contents/applications to the users. According to Armstrong (2006a), interactions between both groups and the platform vary depending on different possible scenarios,[8] but regardless of such possibilities, the utility of users on one side of the market depends on the number of users on the other side, and on the benefit they derive from interacting with them and vice versa. In our example with a two-sided platform, given the relationship between the utility of users on side 1 and the number of users on side 2, Internet users are worse off when there are fewer COPs. In addition, the COP can act as a platform on which end users and advertisers interact. With such a sponsored scheme, Andrews, Ozen, Reiman, and Wan (2013) demonstrate that users benefit from access to more content while the COP earns advertising revenue and is able to pay the ISP so that it is possible to invest in network infrastructure, and remaining profits can be distributed between ISPs and COPs. Although all the involved parts benefit in such a situation, Anderson, Foros, Kind, and Peitz (2012) point out that standard models have usually explored only the possibility in which users single-home and there is no advertising congestion. It is key to note here that when users single-home, the COP has a "monopoly bottleneck" position over advertising to its own viewers. When these assumptions are relaxed, the authors find that competition for limited consumer attention brings direct competition between platforms (COPs, in this case) for advertisers. According to the authors, the presence of multi-homing viewers also generates competition for advertisers.

Another important insight from Anderson, Foros, Kind, and Peitz (2012) is that competing ad-financed platforms have incentives to attract viewers through differentiation, thus leading to more

[7] The motive for price discrimination is, precisely, to extract unexploited surplus.

[8] The relevant scenarios in this case can be either one in which users "single-home" by choosing to use only one platform while COPs multi-home (i.e., they can use multiple platforms) or one in which both single-home. The first scenario, in which COPs pay different ISPs for access to the Internet, is also commonly known as a competitive bottleneck (Armstrong, 2006a). The second one is feasible because of the use of peering agreements by ISPs whom COPs pay for Internet access, which makes it possible for the latter to have access to users of multiple networks (Minne, 2013; Musacchio, Schwartz, & Walrand, 2009).

program diversity. This is highly relevant considering the importance of media diversity for a democratic society and the correlation patterns observed between highly concentrated media ownership and a more limited range of media sources, implying a less pluralistic system (Champion, 2015).

Method and Data

To study the impact of zero-rating practices on demand, the latter is explained by a series of determinants including the former in a regression model. The estimation of such a model is based on the use of panel data sets to analyze specific policies or events that take place between two periods, where some of the sample units (countries) take place in such an event, and others do not (Wooldridge, 2000). In this case, the event is the introduction of zero-rating. The estimation is carried out with the instrumental variables regression technique, as used by Hausman and Ros (2012), which constitutes a way to solve the endogeneity issue that stems from the fact that observed demand and its price are determined by an equilibrium condition ($q^D = q^S$) in a simultaneous equations model.

The use of a logarithmic (log-log) first differences specification is used. By specifying the model in such terms, the model is able to estimate demand based on the Gompertz model of technology diffusion. This model owes its popularity to its ability to consider the diffusion of technologies such as the Internet, computers, and mobile telephony, where costs are initially high, followed by a period of rapid growth, and then a slowing of uptake as saturation is reached (Lee & Lee, 2010). In other words, the evolution of new communication technologies typically exhibits an S-shaped pattern. That is, a difference exists between the number of broadband adopters in the current period and the number of adopters in equilibrium. Such an equilibrium situation denotes a long-run “ceiling,” or saturation point, which considers the number of potential subscribers who have not yet adopted the technology (Lee, Marcu, & Lee, 2011; Lin & Wu, 2013). To account for this equilibrium penetration level, Lin and Wu (2013) explain how it depends on a series of determinants, including a set of exogenous variables and demand-side and supply-side variables.

Based on the relevant literature (Bauer, Kim, & Wildman, 2003; Cava-Ferreruela & Alabau-Muñoz, 2006; Lee & Lee, 2010; Lee et al., 2011; Lin & Wu, 2013), the estimations presented in this article consider price, income, platform competition, and cost conditions, as well as the presence of zero-rating, as determinants of the change in demand. Due to the fact that indicators of education level show little or no variation between the observed periods, this variable is not included in the estimations. Specifically, the following equation is estimated:

$$\Delta lnQ_{it} = \alpha + \beta_1 \Delta ZR_{it} + \sum_{k=2}^{n} \beta_k \Delta lnX_{kit} + u_{it}, \quad (1)$$

where Q = mobile broadband demand, i = countries, t = time, and Δ denotes changes in the variables between the first and the second periods. Unlike Hausman and Ros (2012), whose estimations are based on broadband penetration as a proxy of demand, here demand is measured more directly as mobile data traffic from 3G and 4G technologies. ɑ is the intercept; βs are parameters of the econometric model, which describe the directions and magnitudes of the relationship between the dependent and the explanatory variables; and u is the error term. ZR is a dummy variable that takes the value 0 or 1 to indicate the absence or presence of zero-rating, respectively. The absence refers to periods when zero-rated plans had not yet been offered by operators in the *i*th country. *Xkit* is a vector of the other explanatory variables. Price is measured in terms of revenues per megabyte. Income is measured as per capita gross domestic product in purchasing power parity U.S. dollars. Platform competition, or the competition among different broadband technology platforms (LTE, 1xEV-DO, CDMA2000, W-CDMA, and TD-SCDMA), was measured through the Herfindahl–Hirschman Index, calculated by squaring the share of each technology in the market and then summing the resulting numbers. The Herfindahl–Hirschman Index can take on values up to 10,000, which represents the maximum concentration that a country can exhibit, as opposed to values approaching zero when a country is occupied by a large number of technologies of relatively equal size (see U.S. Department of Justice, 2015). To account for cost conditions, population density, expressed as the number of individuals per square kilometer, is introduced as a determinant. This variable accounts for the cost of investment in broadband coverage.

Data for the estimations are annual, for the years 2012 and 2014; the aggregation level is national; and 16 countries are considered: China, Denmark, Germany, Greece, Guinea, Hungary, Italy, Lithuania, Moldova, the Netherlands, Portugal, Russia, Singapore, South Africa, Spain and Sweden. For periods when information was not available, data from 2009, 2010, 2011, and 2013 were used. In such cases, to make the data comparable, the variables were adjusted for inflation through the use of a deflator, obtained from the Federal Reserve Bank of St. Louis (2016). For the demand, price, and platform competition variables, data were obtained from Informa PLC (2016). For the gross domestic product variable, data were obtained from the International Monetary Fund (2015). Data on population density (people per sq. km of land area) comes from The World Bank Group (2016).

For the zero-rating variable, data collection was based on a search for the time when popular zero-rated applications or websites such as Facebook Zero, Twitter Zero, and Google Free Zone (as well as initiatives such as Free Basics) started being offered in the different countries of the sample (Cullen International and Ovum's Knowledge Center contributed in this search).

Results

The regression estimations (presented in Table 1) reveal that zero-rating is a statistically significant determinant of mobile broadband demand. The interpretation of the variable's coefficient is that, having controlled for other factors, demand is 0.12% higher when zero-rated plans or initiatives are available for the selected sample of countries. Possible explanations could include the efforts that have accompanied the implementation of zero-rating initiatives, such as those aimed at increasing digital literacy or at providing affordable Internet access through public access spots. However, in light of the discussion presented in this article and the nature of the data, this effect cannot be directly attributed to a fall in prices paid for broadband plans. Instead, it is possible that the effect is related to a decrease in relative hedonic prices of popular contents/applications.

Price has a negative effect, and income has a positive effect. Both results are consistent with Hausman and Ros's (2012) findings. Population density is also positive, and also consistent with relevant literature where it is used as a determinant of demand expressed in terms of broadband penetration (Bouckaert, Van Dijk, & Verboven, 2010; Kim et al., 2003; Lee & Brown, 2008; Lee et al., 2011). Platform competition is not significant. Another variable that was included in the regression consists of what is commonly referred to as an interaction term (Gujarati, 2004) between two variables—in this case, zero-rating and income (gross domestic product). The interaction term is significant and has a negative coefficient, indicating that zero-rating has a larger impact on low-income countries. In other words, the larger the income, the lower the effect of zero-rating.

The estimation results were used to estimate the change in consumer surplus, which is an accepted welfare indicator that measures the difference between consumers' willingness to pay for a given good or service and the price they actually pay for it (Church & Ware, 2000). When prices decrease, this difference becomes larger, meaning that consumers are better off by having more money available to spend on other goods or services. Based on the estimation output presented in Table 1 and the formula from Hausman and Ros (2012), the change in consumer surplus was estimated to be US$8.77 billion for the entire sample of countries. That is, when there is zero-rating, consumer surplus is larger than in a scenario where there is no zero-rating.

Table 1. Regression Results.

Estimation results

	Coefficient	**Standard error**
Intercept	0.2365 ***	(0.0965)
Price	-0.7910 ***	(0.086)
Per capita GDP (PPP)	1.3383 ***	(0.4920)
Population density	5.5041 ***	(1.7072)
Platform competition	-0.2987	(0.2675)
Zero-Rating	0.1246 *	(0.695)
Low Income (Zero-Rating*GDP)	-1.3801 ***	(0.7548)
Equation statistics		
R-squared	0.9693	
Estimator	GMM	
No. Of observations	17	
Instrument	Average prices in other markets	

Notes
***, ** and * stand for statistical significance at 1%, 5% and 10% respectively.

Conclusion

In recent years, zero-rating has been proposed as an important driver of broadband adoption, and the latter is expected to play a key role in the development of less favored regions or segments of the population. However, zero-rating has faced criticism and questions due to its potential to violate core net-neutrality principles. Because it is a relatively new subject, it still lacks in evidence and critical analysis. For this reason, this article presented an empirical estimation to determine whether zero-rating is a statistically significant determinant of the demand for mobile broadband. The estimated results demonstrate that, controlling for factors such as price and per capita income, zero-rating can be associated with additional growth in broadband demand and increased social welfare, as measured by consumer surplus. Furthermore, the results indicated that zero-rating has a larger impact on low-income countries. In addition, it can be concluded that, with zero-rating, it has been possible to serve unattended portions of the market. One possible explanation for the results lies in the series of initiatives that have accompanied the promotion of zero-rating. Based on the literature review, it is important to stress that zero-rating could also be a way to recoup investment in networks, which has been one of the main concerns in the net-neutrality debate.

However, zero-rating constitutes a form of price discrimination, and, although it is not necessarily intended as a way for ISPs to undermine other ISPs, it can translate into concentration in the market of COPs. The possibility of COPs to capitalize such an advantage lies beyond the scope of this article. This is an important line of future research that should be properly addressed in a setting where it is possible to account for the joint effects on consumers from impacts on the markets to which they are linked through platforms along the supply chain. This should include an assessment of the extent to which potential negative effects could more than compensate for the social benefits of broadband adoption. Such potential negative outcomes could possibly derive from lack of innovation and plurality.

In any case, these scenarios could not happen once the basic standard net neutrality rules are enforced in a country, regardless of zero-rating's potential for both beneficial and adverse consequences, and a balance between them that is still unclear. With the evidence presented in this article that beneficial effects are possible, a key conclusion is that regulatory authorities should be cautious when designing and implementing the corresponding rules. More specifically, they could explore scenarios such as one in which an ISP offers cheap data plans as equivalent alternatives to zero-rated plans in a way such that consumers are able to decide whether they want to benefit from cheap data by choosing popular zero-rated contents/applications. It would also be important to assess whether it is socially desirable to implement provisions under which zero-rated contents/applications have to be complementary to the data plans, thereby avoiding a situation in which some segments of the population can only get partial access to the Internet. From the competition perspective, in cases where the costs of sponsoring data are absorbed by COPs, it would be important to avoid situations in which ISPs refuse to deal with specific COPs, whereas cases in which the costs are absorbed by ISPs (posing adverse conditions for popular zero-rated COPs' competitors) would deserve further research.

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