Aalto University
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Pricing Sponsored Data Plans in Two-Sided Markets

Sponsoroidun Datan Hinnoittelu Kaksipuolisilla Markkinoilla

Master's Thesis
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Abstract

This thesis shows that a monopoly Internet Service Provider will never offer zero-rated mobile data plans for homogenous consumers if it cannot ask content providers to pay for the traffic increase caused by to zero-rating. Increasing the data allowance will result in similar utility gains for the customers than zero-rating some content, with lower or identical costs for the Internet Service Provider. When a monopoly Internet Service Provider is allowed to collect payments from content providers, prices to both sides of the market are determined by the size of the data allowance. Opposing effects of distorted consumption towards the zero-rated content and increased total consumption of data mean that total welfare effects remain ambiguous and depend on the parameter values.

Tiivistelmä

Tämä pro gradu tutkielma käsittelee mobiilidatasopimuksia, missä Internet-palveluntarjoaja ei laskee osaa asiakkaidensa datan kulutuksesta heidän kuukausittaiseen mobiilidatan rajoitteeseensa (zero-rating). Näytän että monopoli Internet-palveluntarjoaja ei voi saada enempää voittoa zero-rating -sopimusten myynnistä kuin tavallisten datarajoitteellisten sopimusten myynnistä, mikäli se ei voi vaatia Internet-sisällöntuottajia maksamaan zero-ratingin aiheuttamasta kasvaneesta datan käytöstä. Internet-palveluntarjoaja kykenee saavuttamaan saman lisäarvon mitä zero-rating tuottaa kasvattamalla datarajoitteisten sopimusten rajoitetta joko identtisillä tai alhaisemmilla kuluilla. Kun monopoli Internet-palveluntarjoaja voi kerätä maksuja Internet-sisällöntuottajilta, datarajoitteen koko määrittää hinnat markkinoiden molemmilla puolilla. Hyvinvointivaikutukset jäävät monitulkintaisiksi ja riippuvat parametrien arvoista, sillä niihin vaikuttaa kaksi vastakkaista voimaa: hyvinvointia vähentävä zero-ratetun sisällön suuntaan vääristynyt kulutus ja hyvinvointia lisäävä kasvanut kokonaiskulutus.

Introduction

The Internet is perhaps the single most important technological change in our society that has happened in last few decades. It has allowed us to witness an era of unprecedented technological innovation and has completely transformed a myriad of industries. Importance of the Internet in modern day does not need more emphasis, it permeates our everyday lives thoroughly. Open nature of the Internet allows people from all around the world to connect with each other and lets enterprising individuals find large markets not bound by national borders. This can be argued to be the main driver behind innovation in the age of the Internet.

The openness of the Internet is based on principles of net neutrality. The concept of net neutrality demands that all data on the Internet should be treated equally. Companies which control our access to the Internet should not control how we lawfully use the Internet and that they should not discriminate against content providers' access to the network. (Gilroy, 2018). Our path to the Internet goes through the Internet service providers (ISP). ISPs allow us, the end users to connect to the Internet and consume content in there hosted by the content providers (CP). Before, the role of the ISPs has been just that, to enable our access to the Internet and nothing more. Technical development has however allowed the ISPs to better discern between different data packets, allowing them to identify what kind of data we use on the Internet and which content providers' contents we visit. This development could allow them to not only provide access to the Internet but also to influence how we use the Internet, changing their role from a pathway to gatekeepers of the Internet. This possibility has attracted the attention of many national regulators which have instituted regulation to make sure that Internet service providers adhere to principles of net neutrality.

Net neutrality regulations vary from country to country, but it generally bans certain practices which are considered to be discriminatory and against net neutrality. One such practice is paid prioritization. Paid prioritization allows the ISPs to sell prioritized access to certain content providers, such as Google or Netflix, allowing their customers to connect to these services faster than to other content on the Internet. Conversely, the ISPs could, without net neutrality regulation, engage in bandwidth throttling, purposefully slowing connection speeds of its customers to certain content on the Internet, or even blocking access to certain websites altogether. Net neutrality regulation is a divisive issue with proponents of net neutrality arguing that it will safeguard competition and innovation on the Internet (Wu, 2003) and opponents argue that government regulation itself threatens innovation on the Internet (Kastrenakes, 2017a).

Net neutrality debate has raged fiercely since 2017, garnering a large amount of media attention with magazines like Politico and New York Times writing extensively about the subject (McGill, 2017 and Kang, 2017b). The debate was sparked after the chairman of Federal Communications Commission Ajit Pai announced that FCC would hold a vote about demolishing current net neutrality regulation. After the announcement swathes of companies, organizations and experts voiced their opinions on net neutrality regulation and the proposed vote. (Lessig & McChesney, 2006 and Mullins & Nagesh, 2015) After his appointment to chairman of FCC in early 2017 (Shields, 2017) Pai started quickly rolling back many Obama era regulations and announced that FCC would stop its investigation into AT&T, T-Mobile, and Verizon (Kang, 2017a). FCC had investigated whether the companies engaged in anticompetitive behaviour by favouring their own subsidiaries on the Internet over non-affiliated content providers. On 14.12.2017 FCC voted 3-2 to end Open Internet order of 2015. Open Internet order had prevented ISPs from selling paid prioritization access to content providers or throttling access to any content (Kastrenakes, 2017b).

The order also classified Internet service providers as common carriers in accordance with Communications Act of 1934 Title II (United States Communications Act, 1934). Classifying ISPs as common carriers likened them to traditional telecommunications companies setting a considerably stricter regulatory framework for them than before. Even though FCC repealed the Open Internet order, future of net neutrality in the United States is not yet clear. Several lawsuits have been launched, aiming to keep the net neutrality rules intact and some states have passed or considered passing legislation to preserve net neutrality regulation (Reardon 2018). When the new lighter Internet regulations come into effect in the United States, the ISPs have new powerful tools in use. They are allowed to engage in paid prioritization and bandwidth throttling. While the new regulation means that they are no longer expressively prohibited to engage in these practices, they are still subject to US antitrust regulation (Kastrenakes, 2017a).

ISPs rarely set data-allowances for their customers with fixed broadband data plans. These plans allow for unlimited consumption of data. Mobile Internet plans often have data-allowances, which allow for a limited amount of data consumption per month. These kinds of plans, data cap plans, can be subject to another discriminatory practice known as zero-rating. An ISP can zero-rate certain content on the Internet. This means that when customers of the ISP consume content on the Internet, their consumption of the zero-rated content does not count towards their monthly data allowances. When an ISP has zero-rated a content provider such as YouTube, any data used to stream videos from YouTube does not count towards their monthly data limit and customers of the ISP are free to use their data allowance to other content on the Internet. Zero-rating essentially allows the ISPs to choose certain content providers which content the end users can consume without limits, while still having to adhere to their data-allowances when consuming other content on the Internet.

Zero-rating violates principles of the net neutrality as it does not treat all data equally. Zero-rated contracts, however, differ from paid prioritization, since it treats data differently in respect to price while paid prioritization, bandwidth throttling, and other practices treat data unequally based on access or speed of access to content. Even though the practice can be seen as violating principles of net neutrality it is often allowed even in regulatory regimes which otherwise implement strict prohibitions against behaviour which violates principles of net neutrality. European Union, which has its own net neutrality regulation (BEREC, 2016), allows ISPs to zero-rate content and zero-rating practices were allowed in the US even before FCC dismantled the Open Internet order.

While zero-rating does not sound ominous at the first glance, there are some concerns regarding the practice. Zero-rating content makes the content effectively cheaper for consumers to use since there is no opportunity cost in form of data cap. This is liable to increase demand for the zero-rated content, possibly at the expense of other competing CPs. This creates a lucrative business opportunity for the ISPs. They have an ability to increase demand for any content on the Internet and can ask the content providers to pay them in exchange for zero-rating their content. This practice is known as sponsored data since content providers effectively sponsor the data consumption in their websites and applications to customers of the ISPs.

The focus of this thesis is to provide a framework for pricing zero-rated mobile data plans. I will describe how monopoly ISP sets prices for zero-rated plans when they are not allowed to charge payments from content providers and how the prices are set both for the end users and content providers with sponsored data plans. This thesis will show that a monopoly ISP will never offer zero-rated mobile data plans over data cap plans if it cannot extract payments from the content providers if it cannot obtain other secondary benefits from the zero-rating. Additionally, it will show what forces affect the prices that a monopoly ISP sets to end users and content providers when it can collect payments from both parties. The framework also allows for some discussion about potential welfare effects of sponsored data and finds that changes in welfare mainly depend on how much zero-rating increases total data usage and how much it will distort consumption of the end users compared to unlimited mobile data plans.

Section I of the thesis discusses literature related to net neutrality and zero-rated plans. Section II provides a glance to mobile data markets both in Europe and US and discusses zero-rate practices in these markets. Section III shows that a monopoly ISP never prefers zero-rated plans over data cap plans. Section IV shows how the ISP sets prices and data allowances when it can collect payments from CPs. Section V offers numerical solutions to the framework provided in Section IV. Section VI discusses welfare effects of sponsored data. In Section VII, I discuss limitations of the study, possible reasons why Internet service providers offer zero-rated plans even without transfers between ISPs and CPs, despite Section III suggesting otherwise, and offer suggestions for future research. Section VIII concludes.

Section I: Related Literature

Consumption of Internet content differs vastly from consumption of common, non-Internet goods. The Internet cannot be treated as a common good that is consumed, but more as a network between end and content providers. Nature of the Internet as a network means that end users gain little to none benefit from just the act of being able to access the Internet, they derive utility from consuming Internet content provided by third parties. Just as end users end users, content providers do not benefit just by existing in the realm of the Internet. Content providers gain benefit by being accessed by the end users, as their visits to their websites or applications generate revenue or other benefits for them. Neither party benefits from being on the Internet alone and needs the other side. This networked nature of the Internet and cross-group externalities arising from it means that economists often find that studying the Internet is often best done through lenses of two-sided markets. (For example, see Economides & Tåg 2012, Choi & Kim 2010 and Jullien & Sand-Zantman 2018).

When net neutrality regulation is studied it is often assumed that there are some prohibitions in place for the behaviour of the networks, i.e. the ISPs. Usually, it is assumed that when net neutrality is in place that the ISP cannot ask payments from the content providers in exchange to access to the network. Additionally, it is often assumed that the ISP cannot prioritize or throttle any content in their network or free some content from data allowance that they have set to their customers.

Even when the residential ISPs are not allowed to charge access fees from content providers, the CPs do not access the Internet for free. Larger CPs generally own large server farms which host their content, while smaller CPs buy hosting services from companies dedicated to this. (Lee & Wu 2009 and Becker et al. 2010) The important distinction is that even when the CP make payments to ISPs, the payments are for being able to exist in the domain of the Internet, a prerequisite of being able to be accessed by end users using various networks. Access charge set by residential ISP differs from these charges as now the network requires payment from the CP, which already exist on the Internet, in exchange for the network allowing its customers to access the CP. Payments made by the CPs to hosting services are often omitted in research, as they happen outside of the networks which are often in the centre of the research.

Net Neutrality and Two-Sided Networks

General notions about two-sided market generally apply when studying effects of net neutrality. In his seminal paper: *Competition in Two-Sided Markets,* Armstrong (2006) outlined three factors affecting prices in two-sided markets. The relative size of cross-group externalities, the pricing structure of the network and in case of multiple competing networks, whether the two sides of the market aim to join only one or all networks. Armstrong argued that when cross-group externalities are different between the two groups, one group benefiting more from the presence of the other group than vice versa, prices for the group who gains less are determined by the benefit of the other group and not their own benefit, creating a downward pressure for the prices.

The pricing structure of the network has an effect on the pricing when there are multiple competing networks. If the networks charge groups lump-sum access fees to the network, the groups keep the benefit from network externalities for their selves. Networks can alternatively set per transaction fees, having the fees for groups to depend on how well the network performs on the other side of the market. With per transaction charges the network can extract some of the cross-group externalities and is able to set prices higher than with just lump-sum charges.

When there are multiple networks competing for same customers, whether the groups are single-homing or multi-homing affects the prices faced by these groups. Single-homing groups will never join more than one network while multi-homing groups will aim to join all networks. Armstrong argues that Internet is best described by "competitive bottleneck" -model where the end users are single homing, since people do not need to subscribe to multiple data plans in order to access the Internet, while content providers are multi-homing, since content providers want to be able to be accessed from customers of all ISPs. Competitive bottlenecks lead to a situation where the ISPs charge multi-homing group monopoly prices, as the multi-homing group will join all networks either way while competing over the single-homing group and passing some of the profits gained from the multi-homing side to the single-homing side in form of low prices. (Armstrong, 2006 and Rochet & Tirole, 2003).

Paid Prioritization

Effects of net neutrality have been studied by various scholars in the last decade. The focus of the research has often been in paid prioritization, a practice of the ISPs giving priority for data packets of specific CPs in their network. Results from the research have often been ambiguous, with theoretical models suggesting that discarding net neutrality regulation would increase total welfare under some parameter values and decrease total welfare under other, (Economides & Tåg 2012 and Choi & Kim, 2010) while others have found that total welfare either increases or remains unchanged when paid prioritization is allowed (Cheng et al. 2011). While changes in total welfare and consumer surplus often remain ambiguous, paid prioritization clearly sets the ISPs as winners and CPs as losers. ISPs get access to a new revenue stream, and while some CPs benefit from the paid prioritization, ISPs are able to extract part of this surplus, as the CPs are often seen as being the multi-homing side in competitive bottlenecks. Cheng et al. (2011) note that this mirrors views about net neutrality and paid prioritization presented by ISPs and CPs, with former decidedly against net neutrality regulation and latter generally favouring such regulation.

Effects of paid prioritization are similar to effects of access fees to CPs. For example, Economides and Tåg (2012) find that, in monopoly setting, consumer surplus is higher with access fees since the network can set lower prices for the end users when it charges content providers. While these access fees lead to some content providers leaving the network, reducing consumer surplus, the authors argue that effect of lower prices dominate the effect of lower content provision.

Investment Incentives

One common argument found from the ISP side of the debate is that net neutrality reduces investment incentives for the ISPs. For example, Edward Whitacre, then CEO of SBC Telecommunications (now AT&T) commented in 2005 to Bloomberg that: "*How do you think they're going to get to customers? Through a broadband pipe. Cable companies have them. We have them. Now what they would like to do is use my pipes free, but I ain't going to let them do that because we have spent this capital and we have to have a return on it. So there's going to have to be some mechanism for these people who use these pipes to pay* *for the portion they're using. Why should they be allowed to use my pipes?* (O'Connell, 2005)

Arguments like that of Whitacre have sparked debate among scholars on investment incentives of the ISPs under different regulatory regimes. Cheng et al. (2011) find that investment incentives of the ISPs are stronger with net neutrality than without it and argue that *"This goes against the assertion of the broadband service providers that under net neutrality, they have limited incentive to expand."* Choi & Kim (2010) found that capacity expansion without net neutrality is affected by two opposing effects. By expanding capacity thus reducing congestion in the network, the ISP can increase payments it collects from the end users but is also discouraged from investing in additional capacity, as it reduces benefits that it can offer with paid prioritization. With less congested network wait times for content are reduced and the CPs are less willing to pay for having first priority of data packet delivery in case of congestion. Krämer & Wiewiorra (2012) have a different take on investment incentives, they argue that paid prioritization will be beneficial in the short run and in the long run increase investment incentives of the ISPs. However, both Choi & Kim (2010) and Krämer & Wiewiorra (2012) find that paid prioritization reduces investment incentives of content providers. With net neutrality, the CPs can keep all returns on their investments but under discriminatory regime the ISPs can extract part of their surplus, lowering their investment incentives.

Zero-Rating

Effects of paid prioritization and pure access charges to the CPs have been studied extensively before, but the issue of zero-rating or sponsored data has been left with relatively little attention, until recently. While general issues with sponsored data have been discussed extensively before, for example by Schewick (2014 and 2016), Lee & Wu (2009) and Yoo (2016), there are only a few formal theoretical models describing the effects of zero-rating. Of the few formal models out there, Somogyi (2017) and Jullien & Sand-Zantman (2018) found similar results, even with relatively different approaches. Somogyi argues that total surplus is increased with sponsored data over net neutrality setting under certain parameter values and reduced under others, finding similar to ones from Jullien & Sand-Zantman who argue that total welfare effects remain ambiguous. Somogyi found that content is likely to be zero-rated when it is either very preferred by the end users or very unfavoured by the end users and that total surplus increases when the content is preferred but reduced when the unfavoured content is zero-rated. The result is similar to findings of Jullien & Sand-Zantman, who note that in their setting with high-margin and low-margin content providers, the network needs to distort consumption of low margin content to induce high-margin CPs to choose sponsored data option. This is a common result in price discrimination settings where the situation of the “low” group needs to be worsened to reduce rent extraction ability of “high” group. The general sense with both articles is that when the share of the content that will not be zero-rated is large enough, the benefits of an increase in total consumption do not eclipse the benefits from distorted consumption. Jullien & Sand-Zantman additionally find that the general principles of two-sided markets apply for sponsored data too. In competitive bottleneck situations, networks that offer zero-rating will set low prices for the end users to incentivize them to join their networks by transferring their profits from the content provider side.

Outside of theory papers presenting formal mathematical models, the study of sponsored data is often focused on potentially harmful effects of zero-rating, especially on CP side. Barbara van Schewick, professor of Law at Stanford Law School, claims that even though sponsored data practice differs from paid prioritization, the same discriminatory effects apply. (Schewick 2014, Schewick 2016). In her report: T-Mobile’s Binge On violates Key Net Neutrality Principles (2016), Schewick argues that such programs limit competition, free expression, user choice, and innovation, especially harming small-players, non-commercial providers, and start-ups. She notes that Binge On does not offer a meaningful choice between consumption of normal and zero-rated video content. T-Mobile’s lowest qualifying mobile plan allows approximately 9 minutes of video content consumption per day (4.5 hours monthly) and Binge On allows T-Mobile’s customers to consume unlimited amounts of Binge On qualifying content. Cheng et al. (2011) arrive at similar conclusions as Schewick. They argue that without net neutrality commercial actors will gain more ground on the Internet, as they have better ability to pay for preferential treatment, hurting non-profit CPs and the end users which prefer them. Schewick’s argument on harm to innovation is also supported by Vincent Cerf, Chief Evangelist at Google (Cerf, 2006) who stated that innovation in the Internet is not done in the centre of the network but in the “edges”, meaning that openness and non-discriminatory nature of the Internet are the reasons for innovations and growth of the Internet, echoing End-to-End arguments presented by Saltzer et al. in 1984.

Net Neutrality and Competition

Scholars have been split in their views on whether discriminatory networks harm innovation or whether they will reduce competition in CP markets. Boliek (2009) finds that especially in mobile networks traditional concerns of net neutrality proponents do not apply since they are aimed more towards fixed cable access networks where competition is scarce. She argues that "*Regulators and analysts alike have consistently found present-day mobile communications market to be competitive",* a notion that is also supported by FCC's Twentieth Mobile Wireless Competition Report (2017). A lighter regulatory approach has been championed by Becker et al. (2010), who argue that instead of more stringent net neutrality regulation, competitive authorities coupled with some light regulation are enough to deal with potential competitive concerns that discriminatory networks might cause. While Boliek (2009) finds that there isn't much empirical evidence suggesting that discriminatory practices on the Internet have created barriers of entry or reduced innovation, especially Wu (2003) and Lee & Wu (2009) have argued against discriminatory networks. Lee & Wu (2009) see that net neutrality safeguards entry of new CPs to the Internet and that it has been important for innovation on the Internet. Wu (2003) even likens net neutrality to Darwinian competition, where all forms of using the Internet are allowed and only the best survive. Competition between CPs will lead to best content being offered to the end users, against short-term benefits of the networks.

Additional concern presented by Lee & Wu (2009) is fragmentation of the Internet. Without net neutrality, discriminatory practices such as paid prioritization, sponsored data and even blocking access to certain sites might become commonplace. Fragmented Internet would mean that all end users would no longer have meaningful ways of accessing the same content on the Internet. Content that the end users could be able to access or would be incentivized to access would be determined by their choice of ISP. Fragmentation of the Internet is not seen in a negative light by everyone. Yoo (2016), argues that consumers can benefit from service differentiation. A discriminatory system can allow the networks to supply varying services to consumers who have different tastes.

Additionally, the CP side can benefit too *"By allowing competitors to target subsegments of the overall market that place a higher value on particular services."* (Yoo, 2016)

Net neutrality is a complex issue, evident from the many views that the articles studying it have taken. In the end, discussion boils down to two different paths. First, there are articles studying total welfare effects of net neutrality from some perspective, often using formal mathematical models. The second set of studies focuses on the potential negative effects of discriminatory networks, often recognized as the losers in the first set of studies. These articles go in depth on the potential losses that end users and content providers might face under discriminatory networks and often argue that net neutrality safeguards open internet and innovation on the "edge." While there is no clear consensus on effects of the net neutrality it is clear that it is a matter of extreme importance and discarding net neutrality could dramatically see how we see and use the Internet.

Section II: Mobile Data Markets in Europe and United States

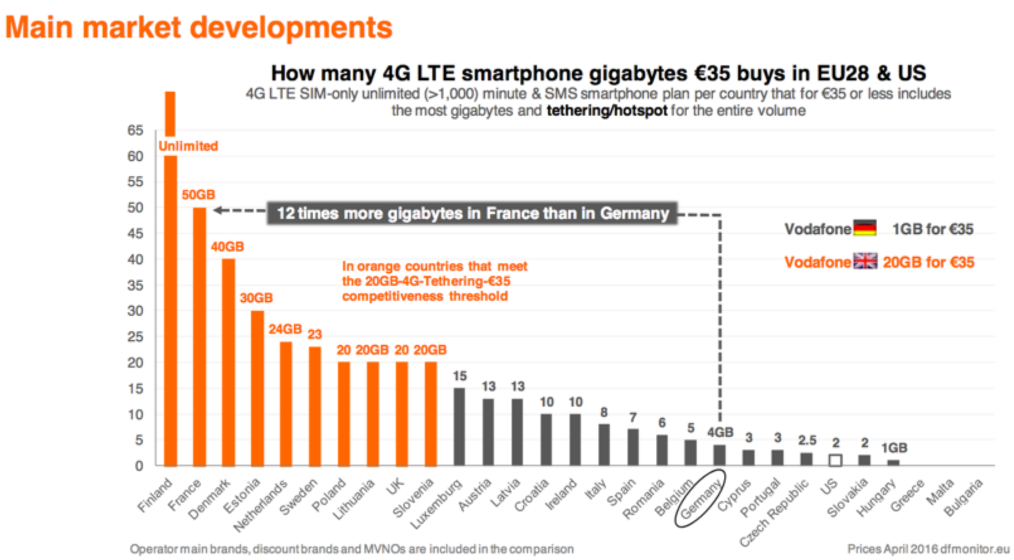
Mobile Data Market in Europe

Mobile data markets in Europe are heterogeneous compared to the United States. In the US most of the market is controlled by four nationwide companies with regional and local Internet service providers sharing only a fraction of the market. Europe however, consists of various countries which all have their own unique mobile data markets and diverse set of Internet service providers.

Almost every European country has at least three Internet service providers offering services, giving end users a choice between operators (World Heritage Encyclopedia). The number of choices for the end users is not insignificant since ISPs in four Internet service provider markets sell three times more 4G data for 35€ than ISPs operating in markets with only three Internet service providers (Rewheel, 2016).

*Figure 1***,** shows that there is a stark difference in price of data between European countries. This variation is also mirrored in data usage, in 2015 average monthly mobile data usage per person in Finland reached 10 GB while data usage in Germany was at 0.6 GB per month. (Rewheel, 2016)

Figure 1.

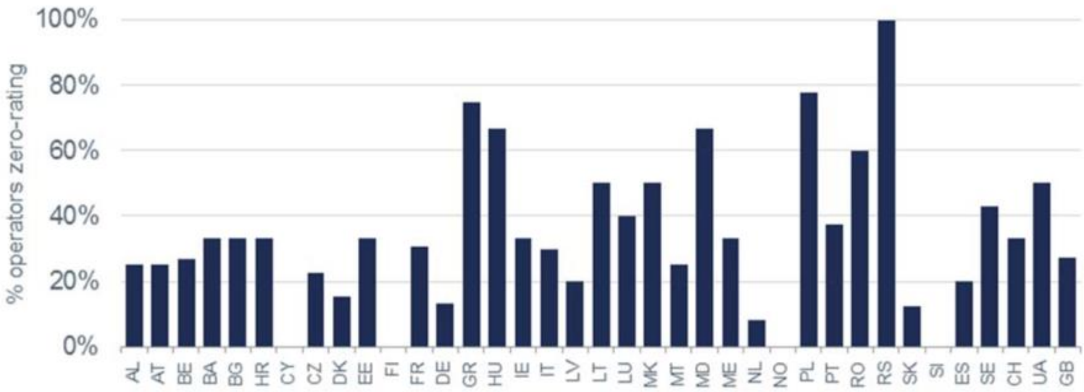


(Rewheel, 2016)

Zero-Rating in Europe

Zero-rating plans have become more common in recent years. A report *Zero-rating practices in broadband markets* (Aetha, Oswell & Vahida and DotEcon Ltd., 2017) notes that before 2012 zero-rated plans were virtually non-existent in Europe. *Figure 2***,** shows that significant growth has happened since. Most European countries had at least 20% of their ISPs offering zero-rated contracts in 2017.

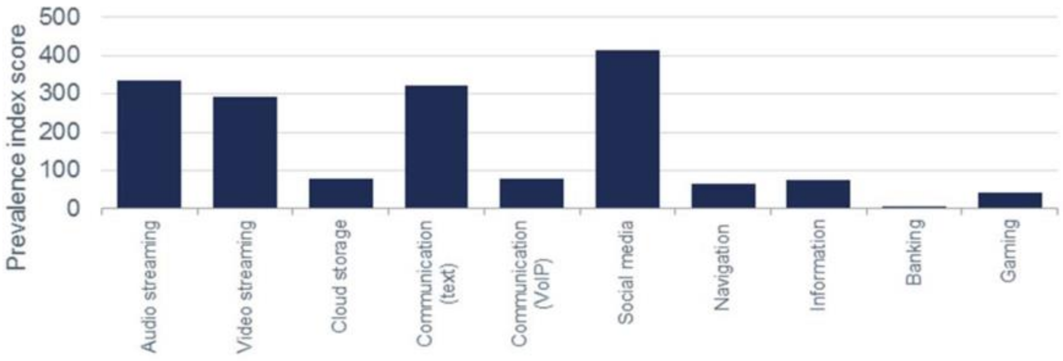
Figure 2. The Proportion of Operators Zero-Rating by Country



(Aetha, Oswell & Vahida and DotEcon Ltd., 2017)

Content types being zero-rated are as diverse as ISPs zero-rating them. Seen from *Figure 3*, most prevalent zero-rated categories in Europe are audio streaming, video streaming, text-based communication and social media. These four categories dominate over all other categories and are all zero-rated relatively as often. Of the four categories both social media and text messaging are relatively data light activities, while audio streaming can be categorized as medium data intensity activity and video streaming as heavily data intensive.

Figure 3. Prevalence Index Scores for Categories of Zero-Rated Content for Europe



(Aetha, Oswell & Vahida and DotEcon Ltd., 2017)

Mobile Data Market in the United States

The US market is dominated by four nationwide carriers: AT&T, Verizon, T-Mobile, and Sprint. FCC's *Twentieth Mobile Wireless Competition Report* (2017) finds that these four Internet Service Providers account for over 411 million connections, over 98% of the nationwide total. With four nationwide operators and a number of smaller operators, coverage and competition situation, measured by the number of operators, seems comparable to Europe. The difference is that US nationwide carriers do not operate universally within the whole United States. The operators may or may not offer coverage within certain areas or regions, leading to less than four options for ISP in some areas. *Table 1* shows that in 2016 only 1 of 716 Cellular Market Areas in the United States had only one mobile wireless provider with over 5% market share operating. With 14.5% of total CMAs having 2 service providers, 21.8% having three service providers and four 63.5% having four or more service providers.

Table 1.

Estimated Mobile Wireless Service Providers Offering Service by CMA, Excluding Territories

Number of Providers Offering Service Anywhere in a CMA	Two Percent Market Share Threshold				Five Percent Market Share Threshold			
	Number of CMAs		Total CMAs (percent)		Number of CMAs		Total CMAs (percent)	
	2013	2016	2013	2016	2013	2016	2013	2016
Total for U.S., excluding territories	*716*	*716*	*100.0%*	*100.0%*	*716*	*716*	*100.0%*	*100.0%*
1 provider	0	0	0.0%	0.0%	2	1	0.3%	0.1%
2 providers	63	54	8.8%	7.5%	139	104	19.4%	14.5%
3 providers	146	84	20.4%	11.7%	214	156	29.9%	21.8%
4 or more providers	507	578	70.8%	80.7%	361	455	50.4%	63.5%

Source: Based on December 2013 and December 2016 NRUF data.

(FCC, 2017)

With only four nationwide ISPs in the US, a comparison between them is easier than in Europe. All four companies offer a range of plans, both limited data allowance plans, and unlimited plans. Limited plans vary from 0.5 GB per month to over 20 GB. Unlimited plans seem to be main products for all four ISPs with heavy promotion in their respective websites. Prices of the unlimited plans range from around 60 to 80 USD per month. Further price comparison between the ISPs is made harder as details of the plans wary. There are differences on how much data their customers are allowed to use with mobile hotspot, whether the ISP starts constricting connection speeds after certain data limits are exceeded, even in unlimited plans, and so on. Pricing practices of the ISPs also hamper more thorough analysis between the mobile carriers. T-Mobile includes taxes and fees in their list prices while other three do not. These taxes and fees are not easily calculated and are varied by region of the customer.

Zero-rating in the United States

All of the four nationwide carriers have included zero-rating in their mobile data plans. The ISPs include zero-rating automatically in all their contracts and do not ask any additional fee from their customers in exchange for having their data consumption in these sites not counted against their data caps.

T-Mobile offers T-Mobile Binge On service for content providers. Content providers are not required to pay anything to T-Mobile to be accepted, but they need to meet certain technical criteria to qualify. Binge On consist of a large bundle of zero-rated content ranging from multiple different news websites to different music and video streaming services.

Verizon's FreeBee Data is a more traditional sponsored data program. Content providers are can pay Verizon to be zero-rated. In 2016 Verizon claimed that any brand is able to participate in their FreeBee Data program. At the moment, only content that is zero-rated seems to be Verizon's video streaming service Go90, which launched in 2015 with intention of attracting millennials (Morgan, 2015).

As Verizon, AT&T also has a sponsored data program where content providers are able to pay AT&T to be zero-rated. AT&T zero-rates its own video streaming services DirectTV and DirectTV Now, while technically allowing for other content providers to sign up for the program.

Sprint does not zero-rate any content at the moment but has made forays into zero-rating before. In 2016, Sprint partnered with Fubo TV to offer a bundled subscription zero-rating for Copa Americano Soccer Tournament. Sprint customers were able to watch the tournament from Fubo TV for free (normally costing 9.99 USD per month) and have that data not count towards their data caps (Brodkin, 2016).

Section III: Zero-Rating Without Transfers

Mobile data usage takes over half of the total Internet traffic in the world, but data allowances are still relatively small even in many developed countries. (Statista, 2018; Rewheel, 2016). Combined with the fact that the prominence of zero-rated mobile data plans has increased rapidly in both sides of the Atlantic during last few years, means that having formal theoretical models explaining how zero-rated plans affects the consumers and society at large becomes more important every year. Paid prioritization and bandwidth throttling can drastically alter how we use the Internet in the future, but potential issues caused by them have been widely known for years and have been studied extensively. The practice of zero-rating has not garnered as much attention. It is often seen as less harmful practice than paid prioritization or bandwidth throttling, evident from European Union's BEREC net neutrality guidelines banning these practices but allowing zero-rated data plans in most situations (BEREC, 2016). Effects of zero-rating practices have been discussed by scholars for years but formal models depicting effects of sponsored data have been scarce. In addition to research in sponsored data being rare zero-rated plans where the ISP does not charge payments from the content providers have been left with little or no attention. Section III provides a formal framework which allows us to better understand zero-rating in situations where transfers between the ISP and the zero-rated content providers are not allowed.

This Section shows that an ISP never offers zero-rated plans to end users if they are not allowed to extract payments from CPs in exchange for zero-rating. In this section, zero-rating signifies the situation where no transfers between the ISP and CPs are allowed. Sponsored data is used to specify situation where the ISP can ask payments in exchange for zero-rating. Data cap plans will mean limited data allowance plans where the ISP does not zero-rate any content.

With net neutrality, the ISP is only allowed to collect payments from end users in exchange for providing them a mobile data plan with either a limited data allowance for a period or an unlimited data plan. Size of data allowance K_0 determines costs of the ISP $C(K_0)$. The cost function is assumed to be increasing in K_0 with $C'(K_0) > 0$ and $C''(K_0) < 0$. The cost function is assumed to including investments required to network capacity so that the network can always meet all demand for data without congestion. With net neutrality profit maximization for the network is reduced to setting K_0 and price for end users P to profit-maximizing levels based on cost and demand functions.

When the marginal cost of data is identical for all types of mobile data plans, the only factor affecting the profits is the price set by the network and by extension, end users' willingness to pay for data. This section will show that end user never values a zero-rated plan more than data cap plans or unlimited plans if they lead to same data consumption. Identical costs for same amounts of data and same or lower valuation for zero-rated plans lead the network never offering zero-rated plans over data cap plans or unlimited data plans.

Framework

This thesis uses a modified version of a framework provided by Somogyi (2017). As Somogyi, I assume end users to have Cobb-Douglas utility between two competing content provider types video provider content v and other content o. Video content can be zero-rated while other content can never be zero-rated. Both content provider types are assumed to consist of a large group of small identical content providers which all receive an equal share of the groups' data demand. End users gain utility from consumption of data from the two content categories and are bounded by data allowance set by the network. If the network does not set consumption constraint for v or any of the data, end users will consume up to their maximum consumption point B. Upon reaching point B they will not gain any utility from increased consumption.

There is only one monopoly ISP in the market which sells mobile data plans to end users with price P for K_0 amount of data per period. End users are identical and atomistic and divide their data consumption, limited by K_0, between v and o. Video content can be zero-rated while other will never be zero-rated. With data cap plan and budget constraint K_0, end users will consume αK_0 of v and (1-α)K_0 of o, the normal Cobb-Douglas consumption shares. Identical utility functions between end users allow the monopolist network to extract all surplus from the end users by setting the price to match their willingness to pay $P = U(K_0)$.

Zero-rating will, contractually, allow end users to consume an infinite amount of the zero-rated content. Consumption of the end users is bound by maximum consumption point B, where $K_0 \leq B$, for the total amount of data consumed per period. Combined consumption of v and o cannot exceed this point. Zero-rating has the effect of increasing data consumption of end users from K_0 to B. Consumption of o is still bound by data allowance K_0 and cannot exceed it but can be lower than it. Consumption of v is set by the difference between B and data consumption to o.

Third mobile data plan type that the network can offer is unlimited data plan. Unlimited data plan does not contain data allowance and offers unlimited consumption of data for both content types. Unlimited plan will lead to total data consumption of B. This plan is a special case of data cap plan where data allowance K_0 is set to B.

The ISP only offers one of the three plans. K_0 is identical between the data cap plan and the zero-rated plan, set at profit maximizing level for the data cap plan.

As a major difference to the framework presented by Somogyi (2017), I assume that video content providers are noncompeting and completely identical. Essentially, they act as one content provider without any bargaining power. Removing competition between two content providers vying to be zero-rated serves two purposes. First, it reduces the mathematical complexity of the models and secondly it allows the model to determine surpluses and prices better as a function of the data allowance. The framework also omits the assumption that when content is zero-rated the network is congested and total data consumption is less than demand for total data. The network is never congested. Cost of increasing network capacity due to larger data demand is assumed to be included in the cost function of the network. In addition to allowing both end user and v-type content provider prices to be determined endogenously as a function of the data allowance, these changes are made to allow the analysis focus more on pricing decisions of the network.

In the context of this framework, consumer surplus does not offer any meaningful insights as the network always leaves the end users indifferent between buying the plan or not, leaving net consumer surplus at zero. In this thesis, consumer surplus will mean gross consumer surplus unless other mentioned. Gross consumer surplus describes how much end users will benefit from the plan before payment to the network. This works as a proxy for net consumer surplus for cases where the network cannot extract all CS. It can be assumed that increases in net consumer surplus can be roughly proxied by increases in gross consumer surplus in the framework of this thesis.

The Model

End user utility:	$U = v^{\alpha} o^{1-\alpha}$	(1)
The budget of data cap plan:	$v + o = K_0$	(2)
The budget of zero-rated plan:	$v + o = B \text{ and } o \leq K_0$	(3)
The budget of unlimited data plan:	$v + o = B$	(4)

End users allocate their data consumption to content categories according to their Cobb-Douglas preferences. Content type's share of the budget is determined by α, as the prices for both content types are identical. Consuming 1 GB of v content will decrease remaining data per period as much as consuming 1 GB of o content. With data cap plans, the end users will consume αK_0 of v and (1-α)K_0 of o. An unlimited plan leads to consumption distribution of αB of v and (1-α)B of o. The zero-rated plan introduces additional constraint $o \leq K_0$ affecting the data distribution between content types. Zero-rate plans have two different consumption distributions, determined by the relative size of end users' preferences of the video content over the other content, denoted by α. When α is sufficiently large, the end users prefer v content over o content enough that consumption of other content is always less than data allowance, meaning $o < K_0$. Somogyi (2017) showed that large α then leads to a distribution similar to the unlimited plan, where end users consume αB of v and (1-α)B of o. Relative low levels of α mean that other content is preferred enough over video content and that when v is zero-rated the end users will consume o up to data allowance K_0. Given a choice, they would consume more o but are constrained by K_0. Consumption shares are now $B - K_0$ for v and K_0 for o.

Somogyi (2017) presented a threshold value for α:

$$\bar{\alpha} \equiv 1 - \frac{K_0}{B} \tag{5}$$

This threshold value is dubbed attractiveness of content. Video content is attractive when $\alpha \geq 1 - \frac{K_0}{B}$ and unattractive when $\alpha < 1 - \frac{K_0}{B}$.

Table 2. summarises consumption distributions under different plans.

Table 2.

	v	o	Total Data Consumption
Data Cap	αK_0	$(1-\alpha)K_0$	K_0
Zero-rate $\alpha < \bar{\alpha}$	$B - K_0$	K_0	B
Zero-rate $\alpha \geq \bar{\alpha}$	αB	$(1-\alpha)B$	B
Unlimited Data	αB	$(1-\alpha)B$	B

Data allowance K_0 is identical in a data cap plan and in a zero-rated plan. If the network could set data allowance to a different level for zero-rating and data cap plans, the network would set K_0 to threshold point with zero-rating. With K_0 set to a level that v becomes attractive, there would be no practical difference between a zero-rated plan and an unlimited plan, as can be seen from *Table 2.* It will be shown later in this section that the network would always set K_0 at threshold point to maximize its profits.

Proposition:

A monopolistic ISP will never offer a zero-rated plan to the end users over a data cap plan or an unlimited plan if the ISP's marginal cost of providing data is identical between options and it cannot extract payments from CPs.

Proof:

The network will offer a zero-rated plan only and only if

$$\pi_1 > \pi_0 \tag{6}$$

Where π_1 is the network's profits from the zero-rated plan and π_0 is the network's profits from the data cap plan with a data allowance that maximizes its profits from a range $0 < K_0 \leq B$.

Table 2. shows that there is no difference between total consumption of data and consumption mix of content types between zero-rating with attractive content and unlimited plan. Both plans lead to similar consumption for end users, thus must lead to identical willingness to pay for a mobile data plan. When both plans have same total consumption, they will lead to cost $C(B)$ to the network. With no difference in either revenue or cost for the network, the network will never prefer the zero-rated plan over the unlimited plan. If there is a level of K_0 that offers higher profits for the network than unlimited plan the network will never offer the zero-rated plan over the data cap plan.

When v is unattractive, consumption of o is lower with the zero-rated plan than with the unlimited plan. End user's utility is always lower with the zero-rated plan where α is under the threshold point. If K_0 would be increased so that the threshold point is reached end user's consumption of o content would increase, meaning that without a change in data budget they could achieve a higher level of utility with the unlimited plan than with a zero-rated plan.

Equations (7)-(9) show that the amount of data that the end users would like to spend to other content is always higher than what they are allowed under the unattractive content zero-rated plan.

When:

$$\alpha < 1 - \frac{K_0}{B} \tag{7}$$

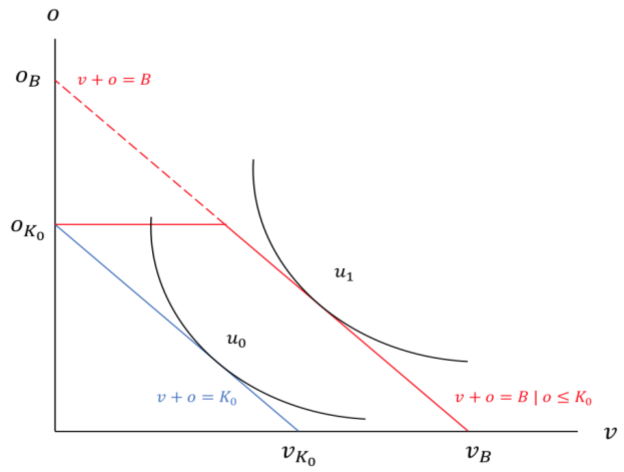
$$\alpha B < B - K_0 \tag{8}$$

$$(1 - \alpha)B > K_0 \tag{9}$$

Without the constraint of data allowance in the zero-rated plan the end users would consume more other content, reducing consumption of v to achieve their maximum utility under budget B. Higher utility derived from an unlimited plan means higher willingness to pay for the unlimited plan and higher revenue for the network. The unlimited plan and the zero-rated plan have both total data demand B and cost $C(B)$ of providing the data. With identical costs and higher revenue from unlimited plan, the network will never prefer the zero-rated plan with unattractive content over the unlimited plan. When the network would set $K_0 < B$ for data cap plans, there will always exist at least one level of K_0 that is more preferable to the network than the zero-rated plan, in addition to data cap plan with $K_0 = B$.

Graphs 1. and *2.* illustrate the differences between unlimited plans and sponsored data plans, where *Graph 1.* $\alpha \geq \bar{\alpha}$ and in *Graph 2.* $\alpha < \bar{\alpha}$.

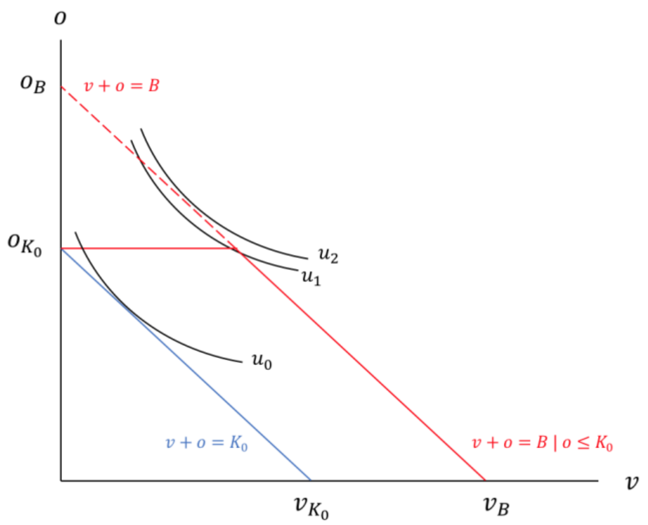
Graph 1.



***v* is attractive**

Switching from data cap plan with data allowance K_0 to either unlimited data or zero-rated plan increases utility from u_0 to u_1. The end users achieve same utility level with the zero-rated plan and the unlimited plan.

Graph 2.



***v* is unattractive**

Switching from the data cap plan with data allowance K_0 to the zero-rated plan increases utility from u_0 to u_1. The unlimited plan with higher consumption of o offers higher utility level u_2 than the zero-rated plan.

The Credibility of the Assumptions

The model requires some strong assumptions to keep it simple. While assumptions about monopolistic ISP, an identical mass of end users and certain assumptions about nature of the maximum consumption point do not necessarily reflect reality very accurately, relaxing these assumptions does not change the conclusions.

Monopolistic Network

Mobile data plan markets are highly competitive in both EU and United States. An assumption of monopoly ISP is a large deviation from reality. Increased competition affects prices and data allowances set by the ISPs but does not change the results. As long as the marginal cost of data is identical between plans there is no point for the ISPs to offer zero-rated plans. If one ISP sells zero-rated plans, it must either set lower average price per data than its competitor offering data cap plans or set same the price and lose customers to the competition. Both options lead to reduced profits, making the best response of the ISP to sell data cap plans instead of zero-rated plans. Situations where a company would prefer a less valuable product over more valuable one with identical costs are rare. This realization should carry over to most competition situations and distributions of end users' valuations for mobile data plans.

Multi-Period Games and Uncertain Demand for Data

The model can be applied to a multi-period framework without much effort. If the same game is repeated over multiple periods, the results do not change. If the network can alter K_0 and P between periods without cost, it can always find a data cap plan which offers equal or higher profits than a zero-rated plan. If costless switching is possible, parameter changes between periods do not matter for the network's optimal strategy since data cap plans are optimal strategy regardless of parameter values. The data cap plan, which is an optimal choice during the first period, remains the optimal plan on all of the following period. Every period is essentially an individual game with no direct link to previous or following games as the network can optimize profits individually for all of them.

Costless switching between plans is not a very realistic assumption and the costs are often directed at the end users. Some mobile data plans require a minimum amount of time that the plans must be held before changing them. Changing plans might also cause costs for the end users in form of direct costs such as one-time fees required by the new plan or indirect costs such as search costs for the best alternative contract.

Even if it is assumed that end users cannot change data plans between periods and their data demand is uncertain, zero-rated plans are never optimal for the network. Changing demand for data can be modelled by adding demand multiplier θ_i, $0 < \theta_i < 1$, to the utility function. The utility is now derived from function $u = \theta_i(v^{\alpha} o^{1-\alpha})$, where θ_i can take different values in different periods. I additionally assume that end users can consume more data than their data allowance K_0 but must either pay overcharge fees for additional data consumption. The network sets overcharge fees endogenously but it can be assumed relatively safely that the network faces larger costs when data consumption exceeds the data allowances. For example, the network can service all its customers with its current capacity when the demand is K_0 but when it is larger than K_0 it needs to buy additional capacity from outside with a higher cost. Higher cost for data for demand over K_0 suggests that when the network sets overcharge fees, per data overcharge fees are larger than per data price for consumption within the data allowance.

The decision in this kind of setting is where to set K_0. In periods where data demanded is less than K_0 end users will end up paying more than they gain in utility from consumption. In periods where demand is high, they must either pay overcharge fees or gain reduced utility from consumption. If changing between plans would be free, the optimal solution would be simply to change data allowance according to demand per period. If we assume that overcharge fees are larger than the cost of unused data, data allowance should be set higher than with earlier model. As overcharge fees increase the optimal level of data allowance nears B, where the end users will rather pay for the unlimited plan than pay the overcharge fees. Even in this situation, zero-rating will not be a better option, since better results could still be obtained by unlimited plan or plans with lower data allowance.

Maximum Consumption Point Assumption

A maximum consumption point can be thought to be formed from multiple sources. Essentially, people are not able to consume an infinite amount of data in a finite amount of time. End users can also have other activities as Internet usage. It can be assumed that at the maximum consumption point end user will gain more utility from other activities, essentially capping Internet and data consumption to B.

While the existence of a maximum consumption point is a realistic assumption, same cannot be said for assuming that there is a common aggregate point B for all data consumption. The assumption of aggregate point B leads us to a conclusion that if any kind of Internet content is removed from data allowance, this contents consumption will increase so much that it reaches the upper bound B.

Different content types have extremely large differences on how much data they use per time unit. Video streaming, especially HD video streaming, is an extremely data-intensive activity. For example, with 10 GB monthly data allowance one can only watch HD videos for approximately 4 hours (AT&T Data Calculator). It can be fairly easily believed that if video streaming is zero-rated, even if it not very preferred by end users, total consumption can easily increase enough to justify assumption for aggregate maximum consumption point. This, however only applies to extremely data-intensive content. For example, music streaming is considerably less data-intensive than video streaming. Streaming music for 7 days a week and 24 hours in a day would consume only little under 3 GB of data in a month. If it is assumed that there is a common maximum consumption point which is higher than 30% of current 10 GB data allowance, end users could never upper bound for total consumption by just zero-rated music streaming alone. The situation is even worse for data-light activities, one could send just shy of 19000 emails with 3 gigabytes or surf the web for 200 hours. Assuming that zero-rating even moderately data-intensive content could lead to the same amount of data consumption than an unlimited plan, where one also streams HD videos as much as one wants, is extremely unrealistic. Since ISPs do not rate only data-intensive content but feature multiple different data light contents in their zero-rated plans, as seen from *Figure 3.* discussion about nature of maximum consumption points is warranted.

Assuming that there are individual maximum consumption points for all different content types or even content providers does not change the results in this section. In this framework, it would mean that there are points B_v and B_o, $B_v + B_o = B$, for video content and other content respectively. End users cannot consume more video content than B_v nor consume other content over B_o. Data demand with an unlimited plan is B as both contents are freed to be consumed up to their respective upper bounds. With zero-rated plans, total data consumption is $B_v + K_0$ as end users consume up to video content's maximum consumption point but are constrained in consumption of other content by the data allowance.

When v is zero-rated and consumption is increased to $B_v + K_0$ it is no different from the original model. Cost for providing that amount of data is $C(B_v + K_0)$, which is identical to the cost in a data cap plan with a data allowance of $B_v + K_0$. The data cap plan either does not lead to less utility than the zero-rated plan, or in case of unattractive content leads to a higher utility. When the content is unattractive, end users are not constrained in their consumption mix. With data cap plan consumption of v will be less than B_v and consumption of o will be more than K_0, still with the budget of $B_v + K_0$. End users can thus gain similar or increased utility from the data cap plan than with the zero-rated plan while causing identical costs for the network. Thus, the network will never favour zero-rated plans over data cap plans.

The Credibility of Assumptions: Conclusions

While some assumptions made in the model have little basis in reality, in case of extremely data light content even requiring one to break several laws of physics to be able to use enough data, relaxing these assumptions did not change the inferences that one can make from the model. In every situation where having a larger choice over consumption mixes does not lead to smaller gross utility than having restrictions over choosing the consumption mix and costs of producing data for different contract types are identical, the zero-rated contract is never optimal.

Section IV: Zero-Rating with Transfers

Section III discussed a situation where the network was not allowed to extract payments from content providers in exchange for zero-rating their data. This section discusses a situation where transfers between the two parties are allowed. Section IV shows that sponsored data plans increase the amount of data consumed in the network. Effect of sponsored data to social surplus, compared to data cap plans, remains ambiguous and depends on parameter values.

Framework

The monopoly ISP is not allowed to exclude any content provider from the market, i.e. access fee for the CPs is constrained to zero. The network collects price P from the end users and is allowed to charge fee $F_i, i \in a, u$ from v content providers in exchange for zero-rating their content. Fee F_a is charged when a content that is zero-rated is attractive and fee F_u is charged when the content is unattractive. Other content providers can never be zero-rated. Identical and atomistic end users allow the network to collect all consumer surplus from them in form of price P. Content providers offer their content to end users free of charge but generate revenue from advertisements and other benefits, which depend on the amount of data that the end users consume in their content. Revenue generated by both CP types is the amount of data demanded from them, multiplied by revenue multiplier r. Consumption of K_0 amount of content will lead to revenue of rK_0, where $r > 0$. Revenue generated by the content providers is not assumed to incur any costs for any agent in the network, outside of the costs to the network for providing the data demanded. Profits of the content providers are strictly increasing in the amount of data consumed in their content, before factoring the fee F_i.

The network can set different data allowances for data cap plans and sponsored data plans. Data allowance for data cap plan K_0 is set to a profit-maximizing level

$$u'(K_0) - C'(K_0) = 0 \tag{10}$$

K_0 is assumed to be exogenous when determining data allowance K_1 for a sponsored data plan.

End users' utility is based on Cobb-Douglas utility and their data consumption is constrained by data allowance set by the network. When consumption of some or all content is not constrained by K_1, total data consumption increases to the maximum consumption point B. This happens if the network zero-rates v-type content or it the network offers an unlimited plan with $K_1 = B$. Price P is set by the network so that it matches the gross utility that the end users gain from their total data consumption. With data cap plan, end users will consume αK_0 of v-type content and $(1-\alpha)K_0$ of o-type content. Threshold point $\bar{\alpha} = 1 - \frac{K_1}{B}$ determines the amount of data usage for both content types when v-type content is zero-rated. When video content is attractive consumptions are αB and $(1-\alpha)B$ for v and o. When video content is unattractive, i.e. K_1 is set to a level where $\alpha < 1 - \frac{K_1}{B}$, consumption is $B - K_1$ and K_1 for v and o.

Video content providers' benefit from zero-rating is determined by their revenue multiplier r, data demand faced when zero-rated and data demand when they are not zero-rated. If v-type content providers refuse to pay for zero-rating data plan offered by the network will be data cap plan, and v-type content providers face demand αK_0. Increased demand from zero-rating is then $\alpha B - \alpha K_0$ for attractive content and $B - K_1 - \alpha K_0$ for unattractive content. This corresponds to a net benefit of $r(\alpha B - \alpha K_0)$ and $r(B - K_1 - \alpha K_0)$ for attractive and unattractive content. Since all content providers are identical and atomistic the network can set fee to a level where v-type content providers are indifferent between being zero-rated and having data demand associated with data cap plans. The network achieves this by setting fees:

$$F_a = r(\alpha B - \alpha K_0) \tag{11}$$

and

$$F_u = r(B - K_1 - \alpha K_0) \tag{12}$$

Fee F_a is exogenous as the network cannot alter it in any way. Revenue multiplier r, the end user preference for video content α and maximum consumption point B are all exogenous by their nature. The network cannot credibly threaten to reduce data cap plan's data allowance K_0, as it is at profit maximizing level if v-type content providers refuse the zero-rating and can also be assumed to be exogenous. F_u has same exogenous parameters as F_a, but the network can influence the size of the fee since it can alter K_1.

The Model

The timeline is following:

1. The ISP calculates whether a sponsored data plan can achieve larger profits than a data cap plan.
2. If the sponsored data plan is more profitable, then the network chooses levels for K_1, P, and F_i.
3. Video content providers choose whether to pay F_i and be zero-rated or not pay and have data demand associated with the data cap plan.
4. The end users choose whether to pay price P for a sponsored data plan with data allowance K_1 and zero-rated video content or not to subscribe to the mobile data plan. If the network did not zero-rate video content the end users will choose between paying the price of data cap plan with data allowance K_0 and not subscribing.

The networks profit is generated from revenue from end users P and fees from v-type content providers F_i deduced by the cost of providing B amount of data to the network $C(B)$. When the video content is attractive, the network cannot influence its profits outside of deciding between the data cap plan and the sponsored data plan. When the video content is unattractive the network can choose K_1 to maximize its profits.

Profits of the network when the video content is attractive:

$$(\alpha B)^{\alpha}((1-\alpha)B)^{1-\alpha} + r(\alpha B - \alpha K_0) - C(B) \tag{13}$$

$$s.t.\ \ \alpha \geq 1 - \frac{K_1}{B}$$

When video content is unattractive the network maximizes profits by:

$$\max K_1 : (B - K_1)^{\alpha} {K_1}^{1-\alpha} + r(B - K_1 - \alpha K_0) - C(B) \tag{14}$$

$$s.t.\ \ \alpha < 1 - \frac{K_1}{B}$$

Sponsored Data Plan with Attractive Video Content

If the network sets $K_1 \geq (1-\alpha)B$, v-type content is attractive, and profits of the network come from equation (13). At this level of K_1, profits of the network are exogenous as K_1 does not affect anything in the function. With K_1 over the threshold point, the end users are not bound by the data allowance, as their consumption of the o-type content is $(1-\alpha)B$ with total data budget of B. When K_1 is set to a level where video content becomes attractive the end users are not bound in their consumption by anything else than the maximum consumption point B. Sponsored data plan with attractive video content essentially becomes an unlimited data plan, but the network can extract payments from the v-type content providers.

Sponsored data plan with attractive video content will increase social surplus if $K_0 < B$. Gross consumer surplus is increased since data consumption increases from K_0 to B and consumption mix between v-type content and o-type content does not change between the plans. Video content providers' gross surplus is increased from $r\alpha K_0$ to $r\alpha B$ but the difference is extracted by the network by fee F_a. Profits of the o-type content providers are increased, end users' data consumption in their content is increased from $(1-\alpha)K_0$ to $(1-\alpha)B$ and the network cannot extract any payments from them.

If the network would offer sponsored data plan with attractive video content no party would lose any surplus and some parties would gain some surplus. However, section V will show that the network can always get higher profits by setting K_1 under the threshold point, meaning that sponsored data plans with unattractive video content are always more profitable to the network than sponsored data plans with attractive video content. As the network can freely choose the level of K_1, it will never offer sponsored data plans with attractive video content. For this reason, rest of the thesis focuses on the unattractive option.

Sponsored Data Plan with Unattractive Video Content

The network maximizes its profits with equation (14). The problem of the network is that K_1 influences both price $P = (B - K_1)^{\alpha} K_1^{1-\alpha}$ and fee $F_u = r(B - K_1 - \alpha K_0)$. When the network reduces the data allowance K_1 it increases profits from the video content providers, as their share of total data consumption increases. Reducing the data allowance decreases the end users' utility as they are driven further from their optimal consumption mix, which reduces the price that the network can collect from the end users.

Costs of the network are fixed as the total data consumption is set to B. The network's dilemma is to find a level of K_1 which balances between P and F_u and maximizes its profits.

First order condition for the profit function (14) w.r.t. K_1 is:

$$-\alpha \frac{K_1}{B- K_1}^{1-\alpha} + (1-\alpha) \frac{K_1}{B- K_1}^{-\alpha} - r = 0 \tag{15}$$

Equation (15) cannot be explicitly solved for a profit-maximizing level of K_1. Numerical solutions for the profit-maximizing level of K_1 with different parameter values can be easily calculated with any optimization tool. Even though K_1 cannot be derived from equation (15) to explicit function form, equation (15) can be used to gather important information about nature of sponsored data plans. Taking total derivative from equation (15) makes it possible to see how K_1 behaves when different parameters are changed.

Calculating partial derivatives of K_1, B and r from equation (15) yields:

$$F_K = \frac{B}{(K_1 - B)^2} \left(\frac{K_1}{B- K_1}^{a} + \frac{K_1}{B- K_1}^{-a-1} \right) \tag{16}$$

$$F_B = \frac{K_1}{(B- K_1)^2} \left(\frac{K_1}{B- K_1}^{a} + \frac{K_1}{B- K_1}^{-a-1} \right) \tag{17}$$

$$F_r = -1 \tag{18}$$

Where F_K is the partial derivative of (15) with respect to K_1, F_B the partial derivative of (15) with respect to B and F_r the partial derivative of (15) with respect to r.

Proposition:

For the ISP to maximize its profits any changes in B must be met with identical relative changes in K_1 and any changes in r require K_1 to change in opposite direction.

Proof:

The rate of change between K_1 and B:

$$\frac{-F_B}{F_K} = -\frac{K_1}{B} \tag{19}$$

And the rate of change between K_1 and r

$$\frac{-F_r}{F_K} > 0 \tag{20}$$

Exact calculations for equations (19) and (20) can be found from Appendixes 1 and 2.

Effect of the Maximum Consumption Point on the Data Allowance

With data cap plans, maximum consumption point does not affect data consumption of the end users or any decisions of the network as long as $K_0 < B$. For an unlimited data plan, the network's revenues and costs are determined by the level of the maximum consumption point.

Sponsored data plans with unattractive video content level of B affects the network's choice for level of K_1. Equation (19) shows the rate of change between B and K_1 and shows that maximum profits are reached by parallel changes to K_1 for different levels of B. Larger level of the maximum consumption point will increase the profits of the network, but the network maximizes its profits by matching changes in B with similar changes in K_1. For example, assume that the network optimizes its profits and sets K_1 at some initial parameter values. Doing the optimization again with 20% higher value of B will lead to a new profit-maximizing value of K_1, which is 20% higher than the initial value of K_1. Not changing K_1 with 20% higher K_1 will increase profits of the network but increasing it by 20% will increase the profits even more.

Effect of the Revenue Multiplier on the Data Allowance

Level of the revenue multiplier r naturally affects revenues of the content providers. Level of r also affects v-type content providers' willingness to pay for zero rating. Higher levels of r are associated with a larger difference in revenue between the sponsored data plans and the data cap plans. The absolute difference between revenues between sponsored data plan with unattractive video content and data cap plans is dependent on the level of r. Larger levels of r also lead to higher willingness to pay for zero rating by the v-type content providers, as can be seen from equation (12).

The equation (20) shows that there is an inverse relationship between r and K_1. Higher the revenue multiplier is, lower the network will set the data allowance. This can be best understood through the two revenue streams of the network: P and F_u. Decreasing K_1 reduces the end users' willingness to pay for the data plan but increases the amount of data that the end users use to v-type content providers, increasing their willingness to pay for zero-rating. The network sets K_1 to a point, with given parameter values, where increasing it any further would increase P less than it would decrease F_u and vice-versa for decreasing K_1. With higher values of r, this point comes later if we imagine K_1 to gradually reduced until reaching this point. When the revenue multiplier is low, the network places more focus on the revenue from the end user side and is more focused on their utility. With high revenue multiplier, a larger share of the network's potential revenue comes from v-type content providers' side and lower values of K_1 are set to take this into account.

The rate of change between K_1 and r allows for further analysis of differences between sponsored data and data cap plans, namely size of data allowance in two contract types. Only the case of unattractive video content is considered since the network will always choose a sponsored data plan with unattractive video content over a sponsored data plan with attractive video content.

Consider a situation where r is set to a low-value ε, which is near 0. I additionally assume that $r = \varepsilon$ is enough to incentivize the network to offer a sponsored data plan instead of a data cap plan. With $r = \varepsilon$, F_u is close to zero and the network will set K_1 close to maximizing the utility of the end users. Consumption of v and o are close to αB and $(1-\alpha)B$. Total data consumption is increased if $B > K_0$. When r starts increasing K_1

decreases and moves further away from $(1-\alpha)B$. The consumption of o decreases while v increases. When r is high enough, the network sets $K_1=(1-\alpha)K_0$, making consumption of o-type content identical between the plans. This level of r offers increased consumer surplus as consumption of o is identical between the plans but consumption of v is larger with the sponsored data plan. When r increases even further and K_1 shrinks the sponsored data plan leads to lower consumption levels of o, but the utility from increased consumption of v still eclipses the utility losses from lower consumption of o. With high enough r, K_1 will be set low enough that consumer surplus from the sponsored data plan will be lower than with the data cap plan as the increased consumption of v can no longer offset the reduced utility from consumption of o.

Depending on the levels of r and B, it is possible to determine three different points in the consumer surplus

1. v, o and the gross consumer surplus are larger with the sponsored data plan than with the data cap plan.
2. v is larger and o is lower with the sponsored data plan. Benefits from the large v offset losses from the lower o, and the gross consumer surplus is larger.
3. v is larger, and o is lower with the sponsored data plan. Benefits from the increased v do not offset the utility losses from the lower o and the gross consumer surplus are smaller with the sponsored data plan.

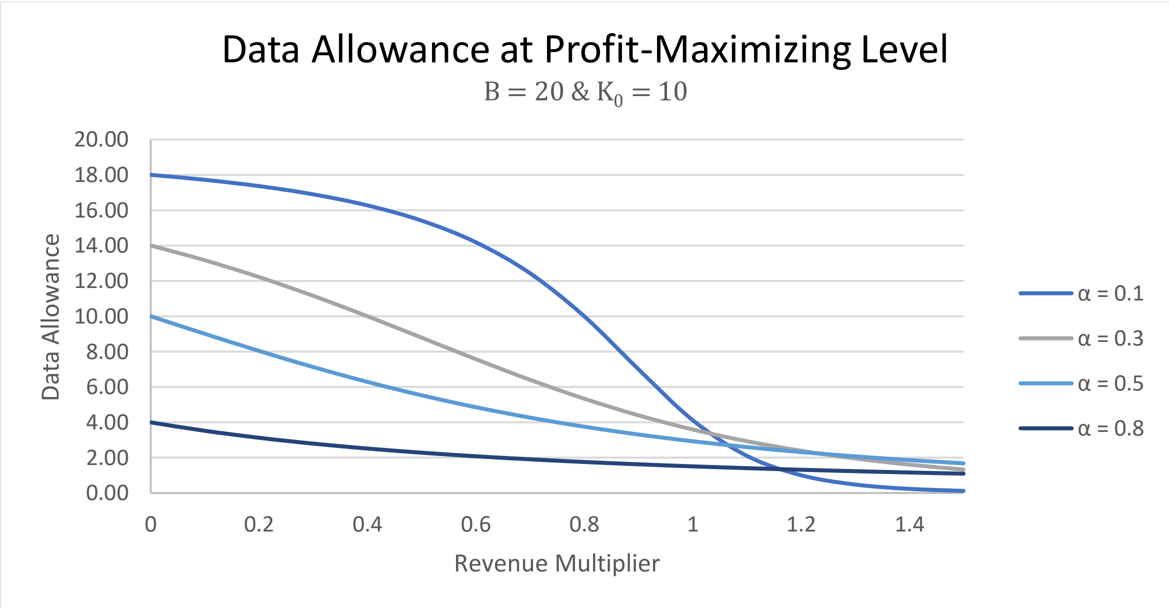
Section V: Numerical Solutions

A drawback of the Sponsored Data model presented in Section IV is that it's impossible to find an explicit formula for the profit-maximizing K_1. Numerical solutions can, however, be found as the profit function of the network has a clear maximum point for all combinations of parameter values. These profit-maximizing values of K_1 can be easily found with any common optimization tool. This section presents some numerical results for the model and discusses their implications. These results work in conjunction with rates of change for B and r, presented in equations (19) and (20). Graphs in this section show how larger values of r will lead the ISP to set a lower level of K_1 and increases in B will be met with identical and parallel changes in K_1. This section adds to the previous section, showing how increased end user preference over video content α, reduces the optimal level of K_1. Finally, section V presents numerical results which suggest that the network will never set K_1 in such way that it crosses the threshold point $\bar{\alpha} \equiv 1 - \frac{K_1}{B}$, as it will always gain higher profits by setting K_1 to such value that zero-rated content is categorized as unattractive and not attractive content.

Effect of the Revenue Multiplier on the Data Allowance

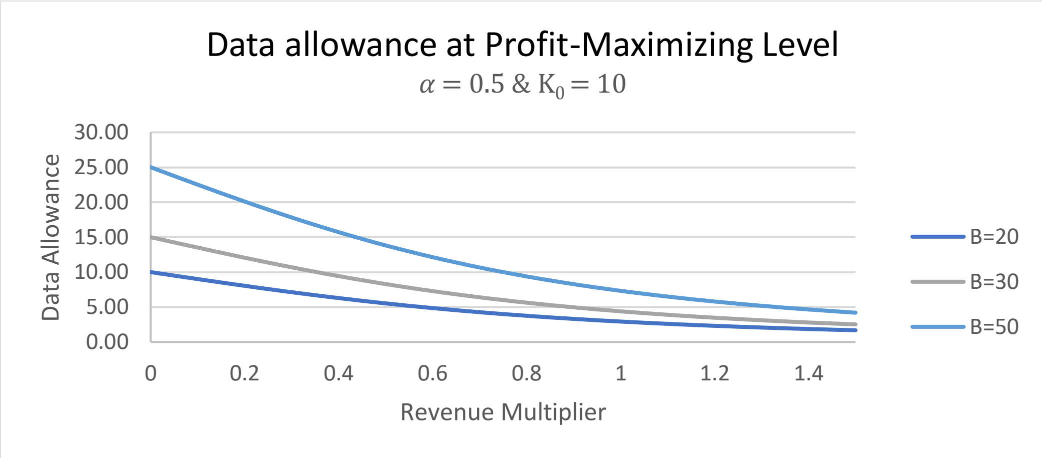
By looking at *Graphs 3 and 4*, it can be clearly seen that r reduces the optimal value of K_1. Regardless of the parameter values, increased revenue of the video content providers will lead to the network setting a lower value of K_1. This effect happens in a similar fashion across different levels of α and B, with K_1 decreasing gradually as r increases. A notable difference to the general trend happens when $\alpha = 0.1$. With this low level of α, the optimal level of K_1 at first decreases at a relatively slow speed but starts decreasing rapidly as r increases. This can be most likely attributed to the fact that with $\alpha = 0.1$, end users prefer the o-type content heavily and any reduction to K_1 in sponsored data setting will lead to them losing much surplus and trough that the network losing profits from the end user side. With small r, the gains that the network gets from v-type content providers by reducing K_1 are not enough to offset the losses from end user payments if K_1 is reduced too much. When r starts to increase, the situation changes. Since v-type content is not preferred by the end users, gains in data consumption that the v-type content providers will get when they are zero-rated are large. When K_1 is reduced to a lower level, the end users will distribute a large share of their maximum consumption to v-type content, as they have no other options, outside of using the small amount of data marked by K_1 to o content. When this large increase in the demand faced by v-type content providers is coupled with larger levels of r, the network will start to gain larger and larger profits from the content provider side of the market. These gains start to offset the losses from the end user side to even smaller and smaller levels of K_1, meaning that K_1 will decline rapidly and will end up to extremely small value with large enough values of r.

The situation can be easily compared to the series in *Graph 3* where $\alpha = 0.8$. With this high value of α, video content is very preferred by the end users and the network is incentivized to set K_1 at a low level even with small levels of r. The end users would not use much of their data to consume o content anyway. The reason for the network to set K_1 at initially small levels and reducing it slowly are due to the fact that while v-type content providers will face large demand when zero-rated as K_1 is set so low, they have the option to refuse from zero-rating. By turning down the offer they will face lower consumption in total, but it will gain a large share of the reduced consumption, without the network being able to extract any payments from it. By setting K_1 lower than threshold point the ISP will lose profit from the end user side and only gain a small amount of profit from CP side. When r increases it will be more profitable to reduce K_1 a bit but the effect is gradual and not as large as we saw with a situation $\alpha = 0.1$.



Graph 3

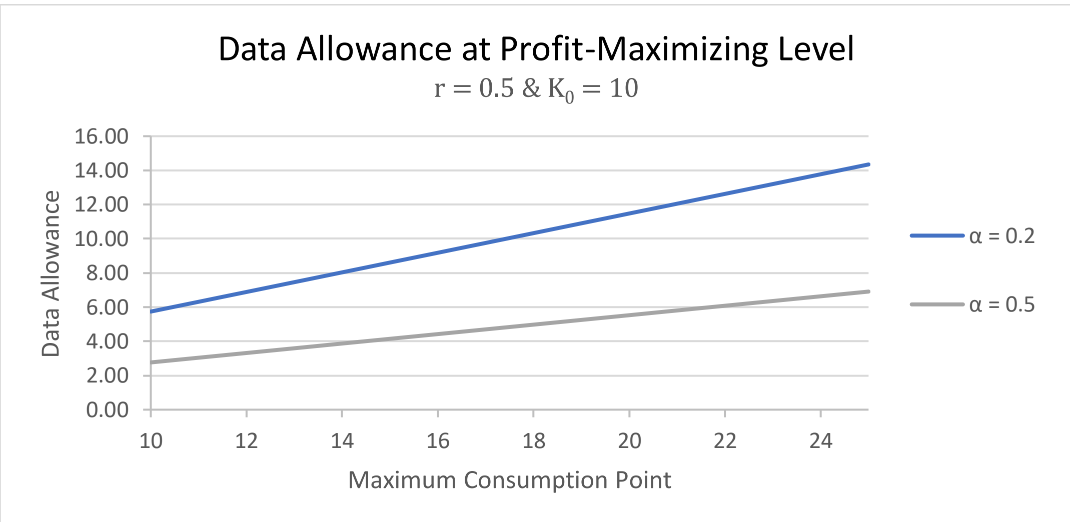
Graph 4 shows that B affects the optimal level of K_1, with r nearing 0 the optimal level of K_1 is set near to the threshold point. Increases in r all gradually reduce optimal level of K_1.



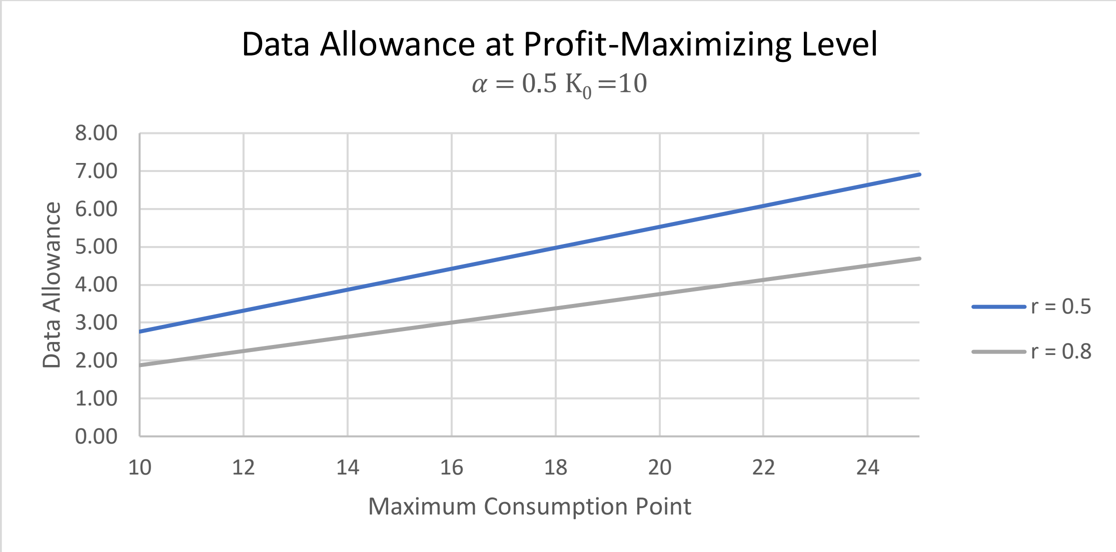
Graph 4

Effect of the Maximum Consumption Point on the Data Allowance

Graphs 5 and 6 show that optimal level of K_1 increases in parallel with B. Any change in B will be met with an identical change in K_1, regardless of levels of α or r. For example, *Graph 5* shows that with $\alpha = 0.2$, the network will maximize its profits by setting $K_1 = 5.74$ when $B = 10$ and $K_1 = 14.35$ when $B = 25$. With B 2.5 times larger profit-maximizing level of K_1will also be set at 2.5 larger level.



Graph 5

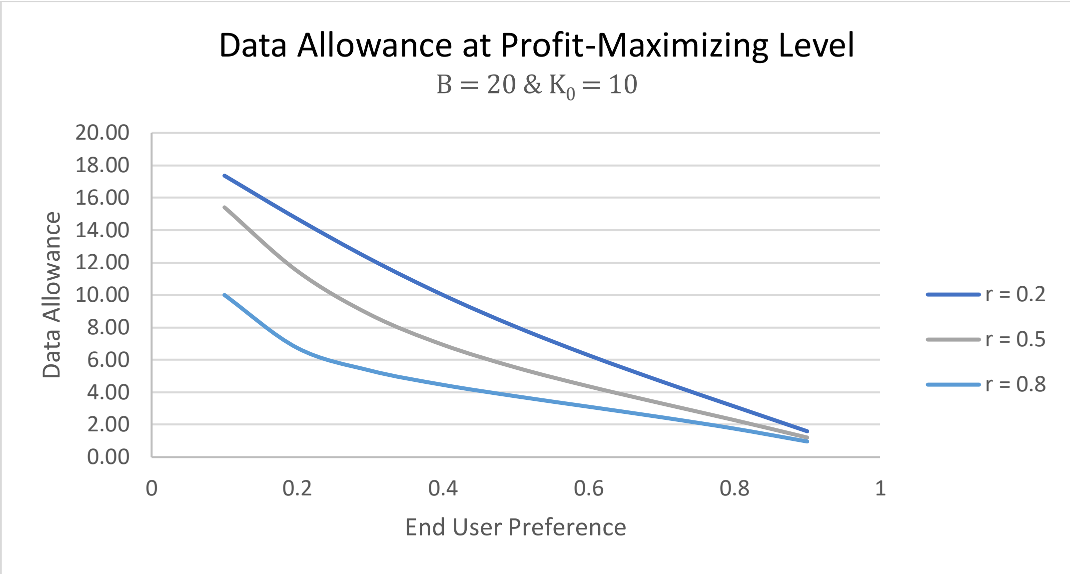


Graph 6

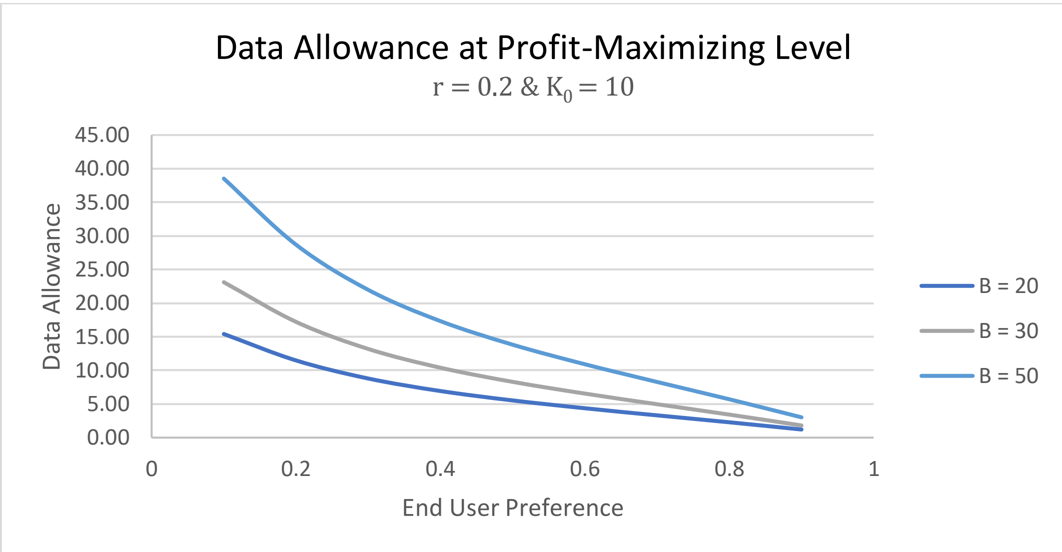
Effect of End User Preferences on the Data Allowance

Section IV does not include mathematical formulation on effects of the end user preference of video content, α, to K_1, but it stands to reason that larger values of α will tend to decrease the optimal level of K_1. As discussed earlier in this section, this is mainly due to end user preferences. Larger levels of α mean that end users prefer to consume v content, thus high levels of K_1 are not required. The network will always set K_1 lower than the threshold point, which means that higher α leads to lower K_1. With high α the consumers prefer to consume v content, decreasing K_1 thus reducing their consumption possibilities of o and increasing the amount that they consume v does not hurt their utility as much as with low levels of α. While high α reduces the ability of the ISP to extract payments from the CPs.

From *Graphs 7 & 8* it can be clearly seen that while increases in r lead to lower levels of K_1 and increases in B to higher levels of K_1, increasing α rapidly reduces the optimal size of K_1.



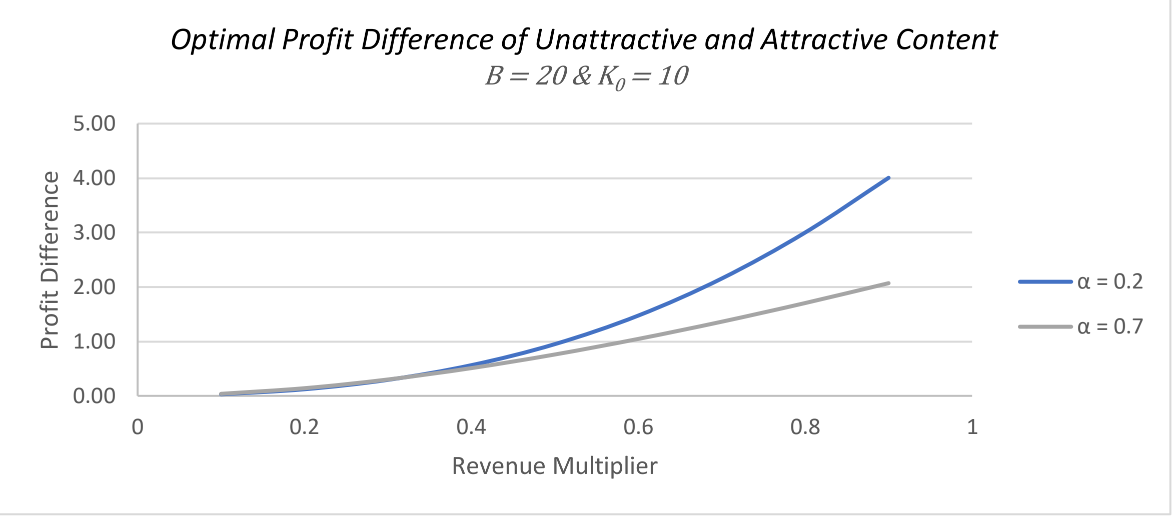
Graph 7



Graph 8

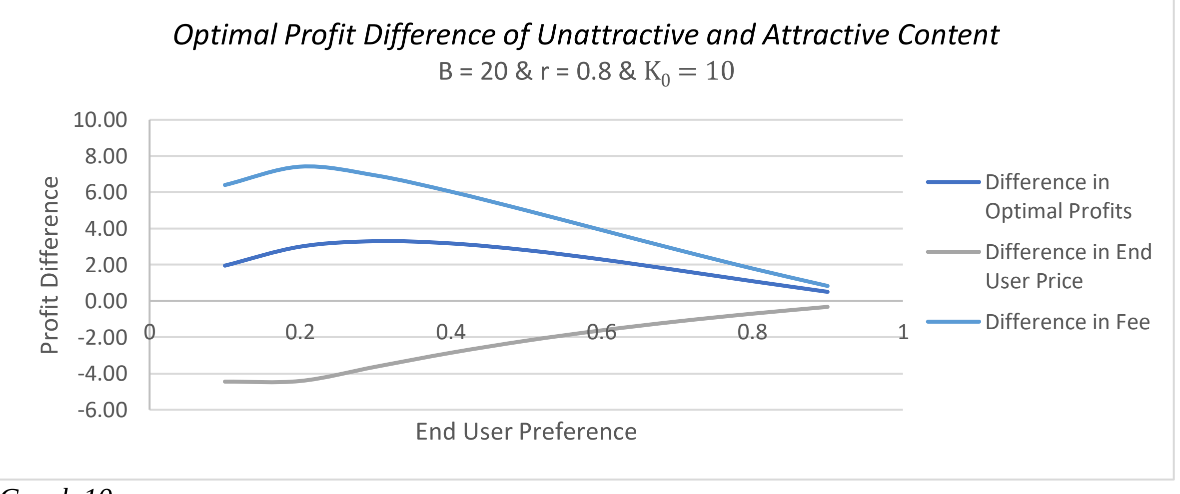
Profits with Attractive and Unattractive Content

The profit function of the network is defined differently for over and below the threshold point. Profits of the network are determined by equation (13) when the network sets K_1 to equal over exceed the threshold point. When K_1 is under the threshold point the profits are determined by equation (14). If the network sets K_1 over the threshold point it effectively relinquishes control over the prices in the network. It can no longer alter K_1 to influence its profits. The network has two options. Either to set K_1 to profit-maximizing value under the threshold point or set it at the threshold point. *Graphs 9 and 10* suggest that the network will always earn higher profits when K_1 is under the threshold point. While this notion is not mathematically proven in this thesis, numerical results strongly suggest this.



Graph 9

Graph 9 shows that the network always profits more from setting the video content to be unattractive. For low values of the revenue multiplier, r, the difference in profits of the options is negligible. This can be understood in conjunction with *Graph 3*. When r is small, K_1 is set near to the threshold point, naturally leading to small differences between the profit functions. As r increases optimal K_1 for unattractive content decreases and the difference in profits starts to increase. From *Graph 9* additionally shows that gap in profits for different levels of α is almost non-existent when r is small, for larger values of r, smaller values of α start yielding larger profit differences between options.



Graph 10

Graph 10 shows the evolution of the total profit difference between unattractive video content and attractive video content and its different components, profits from the end users and profits from the v-type content providers, across different values of α. The profit difference between the options is always positive. The network is always able to extract more profits from the video content providers when their content is unattractive, even though the difference between the options diminishes as α approaches 1. Contrary to the total profits and profits from video content providers, revenue from the end users is higher for the network when the video content is attractive. While the network gains larger revenues from end users by setting v-type content to be attractive, the effect of larger profits from content provider side with unattractive video content always dominates the first effect and the network is always better off with unattractive video content.

The graphs clearly show that there always exists a value of K_1 under the threshold point which leads to higher profits for the ISP than setting $K_1 \geq B - \alpha B$. Further analysis can thus be focused on situations where the network sets the data allowance under the threshold point.

Section VI: Welfare Effects of Sponsored Data

There are four parties which are influenced by zero-rating. The network, the end users, video content providers and other content providers. This section discusses welfare effects of sponsored data to these parties, compared to data cap plans, when the network sets K_1 under the threshold point. Technically the end users and video content providers are always indifferent between sponsored data plans and data cap plans since the network exercises its monopoly power and reduces their benefits from it to zero. The network's revenue streams are however discussed separately, to allow for better understanding of situations where the network cannot extract all surplus.

For the network, the surplus analysis is trivial. The network chooses whether to offer sponsored data plans or data cap plans. If sponsored data plans do not lead to higher profits for the network, it will not offer those. The network's revenue from the video content providers is always larger with sponsored data, as it does not exist with data cap plans.

The network's revenue from the end users is largely dependent on the parameter values and can be lower or higher with sponsored data. The first effect of the sponsored data is that the end users are forced to a new worse consumption mix, where they are forced to consume less other content than they would like. This reduction in utility is balanced by increased total consumption as their total data consumption is increased from K_0 to B. Data allowance K_1 sets a limit for consumption of o, limiting the end users' utility from its consumption. Depending on the level of r and B reduction of o can be offset by increased consumption of v, but as r increases the ever-smaller data allowance leads to more utility losses than gain from larger consumption of v, reducing end users' willingness to pay.

The surplus of o-type content providers depends on the total data consumption that they face, K_1. If the jump in total data consumption is high enough, the network is incentivized to set K_1 at a relatively high level, possibly increasing other content providers profits. When $K_1 > (1-\alpha)K_0$ o-type content providers are better off than before. If the network sets K_1 at a lower level, their surplus is reduced. When K_1 is set to a low level, the end users were at least partially compensated with increased consumption of video content, but there isn't any such mechanism for the o-type content providers, which are undoubtedly worse off than before when $K_1 < (1-\alpha)K_0$.

Social surplus is measured by:

$$\Delta SS = \Delta P + \Delta F_u + \Delta oS - \mathrm{C(B)} - \mathrm{C}(K_0) \tag{21}$$

Where:

ΔSS = Change of social surplus between plans

ΔP = Change of end user price between plans

ΔF_u = Change video content provider fees between plans

ΔoS = Change of other content producer surplus between plans

$\mathrm{C(B)} - \mathrm{C}(K_0)$ = Change in costs of the network between plans

$\Delta P + \Delta F_u - \mathrm{C(B)} - \mathrm{C}(K_0) > 0$ is the individual rationality constraint of the network. $\Delta P + \Delta F_u$ is the change in revenue for the ISP while $\mathrm{C(B)} - \mathrm{C}(K_0)$ shows a change in costs when changing from data cap plan to sponsored data. Change in social surplus is ambiguous between the two plan types and depends whether increased profits of the network are higher than potential losses for other content providers. When the network maximizes its profits by setting K_1 to a high enough level, o-type content providers are better off than with data cap plans and social surplus is increased with sponsored data plans. With lower levels of K_1, additional profits of the network might not be enough to cover losses of the o-type content providers, leaving society worse off than before.

Section VII: Discussion

This section discusses limitations of models presented in the thesis, suggests reasons why ISPs zero-rate content without collecting payments from the content providers and suggests some possibilities for future research.

Limitations of the Study

A mathematical framework for zero-rating presented in this thesis is best suited for data-intensive content. While it is my firm belief that in the future zero-rating will be focused mainly on data-intensive content, at least in developed countries, this limits the scope of the study. This section will, however, present an alternative framework, which can be used to understand ISPs decisions to zero-rate data-light contents in their sponsored data plans. Another major limitation of the framework is that it requires an assumption that there are only two content provider types, where one can never be zero-rated.

Maximum Consumption Points

Much of this thesis rests on assumption that there is a common maximum consumption point for all Internet content. An end user will always reach this maximum consumption point when consumption of even one content type is not restricted by the data allowance. This assumption limits use of the framework to more data-intensive content. It is not realistic to assume that an individual would reach similar amounts of data consumption with a plan that zero-rates some data-light content like instant text messaging as the individual would reach with an unlimited data plan, assuming that the individual prefers to use even some data-intensive content. The framework still works well for data-intensive uses of the Internet.

Assuming that the end user has individual maximum consumption points for all different content types on the Internet, where maximum consumption points for data-intensive content are higher than those of data-light content, results of zero-rating are essentially same for pooled maximum consumption point and individual maximum consumption points. If the pooled maximum consumption point is thought as an aggregate of all the individual maximum consumption points and it is assumed that the video content's maximum consumption point will be extremely large the analysis does not change. By zero-rating video content, consumption of video content will be at its individual consumption point. Consumption of other content will not be at its maximum consumption point, but the data allowance allows for some consumption of this content. Now if the zero-rated plan would be changed to unlimited plan consumption of video content would not increase, but consumption of other content would increase from the amount set by data allowance to its maximum consumption point. When the video content plays a major factor in total data consumption, this change from zero-rating video content to allowing unlimited consumption of all content will only increase total data content by a small amount. With a small enough increase in total consumption from this, it can be argued that individual maximum consumption point of video content does not differ meaningfully from a maximum consumption point for all content.

The fact that the framework is best suited for data-intensive content allows further speculation. For the pooled maximum consumption point to be realistic option large share of data consumption of end users would need to come from watching video content, given unlimited consumption options. This suggests that when zero-rating video content or similar data-intensive contents when all of the other content is relatively data light, α will be large. As seen from *Graph 10,* with high levels of α the network's profits are not much higher with unattractive content than with attractive content, suggesting that data allowances in these options are fairly similar. With sponsored data and attractive content, total surplus is always higher than with data cap plans since no party will be left worse off. The network is always better off if they decide to offer sponsored data. The end users are not constrained in their consumption mix and can consume more data. Other content providers are also always better off with attractive content since end users will consume more of their data than before. With this information, it can be speculated that when video content is heavily preferred by the end users, the ISP will not set the data allowance to very low levels, compared to the threshold point. This suggests that there is a chance that social surplus might be increased with this kind of sponsored data plans.

Discarding pooled maximum consumption point assumption affects the analysis considerably. Under the pooled consumption point assumption costs of the ISP are set exogenously as consumption jumps to B. Allowing v and o to have individual maximum consumption points B_v and B_o, the cost function stops being a non-factor in the analysis as it is now determined endogenously by the ISP. Costs are determined now by the cost function $C(B_v + K_1)$. ISPs profits from v-type content providers are now exogenous as data consumption that the v-type content providers will face will be B_v and data consumption without zero-rating will still be set to αK_0. Revenue from v side will now be $r(B_v - \alpha K_0)$. Now the ISPs profit maximization dilemma is a simple problem of finding the point where marginal revenue from the end users by increasing K_1 equals marginal costs of increasing K_1. The ISP can treat costs and revenues arising from consumption of video content as fixed.

Content Providers

Limiting the amount of different content provider types to two does not limit the analysis considerably. Adding more content provider types to the model would complicate the mathematics behind the analysis considerably without adding important additional information. Lumping all content providers outside of the content providers that get zero-rated does not reduce information gained from the model. The o-type content providers do not actively influence any decisions, so nothing is lost when lumping them together.

The assumption that o-type content providers can never be zero-rated limits the analysis somewhat. There is no technical limitation to not allow unlimited consumption of any kind of content on the Internet. Allowing the two content provider types to compete over being able to be zero-rated would complicate the analysis as it introduces a game theoretical situation where either none of them gets zero-rated, only one does or both do. When neither of them gets zero-rated the ISP just offers a data cap plan and with both types being zero-rated ISP just offers unlimited plans to end users. Only the situation where the ISP exclusively zero-rates one CP type is a “true” zero-rating. While analysis could then be focused on exclusive zero rating this will change payoffs of the ISP from the CP side further complicating the calculations as now the CP, which gets exclusive zero-rated, is no longer willing to pay all profits stemming from the zero-rating to the ISP but the maximum amount that the losing CP type would have been willing to pay for the zero-rating. The only situation where o-type content can be assumed never to be zero-rated is a situation where their maximum willingness to pay for it would never cover increased costs of the ISP. In this situation, the ISP never considers o-type for zero-rating and it does not affect v-type’s willingness to pay.

Limiting the analysis is also the assumption that the video content providers do not possess any market power and do no actively compete with each other. All video content providers act as one and receive an equal share of end users' consumption towards their category. Assuming multiple CPs in one content category would complicate the analysis again. The situation would be similar to CP types competing over zero-rating, leading to similar game-theoretical considerations. For more information on how two perfect substitutes competing over zero-rating affect ISPs revenue from CP side see Somogyi (2017).

Why do ISPs Zero-Rate Content for Free?

Results from the "no transfer model" are interesting. When the price that the ISP can charge from CPs in exchange for zero-rating their content is constrained to zero, the ISP should never be inclined to offer zero-rated plans instead of data-allowance plans. This conclusion is in stark contrast to reality. Section II described some common zero-rating practices in use both in the United States and Europe. Especially European ISPs commonly zero-rate content without requiring payments from the CPs, which seems contradictory to findings in Section III. The fact that zero-rating without payments from content providers is so common suggests that zero rating offers some other forms of monetary gains to the ISPs, outside of the model considered in Section II.

Marketing

One possible reason for ISPs zero-rating content without any direct payments is marketing. An ISP zero-rating some popular content on the Internet can use this offer in their marketing efforts and be more attractive to consumers than its competitors. The hypothesis is supported by the fact that the commonly zero-rated contents in Europe seem to be content that is popular among Internet users, such as Skype, YouTube or Spotify. It can be safely assumed that zero-rating popular content is more likely to increase consumer demand for mobile Internet plans of the ISP rather than zero-rating less popular content that is only used by part of the consumers in the market. In addition to identifying popular services that are often zero-rated in Europe, Aetha, Oswell & Vahida and DotEcon Ltd. (2017) find that European ISPs commonly either zero-rate a single content provider or a bundle of similar content providers. Both allow the ISP to promote the zero-rating as an edge against the competitors.

Zero-rating a single service makes the ISP more attractive for current users of the aforementioned service since now they can use it to their heart's content. Bundling similar services together employs a similar tactic. For example, offering a collection of video-streaming services to be zero-rated for their customers the ISP is instantly more attractive for all people who prefer to stream videos on their mobile devices. By offering a bundle they capture a larger segment of the market than just by offering just one service, albeit with a higher cost of increased data consumption. This, however, captures all consumers who prefer just one service in the bundle and makes the offer increasingly attractive to consumers who regularly use multiple video streaming platforms. By focusing on a bundle of similar content the ISP can better focus its marketing efforts than just offering a random assortment of popular services on the Internet, regardless of the category. It can be assumed that sending a message of being "the ISP of choice" for consumers who like to stream videos is a better marketing strategy than offering a bundle of services from different categories.

Customer Retention and Price Competition

Zero-rating content without direct payments from content providers can be useful for the ISPs even outside of marketing purposes. In addition to attracting new customers interested in the content that the ISP zero-rates there is a possibility to increase customer retention and reduce price competition between ISPs via zero-rated plans. European ISPs are generally competitive in their pricing practices, especially since mobile data plans can be seen as close substitutes to each other as the only variables in the Internet connection are often prices and the data allowances. The ISPs often try to reduce this price competition by various means such as locking their customers by offering fixed-period plans in exchange for some benefit to the customers. One such example could be an ISP selling a packet of a brand-new phone and mobile data connection to that phone for a relatively cheap monthly combined price but require the customer not to switch ISPs for next two years. In addition to "locking in" their customers, the ISPs offer various side-benefits to their customers, such as Finnish ISP Telia, which offers free Spotify Premium subscription to all its customers. (Telia.fi). Offering a service which normally costs something to consumers naturally works as a promotional tool but offers an advantage in reducing price competition between the ISPs. By offering free Spotify Premium to its customers Telia makes sure that even if its competitors undercut its prices the customers are less likely to switch since they would lose their benefits from the free Spotify premium. Generally, the ISPs data plan offers are complicated and include multiple different deals bundled in one, in addition to just the normal Internet connection, which makes comparing prices between competitors harder, reducing the price competition between the ISPs. Zero-rating can work in similar fashion. Zero-rating certain content on the Internet, while competing ISPs zero-rate different content the ISPs effectively fragment the market and lessen price competition. Now to capture customers from another carrier the ISP must either zero-rate same contents that the other carrier zero-rates or reduce the price of mobile data plans enough to offset utility losses from losing zero-rating in your preferred content on the Internet due to switching to new ISP.

Zero-Rating and Vertical Integration

Vertical integration of content providers and ISPs can explain some part of the prominence of the "no transfer" zero-rated plans. Choi & Kim (2010) argued that vertical integration with sponsored data does not cause any antitrust concerns and that the ISPs would not favour their own content providers over non-affiliated content providers with higher margins in discriminatory regimes. This notion might hold when the ISPs are not able to extract payments from content providers. Zero-rating content from non-affiliated content providers gains the indirect benefits discussed before but it cannot extract direct payments from the CP. When the ISP zero-rates content providers that it owns it gains all of the benefits of zero-rating non-affiliated content provider and the benefits that the content provider gains from zero-rating. This makes zero-rating enticing prospect for vertically integrated ISPs.

In the United States AT&T and Verizon zero-rate their own video streaming platforms and while the platforms are technically open for third parties, for payment, they mostly zero-rate only their own video streaming services. While the option for third-party CP to pay for zero-rating does not fit exactly in the context, there is a point to be made that the situation resembles a situation where no transfers can happen if either the payments required by AT&T and Verizon are high enough for third-party CPs to find not profitable to join. (AT&T and Verizon haven't disclosed prices for zero-rating.)

When the ISPs are incentivized to zero-rate their own content over non-affiliated content, antitrust problems might be present. Vertically integrated ISPs commonly zero-rate their own video streaming services, which are exceedingly data intensive and can eat a large fraction of one's data allowance in short timeframe. While zero-rating ISPs own CPs can be potentially very lucrative for the ISP, the practice distorts competition between video-streaming platforms on the Internet. Consumers faced with the choice of choosing to view video content between ISPs own zero-rated video streaming platform and their preferred platform, from which they can only stream a limited amount of video face a tough choice. Especially in situations where data allowances are relatively small this kind of practice has a chance of hampering innovation as third-party CPs cannot compete against the ISPs own platform due to the zero-rating.

Zero-Rating as an Insurance

There is an argument to be made that limited knowledge of the end users could be a reason why zero-rating practices exist even when there is no direct monetary gain for the ISPs from CP side of the market. It can be relatively easily assumed that the end users have imperfect information on how much of their monthly data allowance is left and how data-intensive different contents are. A normal end user might have a general idea on the data costs, knowing that video-streaming costs more data per minute than instant messaging, but it's unreasonable to expect that they would have very accurate information on this. Then the argument can be made that zero-rating can work as an insurance. When an end user goes over his/her monthly data allowance ISPs often either set overcharge fees or start throttling the connection. Overcharge fees can be surprisingly large and the effect of your Internet connection slowing to a crawl can be infuriating. It makes sense that end users generally try to avoid going over their monthly data allowances.

If individual maximum consumption points are assumed instead of a pooled maximum consumption point, then zero-rating the data-intensive content can work as an insurance for the end users. With a data cap plan, the end users need to worry that consuming data-intensive content puts them over their monthly data caps. The end users or the ISP cannot solve this problem by increasing the data allowance. Larger data allowance leads to increased consumption across all content types. The end users would consume more but the underlying problem would not be solved. They would still fear going over their data allowances with data-intensive content. One solution for this is zero-rating the data-intensive content. The end users would no longer need to fear that the content which is most likely to put them over their data allowances would cause that since it is zero-rated. This action can be relatively cheap or very costly for the ISPs, depending on types of the end users. An end user who does not stream a lot of videos would probably not stream many videos even when their consumption is not limited. The end user would not increase his/her total consumption considerably, causing limited cost increases for the ISP, but would reap full benefits of the insurance effect. End users preferring to consume video content would likely to increase this consumption sizably if the consumption would be free. For these end users, the insurance aspect of zero-rating is less important than the utility gained from increased consumption. Section II suggest that the ISP would not do better by zero-rating content for end users like these, as it could always achieve better results by simply increasing the data allowance.

The problem for the ISP is that by zero-rating the data-intensive content they are offering their customers insurance and a real benefit but at same increasing their costs a lot if enough of their customers increase their data consumption dramatically in response to the zero-rating. Since the ISPs are not easily able to discriminate between the customer types in this situation, some ISPs have already found an alternative solution to their dilemma. Both T-Mobile and Deutsche Telekom zero-rate a large bundle of content for their customers, but with a catch. Their customers can enjoy a large amount of content without any fears of ever going over their data allowance, but the quality of their video streaming is constrained. T-Mobile constrains streaming quality to 480p (T-Mobile.com) and Deutsche Telekom reduces the video quality to SD (480p). Germany’s Federal Network Agency has however taken issue with Deutsche Telekom’s practice. Agency had no issue with zero-rating in general but prohibited quality reduction practiced by Deutsche Telekom. (Krieger, 2017)

The practice of combining zero-rating and quality degradation of video streaming can work to alleviate the problems of higher data consumption while preserving the insurance part of zero-rating. While the ISP allows its customers unlimited consumption of certain content, lower quality streaming reduces the data consumed per video, limiting the costs of the ISP. Nature of zero-rating means that the consumers do not need to worry about going over their limits when consuming zero-rated content.

Zero-rating as insurance cannot credibly explain all zero-rating plans in the market. While insurance provided by zero-rating works well in the context of zero-rating data-intensive content, the benefits are considerably smaller when the ISPs zero-rate content that does not consume much data, such as Facebook. If the end users are aware that just browsing Facebook or using Facebook messenger does not use much data, they are not particularly afraid that using these services will take them over their data allowances, making offering an insurance for Facebook only marginally beneficial for the end users. It's more likely that these instances where the ISPs zero-rate data-light content are based on alternative explanations rather than the insurance argument.

Suggestions for Future Research

A potential avenue for new research would be to expand the model from monopoly setting to a more competitive scheme. As mobile internet market is competitive both in the USA and Europe, further research studying duopoly models would be beneficial. Introducing a competitive environment for ISPs can definitely alter the results of the analysis. The current framework can be used to model duopoly competition, but the analysis is more complicated. In monopoly setting the ISP only functions in one dimension, the ISP sets data allowance K_1 which determines prices for end user sides and CP sides. In a duopoly setting, the price is no longer tied completely to K_1, as the ISPs can set the prices under the monopoly prices charged under the current framework.

Nature of the Internet suggests that duopoly is best modelled by bottleneck competition as is done by Jullien & Sand-Zantman (2018). The end users are single-homing, only subscribing to one of the networks, while CPs are multi-homing, subscribing to both of the networks. The model presented in this thesis behaves, as one would expect, similarly to other two-sided market models with bottleneck competition. Both ISPs will charge monopoly payments from the CPs. Industry profit from the CPs will remain identical to monopoly model and the ISPs will end up splitting the profits as they now both share half of the market, assuming that they are identical. End user side of the market will, however, change dramatically by adding a competing network to monopoly setting. The networks compete over end users, pushing the price under one from monopoly setting.

Price competition over end users will lead to zero profit situation for both of the ISPs if they are perfect substitutes. If one sets lower price than the other it will capture the whole market. The ISPs push the prices down, substituting losses from end user side with profits from the video content provider side of the market. Lowest price that the ISPs are willing to offer for the end users is the price, which combined with their profits from video content providers covers their costs.

In addition to competing over prices, the networks compete over data allowance set to the end users. In practice, this means that the networks will set the data allowance in such fashion that it maximizes combined surplus of the end users and the network. When both of the networks have set the data allowance to a point where this surplus is maximized neither has an incentive to defect from this equilibrium. Increasing prices would lead to the end users switching to the other ISP and reducing prices would lead to losses. Lowering the data allowance would also cause all end users to leave the ISP. Increasing the data allowance would increase the amount that the end users are willing to pay but reduce payments from the video content providers more. The ISP would need to increase prices more than the additional willingness to pay from the end users to stay aloft, losing all customers to the competition. Thus, the only equilibrium can be one where both ISPs charge monopoly prices from video content providers, charge zero-profit prices from the end users and set the data allowance to a point which maximizes the combined surplus of the ISPs and the end users.

The only difference between monopoly and duopoly situations is the price charged from the end users. A monopoly ISP will extract all consumer surplus from the end users while with a duopoly the ISPs will set zero-profit prices for the end users which could even be negative. Interestingly the data allowance will be set to the same point with both options, maximizing the combined surplus of the network(s) and the end users. With a duopoly situation, the data allowance arises from the necessity of competition. The monopoly ISP arrives at the same point since it maximizes the combination of gross consumer surplus and profits from the video content providers.

Expanding the monopoly model to a duopoly model with a more formal framework would allow us to expand our understanding of sponsored data. These models can be altered to accommodate more heterogenous end users or to assume that there are multiple video content providers competing for zero-rating. The ISPs can be even assumed not to be perfect substitutes but for the end users to have a preference for one ISP over other, reducing the competition between them.

Another avenue in research is using zero-rating for price discrimination. Identifying situations where ISPs can use this strategy to heterogenous end user masses would be informative. An ISP could use zero-rating as a way to make the end users self-select into categories based on their preference of the zero-rated content and extract more surplus from the end users.

Section VIII: Conclusions

One of the main conclusions this thesis arrives is that when a monopoly ISP cannot charge fees from the content providers, it will never offer zero-rated plans for homogenous end users. The framework presented in Section III shows that the ISP cannot increase its revenue by increasing end users' willingness to pay more with zero-rating than by increasing their data allowances. Zero-rating increases the total consumption but restricts end users' choice of the consumption mix, forcing them to use a larger share of their data consumption to the zero-rated content than they would prefer and forcing them to use a smaller share to other content. The ISP can always find a data-allowance with a data cap plan which leads to similar consumer valuation thus revenue than zero-rating with either smaller or identical costs. Reasons for ISPs offering zero-rated plans to their customers must derive from different reasons. Potential examples discussed in this thesis are using zero-rating for marketing reasons or to increase customer retention and to reduce price competition. Zero-rating can also potentially work as an insurance for the end users, making sure that consuming zero-rated content does not cause them to go over their monthly data allowances.

When the ISP is allowed to charge payments from the content providers it zero-rates it will always set the data allowance to a level where the zero-rated content is unattractive. This level of data-allowance leads the end users using a larger fraction of their total data usage to the zero-rated content than they would if they were not restricted in their choice of consumption with a similar budget. There always exists a level of data allowance which restricts consumption choices of the end users which gives the ISP higher profits than sponsored data plan which data allowance is set to high enough level not to constrain end users' consumption choices. Both the price for end users and the fee collected from the zero-rated content providers is determined by the data allowance. Larger data allowance increases the end users' willingness to pay as the restrictions in consumption of the not zero-rated content are relaxed. Smaller data allowance, while reducing the price from the end users, increases fees collected from the zero-rated content providers. Smaller data allowance reduces the amount of data the end users can use the content that is not zero-rated causing them to substitute it with the zero-rated content, increasing its consumption. The ISP sets data allowance, thus the prices for end users and the fees for zero-rated content providers to a level which equalizes marginal revenues from them. Level of data allowance with a sponsored data plan is mainly influenced by three factors: revenue multiplier of the content providers, maximum consumption point of the end users, and the end users' preference of the zero-rated content. Revenue multiplier increases fees per unit of data collected from the zero-rated content providers reducing the data allowance. Maximum consumption point affects the data allowance in a 1:1 ratio, where larger maximum consumption point leads to an identical parallel change in the data allowance. Larger consumer preference of the zero-rated content over other content leads to smaller data allowances. Data allowance is also influenced by total data consumption with alternative data cap plan.

Total welfare differences between sponsored data plans and data cap plans depend on two opposite effects. Sponsored data leads to utility loss for the end users and other content providers due to the forced suboptimal consumption mix. Secondly, sponsored data increases the total amount of data consumption increasing the end users' utility. If the total increase in consumption is enough to offset the lower share of other content consumption, profits of the other content providers can increase. Change in social surplus is greatly dependent on the parameter values and can be either positive or negative. If the ISPs increased profits are higher than profits lost by the other content providers, then sponsored data increases the social surplus. If the zero-rated content is extremely data-intensive thus takes a large share of end users' total consumption even when the consumption mix is not restricted social surplus is likely to be increased. Large consumer preference of the zero-rated content over the other content leads the ISP setting data allowance to a level where it close to not restricting consumption of the end users. At this level, consumption is distorted slightly but all parties in the network can benefit from increased consumption of data. The social surplus with this kind of sponsored data plan is still worse than unlimited data plan but fees collected from the zero-rated content providers can cause additional incentive for the ISP to expand capacity.

Size of the data allowance is not affected if the competition situation is changed from a monopoly to a duopoly. Both set data allowance to a level which maximizes gross end user surplus plus profit from zero-rating of the zero-rated content providers. Monopoly ISP maximizes its own profits at this point since it collects both. Duopoly ISPs set identical fees to the CPs as the monopoly but subsidize the end users with their profits from content provider side of the market setting zero-profit prices for the end users which can, in theory, be negative.

Tie-in to Other Research

My thesis aims to build on top of works of Somogyi (2017) and Jullien & Sand-Zantman (2018). Adding to Somogyi's framework, I allow for the data allowance to be endogenously determined. While my framework does not provide the reader with a specific formula for ISPs pricing decisions based on the data allowance, it allows the reader to understand how different parameters affect the data allowance and through the data allowance prices for both end users and content providers. Jullien & Sand-Zantman formulate a specific pricing structure for the ISP but approach the concept of sponsored data as a price discrimination situation. Their framework includes two kinds of CPs based on their margin of profit and finds that sponsored data can be used to better direct the end users towards more profitable content providers, improving the network's efficiency. (Jullien & Sand-Zantman 2018). Their framework is more focused on the CP's ability to create value through profits that they earn. There can be, however, a large contrast between the ability of a CP to generate cash flow per data used and utility created to end users from consuming data of this CP. A framework such as Cobb-Douglas utility function for end users can better allow consumer preferences to affect their choice of data usage between content providers instead of all CPs gaining an identical amount of consumption. This kind of framework can help us better understand that zero-rating does not only increase the efficiency of consumption by increasing consumption of higher margin CPs but alters consumer behaviour. Sponsored data can alter end user behaviour in such ways that they are guided away from consuming content which would create more utility for them and towards lower utility consumption, while the ISP partly compensates this via increased consumption.

Importance of Zero-Rating

Studying the effects of zero-rating is important for a multitude of reasons. It is common practice both in Europe and in the US, and after the abolishment of Obama era net neutrality regulation in the US, it is likely that zero-rating is going to be more prevalent in the future. Combined with other discriminatory practices such as paid prioritization, zero-rating has a power to shape how we use the Internet in the future. Potential benefits and problems need to be recognized but there is also a question of how important zero-rating will actually be in the future.

Unlike paid prioritization zero-rating touches only a part of our digital lives. Data consumption with mobile phones is still only approximately half of the total Internet consumption and the share is even lower in developed countries. The prominence of using mobile phones as means of reaching the Internet is, however, increasing rapidly. While mobile data usage reached the 50% mark in 2017, five years earlier mobile data usage constituted only roughly 10% of total data usage. (Statista, 2018). Paid prioritization affects all types of Internet connections, while zero-rating is almost exclusively a mobile data issue. Fixed cable connection plans are in almost all instances unlimited plans, where the determining factor of your plan is the speed of your connection. Constraining factor in mobile plans is the data allowance and not speed of connection, as mobile plans often have similar speeds.

Size of data allowances also matters when we question the importance of zero-rating. Even in some developed countries like Germany, mobile data plans are expensive and only offer small data allowances. (Rewheel, 2016). In countries like these, zero-rating some content can have large effects on consumption mix of the end users. The situation is reversed in countries with high data allowances. If consumers can already consume large amounts of data, making some of the consumption free would not cause major changes. It is possible to argue that zero-rating is less effective in high data-allowance countries and thus matters less in the context of network neutrality. This theorem has some caveats, however. It can be assumed that technology-driven increases in average data allowances have effects on end user behaviour. When data allowances increase it stands to reason that given unlimited data the maximum amount that the end users will consume will increase too, at least over time. If the growth of how much people will consume with unlimited data is slower than the growth of data allowances, the importance of zero-rating will fade over time. When countries reach the stage where virtually all mobile data plans offer unlimited data issue of zero-rating should vanish altogether. This is evident from Finland, where most of the mobile data plans offered are unlimited data plans, and possibly as a result no ISP operating in Finland offer zero-rate plans (Aetha, Oswell & Vahida and DotEcon Ltd., 2017). Even if the issue of zero rating will fade over time, there is still the question what happens in between and how long it will take. Dynamic effects of net neutrality have been studied thoroughly with scholars split on the issue. Chen et al. (2011) argue that the ISPs have reduced investment incentives under discriminatory regimes, while Choi & Kim could not conclude that the ISPs would not slow the pace of investments. Krämer and Wiewiorra (2012) took an opposite view and claimed that investments are likely to increase without net neutrality. All these studies focused on net neutrality issue in general but are likely to be applicable to zero-rating too. If sponsored data practices become widely used by the ISPs and it does indeed slow growth of ISP investment, issue of zero-rating and net neutrality in general will be a topic of heated discussion for a long time.

Appendixes

Appendix I.

$$\frac{dK_1}{dR} = \frac{-F_B}{F_K}$$

$$F_K = \frac{B}{(K_1 - B)^2}\left(\frac{K_1}{B - K_1}^{a} + \frac{K_1}{B - K_1}^{-a-1}\right)$$

$$F_B = \frac{K_1}{(B - K)^2}\left(\frac{K_1}{B - K_1}^{a} + \frac{K_1}{B - K_1}^{-a-1}\right)$$

$$-\frac{F_B}{F_K} = -\frac{\frac{K_1}{(B - K_1)^2}\left(\frac{K_1}{B - K_1}^{a} + \frac{K_1}{B - K_1}^{-a-1}\right)}{\frac{B}{(K_1 - B)^2}\left(\frac{K_1}{B - K_1}^{a} + \frac{K_1}{B - K_1}^{-a-1}\right)}$$

$$= -\frac{\frac{K_1}{(B - K_1)^2}}{\frac{B}{(K_1 - B)^2}}$$

$$\frac{-F_B}{F_K} = -\frac{K_1}{B}$$

Appendix II.

$$\frac{dK_1}{dR} = \frac{-F_r}{F_K}$$

Where

$$F_r = -1$$

$$F_K = \frac{B}{(K_1 - B)^2}\left(\frac{K_1}{B - K_1}^{a} + \frac{K_1}{B - K_1}^{-a-1}\right)$$

$-F_r = 1$ and
F_K is strictly positive as $B, (K_1 - B)^2, K_1$ and $B - K_1$ are > 0, when $B > 0$ and $B > K_1$.

Thus $\frac{-F_r}{F_K} >$

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