Net Neutrality and Price Discrimination: Using Skype as an "Arbitrage" Opportunity

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Foreword and acknowledgments

This thesis is written as completion to the master's program Economics, specialization track Competition and Regulation, at Tilburg University.

The past few months, I enjoyed diving into the economic (and some legal) literature on net neutrality. I came across this topic during a guest lecture of the Dutch competition authority for the seminar Competition and Regulation in Network Industries. Net neutrality is not only very relevant nowadays and high on the agenda of policy makers, it is also a very complex concept, because also moral issues and fundamental rights play a large role. It is interesting to evaluate why regulators should or should not adopt net neutrality regulation from an economic perspective. In order to expose another angle of the possible economic effects of net neutrality regulation, namely the introduction of Skype as an arbitration device between voice and data, I developed two models on price discrimination.

The decision to write about net neutrality is based on several reasons. First of all, net neutrality is especially salient today and the debate is fierce, which makes it a very interesting topic. Secondly, writing on net neutrality allows for combining multidisciplinairy knowledge. Because I am particularly interested in the field of law & economics, I have chosen to combine economic theory with legal considerations in this thesis. Lastly, I had never developed a theoretical economic model before, and I thought it would be challenging to take a leap of faith in this.

I would like to thank my supervisor, Gijsbert Zwart, for his openness, trust and helpful feedback. I really appreciate that he encouraged me to go to China for a few months before writing this thesis. I also would like to thank my family and friends for the great past six years; although I did many things to postpone this moment, the time has finally arrived to take the next step.

Abstract

The economics of the internet is rather complex. The best-effort and end-to-end principle may become impracticable due to the increasing internet traffic and services that have different quality needs. Network management may form a solution, but increases the opportunity for Internet Service Providers (ISPs) to engage in anti-competitive conduct. At the moment, the Net Neutrality (NN) debate is especially salient in Europe. The European Union is about to adopt NN regulation. Opinions of scholars and other stakeholders vary widely and economic literature on the effects of NN regulation is still in its initial phase. ISPs have been trying to block third-party services like Skype of Whatsapp in the past. These services can enable consumers to use data services for voice-purposes, which may hinder ISPs from price discrimination. I show that in a monopoly situation, the effects of blocking Skype on welfare can be ambiguous. In a duopolistic model of vertical product differentiation, blocking Skype can actually unambiguously increase consumer welfare for some parameter values. This result is caused by the asymmetry of the model. For some other values, blocking Skype can be detrimental to consumer welfare. It is optimal for ISPs to always block Skype in this duopolistic setting, even if they would be better off eventually if both decide not to block Skype.

Keywords: net neutrality, price discrimination, arbitrage, vertical differentiation, anti-competitive conduct, European competition law.

Contents

1 Introduction

Nowadays most people cannot imagine a world without the internet. In the past fifteen years, the internet market has grown at an exceptional pace. And internet traffic is still increasing. According to BEREC (2012), IP traffic is estimated to increase nearly threefold by 2015, but the annual growth rate will slow down to 21 percent in 2015. BEREC also notices that for mobile data traffic the growth rate is higher compared to fixed data traffic, with about 152 percent in 2011. The European Commission (hereinafter: the Commission) states that the internet is at the core of the global economy and owes much of its success to the fact that it is open and easily accessible (the Commission, 2012). At the moment, access to information at the internet is usually provided in accordance with the best-effort principle (as fast as possible) and the end-to-end principle (information is routed through the network autonomously) (Krämer et al., 2013); Internet Service Providers (ISPs) thus try their best to convey all the information they handle to its destination (Larouche et al., 2009). These two principles are often linked to the term Network Neutrality or Net Neutrality (hereinafter: NN). However, due to the increasing internet traffic and different types of data that require different traffic classes, these principles may become impracticable.[1] A solution may be to engage in traffic management or to introduce different levels of quality of service, but this may increase the opportunity for anti-competitive conduct.

1.1 Outline and purpose of this research

Regulating the internet market is extremely difficult. Not only the economic considerations are important; also legal, technical and social rules and norms play a large role in internet regulation. Fundamental rights such as the freedom of expression and information[2] are involved. Moreover, for the European Union, internal market considerations also have a large impact on policy making in general. At the moment, Europe is considering adopting NN regulation in order to prohibit ISPs "from blocking or slowing down [...] services"[3]. The proposal for NN regulation of the European Commission is recently adopted by the European Parliament. This indicates that Europe is only a small step away from the introduction of NN regulation. The question rises whether adopting NN regulation in

[1] Note that a large part of the literature on the internet market indicates that a small fraction of end-users (around 10 percent) uses a disproportionate amount of the network traffic (up to 80 percent). For example, one may refer to Larouche (2011).

[2] Article 11 of the Charter of Fundamental Rights of the European Union (2010/C83/02).

[3] Press release European Parliament, April 3, 2014, Ensure open access for internet service suppliers and ban roaming fees, say MEPs, retrieved from *http://www.europarl.europa.eu*.

the still evolving internet market would be a step in the right direction.

In particular, this research considers a theoretical approach to the incentives of ISPs to block applications like Skype and the effects on welfare without NN regulation.

In the first part of this research I evaluate the adoption of NN regulation in Europe. As one will recognize, the NN debate is intransparent and not only politicians, but also scholars and (other) stakeholders are often talking past each other. Therefore I structure the NN debate in the first sections and try to find out what NN encircles and what interpretations different scholars use. Since economics plays a large role in the regulation of the internet, I examine the existing economic theory and related economic literature in chapter 3. In chapter 4, I evaluate whether the European competition law framework would offer (sufficient) tools to fight potential anti-competitive behavior of ISPs. In the final chapter of this first part, I take a closer look at the recent regulatory developments at the European level and also consider the existing Dutch NN regulation that came into force in the beginning of 2013.

In the second part of this research I conduct an economic analysis to identify the incentives for ISPs to block services or applications like Skype. As one will recognize, ISPs decided to block these services in the past. And according to the Dutch legislator, the adoption of the Dutch NN regulation was a direct response to the decision of a large ISP to block such a service.

The presence of Skype allows consumers to use data for 'voice-purposes'; consumers are able to call each other via the internet, without consuming any voice. This affects an ISP's ability to price discriminate between the products data (a certain amount of MBs that consumers can use) and voice (calls and text messages). I investigate this so-called "arbitrage opportunity"[4] between data and voice. Another example would be Whatsapp; with this application, consumers are able to send text messages to each other via the internet. Without NN regulation, it may be beneficial for ISPs to block these applications, in order to price discriminate between data and voice. It is interesting to evaluate the effects of Skype on the behavior of ISPs and eventually on consumer welfare. To the best of my knowledge, there has been no economic analysis of this arbitrage mechanism between data and voice yet.

[4] Although the term "arbitrage" is usually used in economics to describe the opportunity to buy a product in one market at a low price and sell it immediately on another market at a higher price, in this research it is used to describe the mechanism that (partly) hinders price discrimination between voice and data (when it is optimal for the ISP to charge a higher price for voice than for data).

In chapter 7, I evaluate the effects of price discrimination on welfare in the monopoly situation. In the last two chapters, a duopolistic model of vertical product differentiation is introduced, based on the seminal paper of Corts (1998).

2 What is Net Neutrality?

As Valletti & Estache (1998) argue, in order to promote effective competition in network industries, competitors need to have access to facilities that are too costly to duplicate (the so-called *potential bottleneck facilities*). NN is a policy approach that regulates the access of CPs to the network of ISPs and the transmission of data to end-users. The term NN was coined by Columbia Law School professor Wu in 2003 in his paper "Network Neutrality, Broadband Discrimination". In the introduction of his paper, Wu states:

> *"Proponents of open access see it as a structural remedy to guard against an erosion of the "neutrality" of the network as between competing content and applications."*(p.141).

NN regulation stipulates how ISPs manage their networks and price the use of it by Content Providers (hereinafter: CPs) and end-users. Ever since the introduction of this regulatory concept, there have been many different interpretations. NN is complex, covers a number of distinct issues (Larouche & Cave, 2010) and raises many questions for policy makers, especially when internet traffic is growing.

2.1 Approaches to Net Neutrality regulation

According to Schütt (2010), NN is the principle that all data packets that are transfered through the network are treated equally. In the BEREC report (2012) one can find a similar approach to NN.[5] Krämer et al. (2013) use a strict interpretation of NN regulation, stating that this regulation "prohibits Internet service providers from speeding up, slowing down or blocking internet traffic based on its source, ownership or destination"(p.796).[6] Afterwards, the authors introduce a less strict approach to NN, used by Hahn and Wallsten (2006): "net neutrality usually means that broadband service provides charge consumers only once for Internet access, do not favor one content provider over another, and do not charge content providers for sending information over broadband lines to end users"(p.797). According to Faulhaber (2011) the initial NN principle holds that the transmission and routing of data should be "dumb" and only at the end-points (i.e. devices of end-users) intelligence should be present (p.54).

[5] In BEREC's 'Response to the European Commission's consultation on the open Internet and Net Neutrality in Europe' Net Neutrality was described as: "A literal interpretation of Network Neutrality, for working purposes, is the principle that all electronic communication passing through a network is treated equally."

[6] The authors mention that this definition has been put forth by consumer rights groups, for example Save the Internet.

Reggiani and Valletti (2012) state that NN has often been linked to the previously mentioned best-effort principle and end-to-end principle, that hold that the transmission and routing of internet traffic should be neutral and without interfering. However, nowadays, broadband internet allows for different traffic management techniques by ISPs. This ability to interfere in the transmission and routing of data packets can increase efficiency (a reduction of congestion), but may also result in several potential anti-competitive practices. According to BEREC (2012), ISPs can for example construct fast lanes to introduce different traffic classes for different types of data, provide guaranteed network capacity to specific users and block or degrade certain content. According to some, these potential anti-competitive practices of ISPs form a reason to advocate the introduction of NN regulation. Others are clearly against this, or argue that there is a lack of evidence of actual wrongdoing (Faulhaber, 2011).

2.2 The Net Neutrality debate

Due to the complexity of the concept, the NN debate not very transparent. Opponents of NN regulation argue that network management is needed in order to create more efficient use of the network. As a result of the growth of internet traffic, ISPs claim to experience traffic congestion on their networks. Also the increasing demand for services that require a higher QoS than current *best effort* (for example Voice-over-IP (VoIP) services) creates a need for network management with differentiated QoS offerings. Whereas in the past, ISPs only had to transmit data for services that are not sensitive to delay, like e-mail, these VoIP services and other delay-sensitive applications do not function well in times of congestion without prioritization. Moreover, the larger demand for more differentiated QoS offerings requires ISPs to make large investments in their networks. According to Krämer et al. (2013), who summarize the main arguments for and against different types of NN regulation and provide a policy guideline, the famous statement of the CEO of AT&T in november 2005, who said in an interview with Bloomberg Businessweek Magazine:

> "*Now what [CPs] 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*",

particularly stimulated the NN debate. ISPs argue that revenues of end-users hardly counter-balance the necessary investments in the network; in contrast, CPs will benefit from increased bandwidth, which will increase the supply of delay-sensitive services, leading to congestion and the need for new investments,

according to the authors. Charging CPs for higher QoS or prioritizing traffic is needed to encourage new investments and innovation.

On the other hand, proponents argue that NN is needed to protect the innovation of small start-up CPs; the so-called innovation *at the edge* of the internet. ISPs would be able to favor their own CPs, foreclose other CPs for example by blocking certain content, thereby also reducing the availability of content to users. The argument related to the availability of content goes hand in hand with arguments related to the freedom of expression and other fundamental rights, and turns the discussion into a moral one. The *possiblity* of being excluded from access to certain services or information contributes largely to the public opinion, which is advantageous to proponents of NN regulation (Larouche, 2011). Larouche also expresses the concern that different levels of QoS may cause market fragmentation. However, he also clearly states that the effect of NN regulation on innovation remains unclear.

According to Faulhaber (2011) it appears there is no actual problem that needs to be solved by NN regulation:[7]

> *"The litany of evils imagined that might occur in the future have almost never occured in the past, and there is no evidence that the market environment of broadband ISPs is undergoing a change that might justify concerns about as-yet-unrealized threats. Are the problems that net neutrality purports to solve purely imaginary? Are "prophylactic" remedies to non-problems needed? I leave it to the reader to decide."*(p.58)

Faulhaber is perfectly clear; in his opinion, there is no practical evidence that would justify NN regulation. Moreover, by showing an overview of the current economics literature on NN, he also points out that there is no academic result that advocates the introduction of NN regulation.

At first sight, both parties use valid theoretical (economic) arguments that seem to make sense. However, as stated before, one may notice that these arguments depart from different regulatory interpretations or aspects of NN. Moreover, whether these claims are true in practice is also debatable; as we will see in the next sections, scholars have many different opinions and economic modeling is inconclusive. One may ask whether an ISP would block certain content in practice and, if so, what are its incentives to do this? Or is it true that there is no evidence of misconduct as Faulhaber (2011) argues? And, are termination fees posed on

[7] Faulhaber states that in over a decade, only four cases of purported misconduct were reported for the entire broadband industry in the US (p.57).

CPs in line with the two-sided market character of the internet or is it rather the exploitation of a bottleneck facility by an ISP? Importantly, what is the effect of NN regulation on innovation (i.e. the dynamic effects)? These are just a few of the complex economic questions that play a role in the NN debate.

Before diving into the economics of NN, it is noteworthy to mention that according to Krämer et al. (2013) it is "likely that soon other gatekeepers up and down the information value chain may be pushed to a center stage when the debate concentrates on issues like *device neutrality* (e.g. with Apple being the gatekeeper) or *search neutrality* (here, Google is the gatekeeper)" (p.795). Apple controls which software is allowed on their devices and large CPs such as Google have significant market power and may bias search results; the authors compare these developments to NN and state that the "similarity [...] is immediate" (p.810).

3 Net Neutrality and economics

Schütt (2010) distinguishes, roughly speaking, two economic pillars when discussing NN regulation, namely i) the zero-pricing rule and ii) the non-discrimination rule. NN as the zero-pricing rule holds that ISPs are not allowed to charge CPs for transmitting data to their consumers. NN as the non-discrimination rule holds that ISPs cannot engage in network management, e.g. cannot prioritize traffic. One may note that these two economic pillars stem from the definition mentioned in the previous chapter; NN regulation stipulates how ISPs *manage* their networks and *price* the use of it. In other words, as Reggiani & Valletti (2012) duly state, NN is a "data treatment (and its pricing) issue"(p.2).

In this section, I follow this distinction made by Schütt. Later on, I also discuss the distinction between short-term and long-term NN issues of Larouche (one may refer for example to his research in 2011).

3.1 The non-discrimination rule

The NN-principle as the non-discrimination rule can be translated into different levels of regulation. In the literature, the strongest form of the NN non-discrimination rule (i.e. strict NN) holds that all data needs to be treated the same at all times; one may note this is in line with the previously mentioned best-effort and end-to-end rule. Under this regulation, offering different levels of Quality of Service (QoS) is not allowed.

If one relaxes this rule a bit, the *needs-based discrimination* rule can be identified, which holds that data packets needs to be treated according to the best-effort rule except for the situation in which there is network congestion; in this situation, an ISP is allowed to prioritize certain data packets (Allgrove & Ganley, 2006). Economides & Tag (2011) identify a similar regulatory approach that they call *Limited Discrimination without QoS Tiering* (p.4). According to Economides and Tag this approach is similar to one of the principles on NN proposed in 2009 by the US Federal Communications Commission (FCC); charging CPs for differentiation in QoS is not allowed.[8]

The next regulatory approach that Economides and Tag consider is *Limited Discrimination and QoS Tiering*, where exclusive contracts and identity-based

[8]Paragraph 104 of the FCC Notice of Proposed Rulemaking (NPRM) states: "Subject to *reasonable network management*, a provider [...] must treat lawful content, applications, and services in a nondiscriminatory manner". One of the reasonable practices according to this Notice is "[reducing] or [mitigating] the effects of congestion on its network or to address quality-of-service concerns" (paragraph 135, sub a(i)). The term "nondiscrimination" means that ISPs are not allowed to charge CPs for this differentiation in QoS (paragraph 104).

discrimination are forbidden, but ISPs are allowed to offer different levels of QoS each at a different price. A step further would lead to a situation with *Active Discrimination* (Allgrove and Ganley, 2006, p.457) or *No Regulation* (Economides & Tag, 2011, p.5); under this regulatory approach, every form of discrimination is allowed, including exclusive contracts and vertical foreclosure. In other words, ISPs can engage in full traffic management.

3.2 The zero-pricing rule

The internet is often considered to be a two-sided market where users benefit from a greater variety and availability of content by different CPs; CPs on the other hand, benefit from a larger number of users. Armstrong (2006) calls these effects "cross-group externalities". The classical result in a two-sided market is that a particular platform chooses a lower fee from the side that is valued the most.[9] An example of a two-sided market that often pops-up in economics literature is the two-sided market for credit cards; retailers often pay fees for using a credit card payment system, not consumers. But also in the internet market, both sides (i.e. the CPs and the end-users) depend on an ISP that functions as a platform that facilitates interaction between these two groups with cross-group externalities. According to Schütt (2010) a zero-pricing rule can be welfare enhancing when consumers value additional content providers higher than content providers value additional consumers (p.3); he mentions that Amstrong's work shows that a zero-pricing rule implemented by the regulator causes a price decrease in general, which may contribute to welfare.[10]

According to Krämer et al. (2013), two-sided market pricing is "currently not employed"(p.797) in the internet market. The authors state that CPs and end-users are usually connected to different ISPs. End-users are connected to an ISP and cannot switch easily, for example because they are bound by a contract. In contrast, CPs are usually subscribed to more ISPs or have their own "backbone network" (the authors mention Google as an example). One may note that this situation is similar to one of the single- and multi-homing situations described by Armstrong (2006), which he calls "competitive bottlenecks". Armstrong shows that in this situation, ISPs have monopoly power over providing access to their

[9] Armstrong (2006) elaborates on this classical result, stating that the structure of the prices offered depend on i) the relative size of cross-group externalities; ii) fixed fees or per-transaction charges and; iii) single-homing or multi-homing. (p.668-669).

[10] However, if it is profitable for ISPs to subsidize CPs in order to increase the value to the end-users, a zero-pricing rule may actually decrease welfare. Moreover, even in the situation in which a zero-pricing rule increases welfare, end-users may be worse off. For an overview of this discussion and related literature, one may refer to Schütt (2010).

single-homing end-users for the CP side, which - at first sight - may lead to high prices charged to CPs and too little CPs being served (implicating that little content is available to end-users). However, prices charged to CPs will be lower if end-users highly value the availability of content.

Krämer et al. (2013) interpret this zero-pricing rule as the question whether an ISP may charge a termination fee to CPs on top of the access fee, in order to transmit their data to the end-users. The authors state that, without additional benefits in return, these payments are similar to termination fees that are common in the telecommunications market. These termination fees are violations of most (strict) NN definitions that are outlined in the previous sections. Krämer et al. point out that ISPs may also offer a higher level of QoS, for example faster access lanes, to CPs; the termination fee has now become a priority fee, where tiering of QoS is possible. Note that this situation is similar to the regulatory approach of Economides & Tag (2011) called *Limited Discrimination and QoS Tiering*; in other words, this priority fee is a violation of the non-discrimination rule of strict NN.

3.3 Distinction between long-term and short-term issues

Besides the economic distinction between the non-discrimination rule and the zero-pricing rule advocated by Schütt (2010), some scholars introduce other categories to explain NN.

Larouche & Cave (2010) make a practical distinction between short-term and long-term *issues* related to the internet market; in the short run, ISPs need to take measures to deal with imbalances and congestion on their networks, whereas in the long run, they are looking to introduce different QoS offerings in order to differentiate. In the light of two-sided markets, ISPs may ultimately want to offer the broadest possible set of content (Larouche, 2012).

Also Larouche (2011) points out that NN is a cluster of issues, and he again makes the distinction between "shorter-term network management issues" and "longer-term issues about the way Internet traffic is routed and transmitted" (p.2). Larouche states that this distinction between short-term and long-term issues is key; according to the author, even if ISPs continue to follow the best-effort principle, the short-term network management issues will remain. Larouche points out that these short-term issues can be used as an excuse for anti-competitive behavior of ISPs. The author refers to the US cases *Madison River* and *Comcast*[11],

[11] These cases are discussed in the next chapter of this research.

and states that these cases show that ISPs may actually engage in anti-competitive behavior.

One may note the large discrepancy between this last statement of Larouche and the opinion of Faulhaber (2011); whereas Larouche considers these US cases as evidence that anti-competitive behavior may indeed take place, Faulhaber states that the few cases indicate a lack of evidence of actual wrongdoing. I tend to agree with Larouche that these cases, and also smaller cases in European countries (some of these cases I will also discuss in the next section), actually indicate that it may be profitable for ISPs to engage in anti-competitive behavior. In order to solve this issue, a form of NN regulation may be imposed that forbids ISPs to take technical measures to manage their network according to Larouche; network management using prices and usage limits is then allowed. Note that Larouche thus advocates a less strict form of NN regulation that may allow for fees (prices) or even some form of discrimination. However, other legal and policy interests in other fields may require ISPs to actually take technical measures to supervise traffic on their networks, for example with respect to criminal law enforcement or intellectual property rights enforcement.[12]

3.4 Related economic literature

Many scholars in economics investigated the effects of NN on behavior of ISPs, CPs and end-users, and on consumer welfare and total welfare, using different models and different approaches to NN. As duly stated by Faulhaber (2011), the studies that are published by economists vary widely in their emphasis and in the position they take on NN. But economic literature on the effects of NN regulation is still in its initial phase; economic scholars are still figuring out the best models to show the effects. Below, I discuss some recent economic studies.

In a recent study, Reggiani & Valletti (2012) model a monopolistic ISP in a two sided market, located at zero, that invests in capacity μ at a cost $I(\mu)$ and charges both sides of the market. There is a continuum of small CPs that supply one unique application (the authors call this the *fringe*) and one large CP (such as google) that can introduce several applications. The CPs in the fringe pay a connection fee (or, as Reggiani and Valletti call it, the "flat hook up fee") and a linear transportation cost; their revenues stem from advertisements. The large CP also has to pay a linear transportation cost t_G, but it can control how many

[12] With respect to intellectual property rights enforcement, one may think of piracy. Larouche refers to the French law *Loi 2009-669 du 12 juin 2009 favorisant la diffusion et la protection de la création sur internet*, whereby ISPs are conscripted in the fight against piracy (p.4).

applications it introduces along the line. Reggiani and Valletti then introduce congestion to the model using an M/M/1 queuing system and evaluate the effect of the two regimes (NN and the ability to prioritize traffic)[13] on the incentive to invest in μ and on the profitability of advertising. They assume consumers benefit from variety, but also care about congestion. Reggiani and Valletti find that NN is likely to favor innovation *at the edge* by small CPs, but reduces innovation by the large CP. However, they also find that prioritization of traffic leads to a higher efficiency and hence is welfare-enhancing.

Krämer & Wiewiorra (2009) also model a monopolistic ISP in a two-sided market framework including network congestion, just like Choi & Kim (2010) and Cheng et al. (2008), using a M/M/1 queuing system and find that discrimination encourages innovation of CPs in the longrun, but makes them worse off in the shortrun. The authors state that total welfare increases when discrimination is possible. Economides & Tåg (2011) use another approach, focusing on the incentives of a monopolistic ISP to invest in improving QoS, that charges consumers for internet access at price P, and prices s_A and s_B to CP_A and CP_B for access to higher QoS. They conclude that ISPs will have "incentives to implement price discrimination and possibly also to exclude some CPs [...] absent any regulatory intervention."(p.26) However, the authors also state there will be a trade-off between regulatory intervention and the ISPs incentives to invest in QoS.

Economides & Tåg (2012a) develop a two-sided market model and find that cross-group externalities between end-users and CPs may provide a rationale for NN regulation that prevents ISPs from charging positive access fees to CPs for some parameter ranges; for these parameter values, NN regulation can increase welfare. According to the authors, this holds for both monopolistic and oligopolistic situations. However, for other parameter values, NN regulation can be detrimental to welfare. In his comment on this paper of Economides & Tåg, Caves (2012) considers whether these parameter ranges are reasonable and argues that, if the authors use a more reasonable ratio, the welfare enhancing effects of NN regulation dissapear. In their response to Caves' comment, Economides & Tåg (2012b) stress that their model contains simplifications of reality. According to the authors, policy makers must take caution when developing policy conclusions bases on this comment of Caves.

Lee and Wu (2009) use a two-sided market analysis and focus on a model with

[13]Note that Reggiani and Valletti (2012) define NN as the discrimination rule and not the zero-pricing rule, as they allow for the connection fee f. They show that the number of applications produced in the fringe depends on the connection fee; however, the number of applications produced by Google do not depend on this fee.

innovative entrants; a termination fee introduces an entry barrier to these innovative entrants, which may decrease innovation. The authors worry that the introduction of fees leads to *internet fragmentation* (similar to the previously mentioned concern of Larouche (2011) about market fragmentation) if horizontally differentiated ISPs offer end-users access to different content. The authors fully recognize the complexity of the internet in the conclusion of their research when stating that: "although in this paper we have isolated one interesting effect—namely, than a ban on termination fees can be used to encourage market entry by creators and innovators—this point is far from a full understanding of networks and their larger effects on society and the world" (p.75).

Chen and Nalebuff (2006) consider a model with one-way essential complementary products and evaluate the incentives of the producer of the essential product (firm A) to influence the quality of the non-essential product of firm B. The authors state that this model is relevant to "internet-based businesses, such as the internet telephone services provided by Skype and Vonage" (p.3). According to the authors, these services allow end-users to replace their "land-line phone service", but end-users can only use these services if they have high-speed internet access supplied by for example their cable company (the product of firm A). Chen and Nalebuff show that firm A has no incentive to degrade the quality of the non-essential product of firm B, even if firm A enters the market for the non-essential product. Chen and Nalebuff therefore conclude that ISPs have no incentive to disrupt NN (p.3-4). In my opinion, this result seems counter-intuitive to what happens in practice - namely, as we will see, ISPs have been blocking applications like Skype in the past. One should note that the authors assume that product B is of low value to consumers, indicated by λ; according to Schütt (2010) this result is related to the low value of this parameter.

From the previously mentioned studies, one can deduce the consensus that the economics of the internet is very complex. I agree with Larouche (2011) that risks need to be identified before regulators should intervene. The internet market is still developing and evolving. Moreover, it is important to evaluate these potential risks within the existing legal framework; as European competition law regulates anti-competitive behavior of firms in general, order to promote efficiency, it may also address issues related to possible misconduct of ISPs in the internet market. In order to obtain a more practical view on NN, I evaluate the current framework of European competition law in the next chapter.

The following scheme concludes the previous sections;[14]

	NN regulation:	
Two pillars:	1. Management of the network	2. Pricing the use of the network
	⇓	⇓
Related economic concepts:	Foreclosure, blocking, degradating content, introducing different levels of QoS.	(termination) fee, two-sided market, competitive bottleneck, access to end-users.
	⇓	⇓
Strict NN regulation:	No network management: transmission and routing of all data should be "dumb" and equally.	No pricing: ISPs may not charge CPs for transmitting data to their end-users.
	⇓	⇓

Problems caused by increasing internet traffic and different types of data under strict NN regulation:

i. Short-term problems: Network congestion, imbalances

ii. Long-term problems: Investment issues, dynamic issues

[14]This scheme is a simplification of the debate and is intended to provide a simple overview of the issues related to NN regulation only. For example, one may argue that pricing can also lead to foreclosure.

4 European competition law

Anti-competitive concerns are at the heart of the NN debate. In the EU, competition law deters abusive activities. European competition law is anchored directly in the Treaty on the Functioning of the European Union (hereinafter: TFEU).[15] Sector-specific regulation on telecommunications is secondary legislation and is complementary to European competition law.

4.1 Abuse of a dominant position

Article 102 TFEU prohibits the abuse of a dominant position in order to protect consumer welfare and the competition in the market.[16] An ISP may be engaging in abusive behavior for example when it blocks a user from reaching content from a CP (refusal to deal or supply), intentionally causes degradation of the product another CP (yet another form of foreclosure), or charges different prices (price discrimination); depending on whether an ISP holds significant market power, i.e. has a dominant position, blocking could be seen as a form of abuse of a dominant position ex article 102 TFEU.[17] In other words, in order to violate article 102 TFEU, one needs to have a dominant position, but a dominant position is not a concern in and of itself.[18]

In addition to article 102 TFEU, the Significant Market Power (SMP) regime that is applicable to "electronic communications networks" regulates access of CPs to networks, requiring national authorities to impose appropriate regulatory obligations on SMP ISPs (article 8 of *Directive 2002/19/EC*). National regulatory authorities may impose (inter alia) obligations of non-discrimination (article 10 of Directive 2002/19/EC) and access - i.e. no blocking - (article 12) on ISPs that hold SMP. This sector-specific regulatory framework complements European competition policy that is anchored in the TFEU.

[15] European competition law is anchored in articles 101-109 TFEU.

[16] The full text of article 102 TFEU (emphasis added): "Any *abuse* by one or more undertakings of a *dominant position* within the internal market or in a substantial part of it shall be prohibited as incompatible with the internal market in so far as it may affect trade between Member States.

Such abuse may, in particular, consist in:

(a) directly or indirectly imposing unfair purchase or selling prices or other unfair trading conditions;

(b) limiting production, markets or technical development to the prejudice of consumers;

(c) *applying dissimilar conditions to equivalent transactions with other trading parties*, thereby placing them at a competitive disadvantage;

(d) making the conclusion of contracts subject to acceptance by the other parties of supplementary obligations which, by their nature or according to commercial usage, have no connection with the subject of such contracts."

[17] One may note that in case there is a vertical contract between an ISP and a CP, article 101 TFEU may also apply in some situations. One may refer to the literature on vertical restraints.

[18] In the US, paragraph 2 of the Sherman Act prohibits monopolization; however, similar to EU law, monopoly power *ansich* is no violation.

4.2 The relevant market

In order to establish whether an ISP has a dominant position or SMP, a market definition is needed. As the internet market is complex, defining the relevant market may also be complex. First of all, ISPs may have a dominant position or SMP vis-à-vis their end-users (Larouche, 2011). End-users depend on the ISP to receive traffic on the device they are using. However, in order to determine whether ISPs actually have a dominant position, it is important to evaluate end-users' switching costs. Switching may occur between competing ISPs, or, as Larouche states, end-users can also switch from a mobile operator to a fixed-line ISP.

ISPs may also have a dominant position in their relationship with CPs, as also the CP depends on the ISP to reach the end-user. The situation is quite similar to the termination bottleneck facility of a network operator in the telecommunications market; in this market, an network provider is considered to have a dominant position regarding termination of calls, as the relevant market is defined as its own network (Larouche, 2011).

In its Recommendation of 17 December 2007, the Commission outlines "relevant product and service markets within the electronic communications sector suspectible to *ex ante* regulation in accordance with Directive 2002/21/EC"[19]; however, the Annex of this recommendation does not include a "market for the termination of broadband data traffic (delivery of content) from the Internet backbone to the end-user"(Larouche, 2011, p.20).[20] Unlike the situation in the telecommunications market, internet traffic can reach the end-user via many different routes, that are - according to Larouche - not equivalent, but these routes may moderate the market power of an ISP.

The current legal framework in Europe offers tools to deal with possible anti-competitive behavior of ISPs that clearly have a dominant position. However, determining whether an ISP has a dominant position vis-à-vis end-users or CPs may be difficult in the internet market. In contrast, (strict) NN regulation may forbid *all* ISPs to engage in *any* form of network management and pricing.

Nonetheless, as (economic) literature shows, the effect of NN regulation on innovation and dynamic efficiency remains unclear, I would recommend not to intervene in the internet market yet. However, as we will see in the following

[19]European Commission (2007), Commission Recommendation of 17 December 2007, 2007/879/EC, *L 344/65.*

[20]Of course, if necessary, the Commission may add this market to the list. Also, national authorities may identify markets that are not included in the Recommendation of the Commission, but these markets have to meet the three criteria of the Commission; "(a) the presence of high and non-transitory barriers to entry [...];(b) a market structure which does not tend towards effective competition within the relevant time horizon [...]; (c) the insufficiency of competition law alone to adequately address the market failure(s) concerned".

chapter, the introduction of NN regulation in the European Union is at the moment high on the agenda of European policy makers.

5 Net Neutrality in practice

In contrast to the US, NN regulation is only relatively recently of large importance to European policy makers. As mentioned before, in the US there has been some interesting case law on NN.[21] One of the most recent cases on NN was in 2012; AT&T limited the use of Apple's FaceTime for certain customers. The US Federal Communications Commission (FCC) was involved in this case and during the summer of 2013, AT&T announced to expand the FaceTime service to more consumers.

Although there were relatively little lawsuits on NN issues, these examples show that blocking is not only a theoretical problem. Also in Europe, ISPs have engaged in foreclosure activities in the past. For example, Vodafone and Orange blocked VoIP services such as Skype.[22] These examples show that ISPs have an incentive to block or degrade certain services of CPs, or to charge *consumers* for these services. According to Koninklijke KPN N.V. the main incentive to charge consumers for Whatsapp or Skype is to compensate for the loss of revenue from lower consumer voice-use nowadays.[23]

5.1 The Dutch NN regulation

Due to the actions of KPN and other ISPs, and as a result of the conclusions in the BEREC report[24], the Netherlands was the first European country that adopted a NN regulation[25], which came into force on January 1, 2013.[26] The Dutch NN regulation is generally considered to be strict. It is interesting to see that the Dutch law actually lacks definitions of the different terms that are introduced to regulate NN. Another remarkable aspect of the Dutch law is that ISPs may seperately

[21] For example the *Madison River case* in 2005, where the Federal Communications Commission (FCC) started an investigation about Madison River Communications. Madison River was blocking VoIP applications. The case was settled; Madison River Communications agreed to stop blocking these VoIP services and FCC dropped its investigation *(Federal Communications Commission DA 05-543, Consent Decree)*. Another example is the *Comcast* case; the FCC held a complaint against Comcast, the largest US cable company and second largest ISP, which was slowing down or blocking data packets of BitTorrent and other software that enables peer-to-peer file sharing. The U.S. Court of Appeals for the District of Columbia Circuit *(No. 08-1291, April 6, 2010)* ruled in favor of Comcast, stating that FCC had no power based on law to uphold this complaint.

[22] One may refer to several news messages, for example "Ook Vodafone blokkeert diensten"(2011, april 23), retrieved from http://www.nu.nl/internet/2498984/vodafone-blokkeert-diensten.html.

[23] Strategic plan "Strengthen - Simplify - Grow", May 10, 2011, available on the corporate website of KPN.

[24] According to the Minister of Economic Affairs of the Netherlands, Tweede Kamer der Staten-Generaal, this NN regulation was a direct response to the decision of KPN to block a third-party application that offers free texting services (Dutch House of Representatives, document 32 549, June, 2012, nr. 48).

[25] Besides the Netherlands, also Slovenia has adopted a law on NN in December 2012

[26] Article 7.4a of the Telecommunicatiewet. This article states that *ISPs may not block or delay applications on the internet, unless these measures are necessary i) to reduce the effects of congestion, whereby equal traffic needs to be treated equally; ii) for the integrity and safety of the network; iii) to reduce SPAM and other unsolicited communications or; iv) to execute statutory regulation or a court order.* This Dutch law indicates a strong form of NN, but allows for some network management in times of congestion.

charge for a separate service (for example a VoIP service) that is delivered through the internet (in Dutch: "losse diensten"). Moreover, these separate services fall completely outside the scope of article 7.4a of the Dutch Telecommunications Act (In Dutch: "Telecommunicatiewet"). However, in its recent policy consultation, the Dutch government tightened the explanation of this exception and also the Dutch authority Autoriteit Consument & Markt (ACM) has stated that it will maintain a narrow definition of such a separate service.[27]

Although the meaning of this term remains a bit unclear, considering the reason for implementing NN regulation in the Netherlands in the first place - namely, it was a direct response to the blocking behavior of KPN - this "losse dienst" should certainly not be interpreted as a free ticket for ISPs to block applications such as Skype.

5.2 Regulation at the EU level

On April 3 this year, the European Parliament has voted to adopt (an amended version of) the proposal of the EC to introduce NN regulation in Europe[28]. The proposal limits ISPs to charge for different levels of QoS and includes a (rather strict) definition of NN, stating that "traffic should be treated equally, without discrimination, restriction or interference, independent of the sender, receiver, type, content, device, service or application".

Article 23(1) of the amended regulation holds that "end-users shall have the right to access and distribute information and content, run and provide applications and services and use terminals of their choice, irrespective of the end-user's or provider's location or the location, origin or destination of the service, information or content, via their internet access service". Although this definition is rather strict, paragraph 2 of this article states that ISPs are free to offer specialised services to end-users if the network capacity is sufficient to provide them in addition to internet access services; they may not be detrimental to the availability or quality of these services. A "specialised service" is defined in article 2(15) as "an electronic communications service or any other service that provides the capability to access specific content, applications or services, or a combination thereof, and whose technical characteristics are controlled from end-to-end or provides the capability to send or receive data to or from a determined number of parties or

[27] Ministry of Economic Affairs, *Beleidsregel netneutraliteit*, May 2, 2014. The Ministry states that a service can only be qualified as a separate service if it is not supplied with standard internet service or other services at the same time.

[28] *COM(2013)0627*, European single market for electronic communications.

endpoints, and that is not marketed or widely used as a substitute for internet access service". Thus, an ISP may charge for these specialised services, which are often high-quality services that have specific needs, if standard internet service is not degraded.[29]

Some legal scholars state that the term specialised service is related to the Dutch term separate service (Duijvenvoorde & Knol, 2013). However, practice will (probably) show the scope of these terms.[30]

It is interesting to mention that also in the US NN regulation is still high on the agenda. The FCC adopted on May 15, 2014, a proposal on new NN rules[31], which (under certain conditions) allows ISPs to charge for QoS. It also expands transparency requirements for ISPs. The proposed regulation has entered an extended four-month public comment period (until September 10, 2014).

5.3 Remainder of this research

Although the new European NN regulation did not came into force yet, the proceedings indicate that NN is especially salient today. As we have seen, ISPs decided to block or charge for services like Skype in the past, which means that ISPs may indeed have incentives to engage in anti-competitive conduct in practice. For example, according to KPN, the main reason was to compensate for the loss of voice revenue from lower consumption of voice. The remainder of this research will take a different perspective on NN than the literature to date, as it will focus on price discrimination and the incentives for ISPs to block Skype. In chapter 7, I develop a monopolistic model to show the effects of price discrimination and blocking Skype on the pricing behavior of an ISP and consumer welfare; in chapters 8 and 9 I develop a oligopolistic model (more specifically, a duopolistic model) of vertical product differentiation.

[29]For an overview of the debate on these specialed services, one may for example refer to the Briefing of the European Parliamentary Research Service (EPRS), March 25, 2014, Net Neutrality in Europe, retrieved from *http://www.europarl.europa.eu/*.

[30]Note that the Council still needs to approve this new European NN regulation.

[31]FCC, 14-61, In the Matter of Protecting and Promoting the Open Internet, Notice of Proposed Rulemaking (NPRM) May 15, 2011.

6 Net Neutrality and Price Discrimination

Under third-degree price discrimination a rational monopolist may charge different prices to different groups of consumers, depending *inter alia* on the price elasticity of demand. In 1985, Varian showed that third-degree price discrimination may have a positive effect on welfare, provided that marginal costs are common across markets and total output increases. In general, under monopolistic price discrimination, welfare effects are considered to be ambiguous; some consumers are better off and some are worse off. Whereas many scholars focus on monopolistic price discrimination, it is also interesting to evaluate the effects of price discrimination in a competitive market. Economics literature suggests that, like monopolistic price discrimination, competitive price discrimination has an ambiguous effect on consumer welfare, as it is beneficial to some consumers, but detrimental to others - see for example Holmes (1989). Corts (1998) shows that this may not be the case in an asymmetric model; consumer surplus may unambiguously increase in some situations when price discrimination is allowed.

6.1 Arbitrage opportunities

In some situations, a company is unable to maintain price differentials as described above; this occurs for example when parallel trade is possible. Parallel trade occurs when a good is resold in another market, without the authorization of the manufacturer; for example, Szymanski and Valletti (2005) define parallel trade as "the resale of a product by a wholesaler in a market other than intended by the manufacturer" (p.707). A common incentive for parallel trade is a (sufficient) price difference between markets; according to Danzon (1998) "parallel trade [...] 'exports' low prices from low-price countries to other potentially higher-price countries." Parallel trade is therefore a form of arbitrage that hinders price discrimination.

In the same way, Skype, Whatsapp or another application can (partly) hinder price discrimination practices of an ISP. Often, consumers have to pay separately for data (the amount of MBs used) and voice (calls and text messages); ISPs are thus able to price discriminate between these two goods. Applications such as Skype can be seen as "arbitrage devices" that hinder this separate pricing strategy of an ISP if the optimal price for voice is higher than for data. Namely, these applications enable consumers to call or send text messages, without consuming voice; instead, they consume data and use this data for 'voice-purposes'. In other words, they make use of voice services via the internet, (partly) precluding ISPs from price discrimination.

6.2 Monopoly pricing when price discrimination is allowed

Before I outline the assumptions of the models in this research, it is useful to dive into a simple example of monopoly pricing when price discrimination is allowed. A monopolist will determine its prices in such a way that the mark-up over marginal costs is inversely related to the elasticity of demand. In order words, when the elasticity of demand is relatively low for product B compared to product A, the price for product B should be relatively high compared to the price for product A. To show this, consider a monopolist ISP that produces two goods, *voice* (denoted as a) and *data* (denoted as b), and these goods have different demand elasticities, but the same marginal costs. In case price discrimination is possible, the monopolist ISP maximizes its profits;[32] $\pi = (p_A - c)q_A(p_A) + (p_B - c)q_B(p_B) - F$.

The First Order Condition (hereinafter: FOC) gives;

$$\frac{\partial \pi}{\partial p_A} = q_A + (p_A - c)\frac{\partial q_A}{\partial p_A} + (p_B - c)\frac{\partial p_B}{\partial p_A} = 0$$
$$\leftrightarrow (p_A - c) = (p_B - c)\frac{\frac{\partial q_B}{\partial p_A}}{\frac{-\partial q_A}{\partial p_A}} + \frac{p_A}{\eta_A} \text{ and thus } (p_B - c) = (p_A - c)\frac{\frac{\partial q_A}{\partial p_B}}{\frac{-\partial q_B}{\partial p_B}} + \frac{p_B}{\eta_B}$$

η_A and η_B are respectively the negative of the elasticity of demand for voice and data. One can note that this monopoly pricing is similar to Ramsey pricing; this pricing method is also based on the differences in the elasticity of demand for goods, and is often used in industries where large amounts of fixed costs need to be recovered, for example in telecommunications. In case arbitrage between data and voice is possible, this pricing method will not be maintainable. In this case the monopolist will set one price for both data and voice; the monopolist will aggregate demand for both of these goods and sets its marginal revenue (MR) equal to its marginal costs (MC), which is the profit-maximizing output. The monopolist will compare this outcome to the amount of profits it receives when maximizing its profits for either data or voice.

[32] if $\frac{\partial q_A}{\partial p_B} = 0$ (and also $\frac{\partial q_B}{\partial p_A} = 0$)then voice and data are independent and the prices only depend on the price elasticity of demand of the specific good. If not, the price also depends on the cross-price elasticity, which implies that if the price for voice increases, the demand for data will increase.

7 Monopolistic price discrimination

7.1 Assumptions: model with two types of actors

There are two types of actors in this simple monopoly model; end-users (or consumers) and a monopolist ISP. The ISP sells data to end-users at price p_D and voice at price p_V. The marginal cost (mc) of voice and data is zero.[33] The fixed costs of the network are F. As a result, the profit function of the ISP is:

$$\pi_{ISP} = (p_D)q_D + (p_V)q_V - F \tag{1}$$

The demand for data equals $q_D = 1 - p_D$. However, consumer demand for voice is less elastic and equals $q_V = 1- \beta p_V$. Assume that parameter β has a value between zero and one.

Situation i) Price discrimination is possible:
The monopolist ISP is assumed to be rational and thus optimizes its profit function. Optimization leads to prices and corresponding quantities;

$$p_D = \tfrac{1}{2};\ p_V = \tfrac{1}{2\beta};\ q_D = \tfrac{1}{2} \text{ and};\ q_V = \tfrac{1}{2} \tag{2}$$

It follows from these prices that it would be optimal for the monopolist to set the price for voice higher than the price for data if parameter β is between zero and one; namely, the elasticity of consumer demand for voice is lower than for data when β is smaller than one. One may note that in this model, the cross-price elasticity between voice and data is zero; voice and data are independent. The profits of the monopolist ISP are, without taking into account the fixed costs;[34]

$$\pi_{ISP} = (p_D)q_D + (p_V)q_V - F \leftrightarrow \pi = \tfrac{1}{4} + \tfrac{1}{4\beta} \tag{3}$$

The total consumer surplus can be calculated;

$$CS_{total} = \textstyle\int_0^{q_V}[p - p_V]dq + \int_0^{q_D}[p - p_D]dq \leftrightarrow CS_{total} = \tfrac{1}{8} + \tfrac{1}{8\beta} \tag{4}$$

[33] It is reasonable to assume that marginal costs in telecommunications are very small; in network economics, communication networks are often considered to exhibit large economies of scale; these networks have a high fixed cost, but the marginal costs of sending an additional byte through the network are considered to be approximately zero.

[34] From now on, when deriving profits and welfare effects, I do not take into account fixed costs.

Situation ii) price discrimination is not possible anymore:
Now, assume that consumers are able to use data to make calls and send messages as a result of new innovative technologies similar to Skype, and become indifferent between using data or voice for 'voice-purposes'. In other words, the quality and ease of using Skype for voice-purposes is the same as using voice; consumers do not prefer one product to the other and the monopolist is not able to price discriminate between voice and data. In this case, the aggregate demand for data and voice is;

$$1)\ Q = (1–\beta p) + (1–p) = 2 - (1+\beta)p \quad if \quad p \leq 1 \tag{5}$$

In this situation, the monopolist ISP maximizes the profit function $\pi_{ISP} = pQ - F$. This results in $p = \frac{1}{(1+\beta)}$ and $Q = 1$. Its profits are;

$$\pi = \tfrac{1}{(1+\beta)} \tag{6}$$

However, note that if the monopolist sets the price in such a way that the demand for data is zero, but the demand for voice is positive, the aggregate demand is;

$$2)\ Q = (1–\beta p) \quad if \quad 1 < p \leq \tfrac{1}{\beta} \ and \ \beta \leq 1 \tag{7}$$

In this second situation, the monopolist ISP sets the price of voice and data equal to the monopoly price of voice, $p_V = p_D = \frac{1}{2\beta}$. Note that the demand for data will be zero if parameter $\beta \leq \frac{1}{2}$. This indicates that no consumer is willing to buy data at this price-level. In this case, when $\beta \leq \frac{1}{2}$, the profits of the monopolist are;

$$\pi = \tfrac{1}{4\beta} \tag{8}$$

Comparing the profit functions of the monopolist ISP shows that the profits in situation 2 ($\pi = \frac{1}{4\beta}$) can actually be higher than in situation 1 ($\pi = \frac{1}{(1+\beta)}$); this depends on the value of β. More specifically, when price discrimination is not possible anymore, the monopolist ISP maximizes its profits using the aggregate demand function if $\beta \geq \frac{1}{3}$. In case $\beta < \frac{1}{3}$, it would be more profitable to set the prices of voice and data equal to $\frac{1}{2\beta}$, as described by situation 2. Namely, when $\beta < \frac{1}{3}$, the market for voice yields a relatively large benefit for the monopolist. As a result, one can distinguish two pricing strategies;

1. when $\beta \geq \frac{1}{3}$: $p = \frac{1}{(1+\beta)}$, $Q = 1$ and $\pi = \frac{1}{(1+\beta)}$

2. when $\beta < \frac{1}{3}$: $p = \frac{1}{2\beta}$, $Q = \frac{1}{2}$ and $\pi = \frac{1}{4\beta}$

The corresponding consumer surplus under the first pricing strategy is;

$$CS_{total} = \frac{1}{2} + \frac{1}{2\beta} - \frac{3}{2(1+\beta)} \tag{9}$$

In the second situation, when $\beta < \frac{1}{3}$, consumer surplus will be;

$$CS_{total} = \frac{1}{8\beta} \tag{10}$$

One can easily recognize that the consumer surplus is lower if the monopolist charges the monopoly price for voice also for data.

7.2 Welfare analysis

As one may have note, the situation in which price discrimination is not possible is similar to (strict) NN regulation. In contrast, the situation in which a monopolist is able to price discriminate is similar to a situation without any form of NN regulation (or competition law); in this case, the monopolist is able to block Skype.[35]

It is interesting to evaluate the welfare implications of price discrimination. For example, if one assumes that $\beta = \frac{1}{2}$, consumer surplus is $\frac{3}{8}$ and total welfare is $\frac{9}{8}$ if the monopolist ISP is able to price discriminate. In contrast, under situation ii) - when price discrimination is not possible anymore - consumer surplus will be $\frac{1}{2}$ and total welfare will be $\frac{7}{6}$ if $\beta = \frac{1}{2}$. In other words, consumers will be better off and also total welfare is higher in case price discrimination is not possible. In tabel 1 below a more general analysis of the effects of price discrimination on consumer surplus (CS) and total welfare (TW) is provided for different values of β.

Besides measuring the effects of price discrimination on welfare, it is also interesting to consider whether the quantity of voice (or data for voice-purposes) and data increases when price discrimination is possible. When $\frac{1}{3} \leq \beta < 1$, the total quantity supplied under the two regulatory regimes is equal; $Q = 1$ and $q_D + q_V = \frac{1}{2} + \frac{1}{2} = 1$. However, if $\beta < \frac{1}{3}$, the quantity of data is zero and total quantity is lower. These findings are included in table 1 below;

[35] One may note that if the monopolist ISP is able to charge consumers for the use of Skype, it would set its prices in such a way *as if* price discrimination is possible; the monopolist ISP will optimize prices for voice and data and sets the extra price for Skype charged by consumers equal to the difference between the monopoly price for voice and data. Consumer surplus and total welfare will be the same as in the situation in which price discrimination is allowed.

Table 1: The effects of price discrimination on Q, CS and TW

	Effects of price discrimination compared to uniform pricing		
Value β	Q	CS	TW
$0 < \beta < \frac{1}{3}$	larger	larger	larger
$\frac{1}{3} \leq \beta < 1$	equal	smaller	smaller
$\beta = 1$	equal	equal	equal

As one can see in table 1, consumer surplus and total welfare are smaller if price discrimination is possible and output remains the same (i.e. when $\frac{1}{3} \leq \beta < 1$). The uniform price is $p = \frac{1}{1+\beta}$, which is higher than the discriminatory price for data ($p_D = \frac{1}{2}$), but lower than the discriminatory price for voice ($p_V = \frac{1}{2\beta}$). As a result, although the net effect of price discrimination on welfare is negative, consumers will be worse off with respect to voice, but better off with respect to data. However, if output increases, price discrimination may actually contribute to consumer surplus and total welfare; this is the case if $\beta < \frac{1}{3}$.

One can compare these findings to the previously mentioned literature on price discrimination. Varian (1985) confirms that the *necessary* condition of Schmalensee (1981) for third-degree price discrimination to increase total welfare - i.e., the condition that output increases - holds in "much more general circumstances" (p.870). The results show that total welfare is indeed larger when price discrimination causes an increase in output. For most values of β, output stays at the same level; in these cases, price discrimination leads to higher prices for voice and lower prices for data (the ambiguous effect of price discrimination as described in the literature), but in this model, the net effect is detrimental to consumer surplus and total welfare.

7.3 Incentives to block Skype

The monopolistic ISP will always be better off when it blocks Skype as long as the monopoly price in the voice market is higher than the monopoly price in the data market. As Corts duly states, "when a monopolist discriminates, it necessarily earns higher profits than under uniform pricing, as it solves the same profit-maximization problem with fewer constraints" (Corts 1998, p.307). When it chooses not to price discriminate - i.e. to allow Skype - it will have to maximize aggregate demand, which is not optimal.

8 Vertical product differentiation in a duopolistic setting

In this chapter, a model of vertical product differentiation is used. When products are vertically differentiated, every consumer would prefer the same product when prices are equal. For example, this preference for a product may be caused by a quality difference. In this model, consumers, or end-users, are homogeneously distributed along a linear market [0,1]. There are two ISPs that are vertically differentiated. I assume that the locations of the two ISPs are fixed at respectively zero and one on the interval [0,1], which indicates that the two ISPs are maximally differentiated.

8.1 Price discrimination is possible

In this model on vertical differentiation, which is based on the model of Corts (1998), consumers choose to subscribe to the network of ISP_A or ISP_B and buy subscriptions that include voice and/or data. Assume that consumers may subscribe to one network to buy voice and to the other network to buy data. Their demand for data is $Q = \alpha - \beta P_D$; i.e., the quantity of data solely depends on the price. The sales of the two ISPs are split equally if both firms set the same price for data. In the voice market, consumer preferences depend on the quality of voice services.

The voice market:
Consumers buy one unit of voice of either ISP_A or ISP_B and are homogenously distributed according to their preference for the quality of voice services (location x_V) on the interval [0,1].[36] Close to zero, one can identify the *nonchalant type* that does not care about the quality of voice services (he or she does not mind a lower coverage of certain regions). Close to one there is the *picky type*. The maximum valuation for the quality of voice services by the most picky consumers in this model is $1 * t$. Parameter t describes the magnitude of the quality of the service advantage of ISP_B over its rival.[37]

The locations of the two ISPs are fixed in this market for voice; ISP_A is located at location $x_V = 0$ and offers a unit of voice at price p_{V_A}. ISP_B is located at $x_V = 1$, which indicates that it offers a unit of the highest quality voice services

[36] In this model, quality is interpreteed as the coverage of the network. Whereas some end-users consider it extremely important to be able to receive calls or to call at any moment and in any place, this is not required for the usage of data.

[37] Following Corts (1998). More precisely, parameter t describes the magnitude of the advantage to have a higher coverage.

to its consumers at price p_{V_B}.[38]

Accordingly, consumer i in the voice market gets utility $U_i = V_V - p_{V_A}$ from subscribing to the network of ISP_A and utility $U_i = V_V + x_{V_i}t - p_{V_B}$ from the network of ISP_B. The indifferent consumer $\bar{x}$ derives the same utility from both networks;

$$V_V - p_{V_A} = V_V + \bar{x}_V t - p_{V_B} \tag{1}$$

Given prices p_{V_A} and p_{V_B}, the indifferent consumer is located at;

$$\bar{x}_V = \frac{-p_{V_A}+p_{V_B}}{t} \tag{2}$$

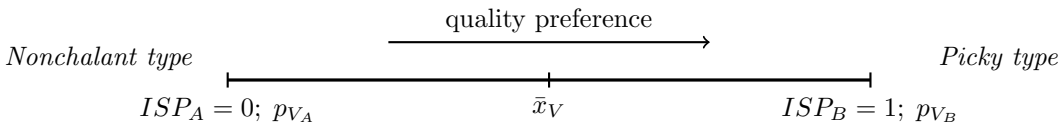
As a result, ISP_A and ISP_B face demand functions for the voice market;

$$x_{V_{ISP_A}} = \bar{x}_V - 0 = \frac{-p_{V_A}+p_{V_B}}{t} \tag{3}$$

$$x_{V_{ISP_B}} = 1 - \bar{x}_V = 1 - (\frac{-p_{V_A}+p_{V_B}}{t}) \tag{4}$$

In the figure below, a graphic overview of the competition in the voice market is provided;

Figure 1: Competition on the interval [0,1] in the voice market



The profit functions of the ISPs in the market for voice are respectively;

$$\pi_{ISP_A} = (\frac{-p_{V_A}+p_{V_B}}{t})(p_{V_A}) \tag{5}$$

[38]The quality difference of the two ISPs in the voice market of this model is comparable to the real-world situation. For example, in the Netherlands, ISP_B is similar to a large ISP such as KPN that offers high-quality voice services and a high coverage of regions; in contrast, ISP_A may be similar to a discount ISP that offers voice services with a lower coverage at a lower price.

$$\pi_{ISP_B} = (1 - (\frac{-p_{V_A} + p_{V_B}}{t}))(p_{V_B}) \tag{6}$$

The FOC for ISP_A gives;

$$\frac{\partial \pi}{\partial p_{V_A}} = -2p_{V_A} + p_{V_B} = 0 \leftrightarrow p_{V_A} = \frac{p_{V_B}}{2} \tag{7}$$

The FOC for ISP_B gives;

$$\frac{\partial \pi}{\partial p_{V_B}} = \frac{-2p_{V_B} + p_{V_A}}{t} + 1 = 0 \leftrightarrow p_{V_B} = \frac{p_{V_A} + t}{2} \tag{8}$$

As one can easily see;

$$p_{V_B} = \frac{2t}{3} \text{ and } p_{V_A} = \frac{t}{3} \tag{9}$$

The data market:
In the market for data the demand of consumers is $Q = \alpha - \beta P_D$. In this simple Bertrand model, ISP_A's reaction function $r_A(p_{D_B}) =$

- $p_{D_A} = p^M$ if $p^M < p_{D_B}$
- $p_{D_A} = p_{D_B} - \varepsilon$ if $0 = mc < p_{D_B} \leq p^M$
- $p_{D_A} \geq p_{D_B}$ if $p_{D_B} = mc = 0$

Note that both ISPs are symmetric in this market for data. The only Nash equilibrium, which is a pair of prices such that no ISP is able to increase its profits by changing its price, is $p_{D_A} = p_{D_B} = 0$.

To conclude, if price discrimination between voice and data is allowed, the ISPs charge prices;

$$p_{V_A} = \frac{t}{3},\ p_{D_A} = 0,\ p_{V_B} = \frac{2t}{3} \text{ and } p_{D_B} = 0 \tag{10}$$

8.2 Uniform pricing

Now consider the situation in which consumers are able to use data to make calls and send messages as a result of the introduction of Skype. Assume that the consumers of ISP_B are able to use the highest quality of Skype, similar to the quality of the voice services offered by ISP_B. Consumers of ISP_A are not able to use this high quality; namely, the quality of Skype of ISP_A depends on the coverage

of the network offered by this ISP.[39] As a result, consumers become indifferent between using data or voice for 'voice-purposes' and price discrimination between the two markets is not possible anymore. If the ISPs do not adapt their prices to this new situation, and thus charge $p_{V_A} = \frac{t}{3}$, $p_{D_A} = 0$, $p_{V_B} = \frac{2t}{3}$ and $p_{D_B} = 0$, all consumers will only use Skype for voice-purposes (the demand for data expands) and the ISPs do not sell voice anymore, resulting in $\pi_{ISP_A} = \pi_{ISP_B} = 0$. Clearly, this would not be the optimal pricing strategy for the ISPs; they would lose all profits in the voice market.

Option 1: Monopolizing the data market
Since ISP_A has a monopoly position in the market for data as long as its price is lower than the price of ISP_B, it would be rational to maximize its profits with respect to the sum of the demand in the data market and its market share in the voice market. Its profit function is;

$$\pi_{ISP_A} = \left(\alpha - \beta p_A + \tfrac{-p_A + p_B}{t}\right) p_A \tag{11}$$

The FOC provides us with the reaction function of ISP_A;

$$p_A^* = r_A(p_B) = \tfrac{\frac{p_B}{t} + \alpha}{2(\beta + \frac{1}{t})} \tag{12}$$

Assume that ISP_B focuses on the voice market. Its reaction function is;

$$p_B^* = r_B(p_A) = \tfrac{p_A + t}{2} \tag{13}$$

The intersection of these two functions can be obtained;

$$p_A^* = \tfrac{(\frac{1}{2} + \alpha)t}{2(\beta t + \frac{3}{4})} \tag{14}$$

and thus;

$$p_B^* = \tfrac{1}{2}\left(\tfrac{(\frac{1}{2} + \alpha)t}{2(\beta t + \frac{3}{4})} + t\right) \tag{15}$$

[39] One may argue that it might be odd that Skype has the same quality as the quality of the voice services offered by a specific ISP. However, as stated before, this quality of the voice network is interpreted as coverage of the entire network. Coverage for voice services is extremely important to some consumers. Although coverage is assumed not to be important for data services, Skype is actually a voice service that uses data; as a result, the coverage of the network is as important for Skype as for voice to some consumers.

These prices p_A^* and p_B^* may form a stable equilibrium. However, whether this is the case depends on the incentive of ISP_B to deviate; if it slightly undercuts ISP_A by setting a price at $p_{B^L} = p_A^* - \varepsilon$,[40] it would capture the whole data market and voice market, and it earns profits (assuming that ε is negligible);

$$\pi_{ISP_B}(p_{B^L}) = \underbrace{p_A^*}_{\pi_{V_B}} + \overbrace{(\alpha - \beta p_A^*)\, p_A^*}^{\pi_{D_B}} = \tfrac{(\frac{1}{2}+\alpha)t}{2(\beta t+\frac{3}{4})} + (\alpha - \beta\tfrac{(\frac{1}{2}+\alpha)t}{2(\beta t+\frac{3}{4})})(\tfrac{(\frac{1}{2}+\alpha)t}{2(\beta t+\frac{3}{4})}) \tag{16}$$

If ISP_B decides to not undercut the price of ISP_A, it will earn profits;

$$\pi_{ISP_B}(p_B^*) = x_{V_{ISP_B}} * p_B^* = (\tfrac{1}{2} + \tfrac{\frac{1}{4}+\frac{1}{2}\alpha}{2(\beta t+\frac{3}{4})})(\tfrac{(\frac{1}{4}+\frac{1}{2}\alpha)t}{2(\beta t+\frac{3}{4})} + \tfrac{t}{2}) \tag{17}$$

Thus, whether or not the pricing strategy (p_A^*, p_B^*) forms a stable equilibrium, depends on the following condition;

Condition 1. $\pi_{ISP_B}(p_B^*) \geq \pi_{ISP_B}(p_{B^L})$.

This condition holds when;

$$\leftrightarrow \tfrac{t(\frac{1}{4}+\frac{1}{2}\alpha)}{2(\beta t+\frac{3}{4})} + \tfrac{t(\frac{1}{4}+\frac{1}{2}\alpha)^2}{2(\beta t+\frac{3}{4})} + \tfrac{t}{4} \geq \tfrac{(1+\alpha)(\frac{1}{2}+\alpha)t}{2(\beta t+\frac{3}{4})} - \tfrac{\beta(t(\frac{1}{2}+\alpha))(t(\frac{1}{2}+\alpha))}{2(\beta t+\frac{3}{4})}$$

$$\leftrightarrow t \geq \tfrac{\frac{3}{4}\alpha+\frac{3}{4}\alpha^2-\frac{3}{16}}{\beta(\frac{3}{4}+\alpha+\alpha^2)} \tag{18}$$

Whether or not this condition holds, depends on parameters t, α and β.[41] More precisely, if the market for data is larger, i.e. when parameter α is relatively large and/or parameter β is relatively small, the market for data will be more attractive to ISP_B and it has larger incentives to deviate from the equilibrium (p_A^*, p_B^*); the condition will not hold. If parameter t, which yields the magnitude of the quality advantage of ISP_B, is relatively large, the condition holds and (p_A^*, p_B^*) forms a stable equilibrium. For example, if $\alpha = 1$ and $\beta = 1$, parameter t needs to be larger or equal to 0.48 for the condition to hold; if α remains one, but $\beta = \frac{1}{2}$ (which indicates that the demand for data is less price-sensitive), the condition only holds if $t \geq 0.95$. And, if β is relatively very small, for example $\beta = 0.2$, t

[40] Note that for every $p_A^* < t$, $p_A^* < p_B^*$.

[41] Note that if the equilibrium condition does not hold, i.e. it is beneficial for ISP_B to deviate and thus to undercut the price of ISP_A, and the data market is sufficiently large, the competition for the data market might become fierce; both ISPs will undercut each other's prices, but there is no Nash Equilibrium in pure strategies. In this case, uniform pricing is beneficial to consumer welfare.

has to be larger than two for the condition to hold. In the same way, if β remains one and α becomes relatively very large, i.e. $\alpha = 10$, t needs to be at least 0.74. However, one may note that if β remains one, the effect of α is limited to $t = \frac{3}{4}$. In other words, even if α becomes extremely large, i.e. $\alpha \to \infty$, t has to be $\frac{3}{4}$ at most in order for this condition to hold.

Option 2: Maintaining prices in the voice market
In some situations it may be optimal for ISP_A to maximize its profits with respect to its share in the voice market and ignore the data market. This is the case when $\alpha - \beta p_A^* < 0 \leftrightarrow p_A^* > \frac{\alpha}{\beta}$. In this situation, prices will be $p_{V_A} = p_{D_A} = \frac{t}{3}$ and $p_{V_B} = p_{D_B} = \frac{2t}{3}$. Note that ISP_A will become the only ISP that sells data for data-purposes at price $p_{D_A} = \frac{t}{3}$.[42] Its profits are;

$$\pi_{ISP_A} = \underbrace{\frac{t}{9}}_{\pi_{V_A}} + \overbrace{\frac{\alpha t}{3} - \frac{\beta t^2}{9}}^{\pi_{D_A}} = \quad \frac{t+3\alpha t-\beta t^2}{9} \tag{19}$$

ISP_B sells voice at price $p_{V_B} = \frac{2t}{3}$, resulting in profits;

$$\pi_{ISP_B} = \frac{4t}{9} \tag{20}$$

Whether or not this pricing strategy forms a stable equilibrium depends again on ISP_B's incentive to deviate; if it slightly undercuts ISP_A by setting a price $p_{V_B} = p_{D_B} = \frac{t}{3} - \varepsilon$, it steals the data market and earns profits;

$$\pi_{ISP_B} = \frac{3t+3\alpha t-\beta t^2}{9} \tag{21}$$

If the following condition holds, namely;

Condition 2. $\frac{4t}{9} \geq \frac{3t+3\alpha t-\beta t^2}{9}$,

ISP_B has no incentive to deviate and pricing strategy $(p_A, p_B) = (\frac{t}{3}, \frac{2t}{3})$ may form a stable equilibrium. Whether or not this equilibrium holds, depends on parameters t, α and β. This condition will hold if;

[42] I assume that, when prices for voice and data are equal, consumers will use voice to make calls. Recall that the demand for data solely depends on the price.

$$t \geq \frac{3\alpha - 1}{\beta} \tag{22}$$

which indicates that if α is relatively large and/or β is relatively small (indicating that the data market is relatively large), the condition will not hold. In contrast, if parameter t is relatively large, the condition holds. However, one may note that if ISP_A ignores the data market, $p_A^* > \frac{\alpha}{\beta}$. This means that p_A^* is necessary smaller than $\frac{t}{3}$, which indicates that the condition always holds. This result is rather intuitive; the condition shows that if it is profitable for ISP_A to ignore the data market, this will also be the case for ISP_B.

8.3 Welfare analysis

As we have seen, the ISPs will charge prices $p_{D_A} = 0$, $p_{V_A} = \frac{t}{3}$, $p_{D_B} = 0$ and $p_{V_B} = \frac{2t}{3}$ when price discrimination is possible. However, if price discrimination is not possible anymore due to the introduction of Skype, the ISPs may set prices at p_A^* and p_B^*. In general, if the market for data yields a relatively small benefit compared to the market for voice and/or parameter t is relatively large (which indicates that the quality advantage of ISP_B is relatively large), the equilibrium (p_A^*, p_B^*) holds. Note that the uniform prices p_A^* and p_B^* can be higher than the prices charged for voice when price discrimination is possible, i.e. $p_A^* > \frac{t}{3}$ and $p_B^* > \frac{2t}{3}$. This is the case if the monopoly price in the data market (p_D^M) is higher than $\frac{t}{3}$, which makes it optimal for ISP_A to raise its price.[43] In this situation price discrimination leads to intensified competition and is conducive to consumer welfare, as shown by Corts (1998). However, if $p_A^* < \frac{t}{3}$ and thus $p_B^* < \frac{2t}{3}$, the welfare effects are less clear.

Finally, if ISP_A would maximize its profits with respect to its market share in the voice market, resulting in the equilibrium $(\frac{t}{3}, \frac{2t}{3})$, uniform pricing is detrimental to consumer welfare as well, as the prices in the data market increase, whereas prices in the voice market remain the same.

[43] This is possible if the market for data is sufficiently large. However, one may note that if the data market is too large, ISP_B may have incentives to undercut its rival in order to steal this market, as shown before.

An overview of the effects of competitive price discrimination on consumer welfare in this model, if the equilibrium conditions hold, is shown in the table below;

Table 2: The effects of competitive price discrimination on CS

	Effects of price discrimination compared to uniform pricing		
equilibrium	p_V	p_D	Effect on CS
1. $(p_A^*, p_B^*) > (\frac{t}{3}, \frac{2t}{3})$	smaller	smaller (zero)	larger
2. $(p_A^*, p_B^*) < (\frac{t}{3}, \frac{2t}{3})$	larger	smaller (zero)	ambiguous
3. $(p_A, p_B) = (\frac{t}{3}, \frac{2t}{3})$	equal	smaller (zero)	larger

To conclude, consumer welfare may actually unambiguously increase in some situations if competitive price discrimination is possible. As stated before, according to Corts (1998) this result is generated by the asymmetry in the model; whereas ISP_B focuses on the voice market, since it clearly has a quality advantage in this market, ISP_A focuses on the market for data because of its quality disadvantage in the voice market. In the words of Corts, the two ISPs have different "strong markets" (p.311). If ISP_A does not see the data market as its strong market, which may be the case if the monopoly price in the data market (p_D^M) is lower than $\frac{t}{3}$, price discrimination has ambiguous effects; in this case, the model lacks asymmetry in ranking the strong market. However, one should note that if ISP_A ignores the data market and ISP_B has no incentives to steal this market, uniform pricing may be detrimental to consumer welfare as well, as described by the third situation in table 2.

In short, if two ISPs have different "strong markets", price discrimination (i.e. the decision to block Skype) can be unambiguously beneficial to consumer welfare compared to the uniform pricing situation. In the next chapter I show that this result can also be obtained if ISP_A obtains a quality advantage in the data market.

8.4 Incentives to block Skype

Before introducing the adapted model in the next chapter, it is interesting to evaluate whether the ISPs have an incentive to block Skype in the case that uniform pricing leads to higher profits, i.e. when $(p_A^*, p_B^*) \geq (\frac{t}{3}, \frac{2t}{3})$. Although both ISPs will be better off when price discrimination is not possible, and thus allowing Skype, they will be even worse off when the other ISP engages in blocking Skype. One may recognize the following Prisoner's dilemma;

Table 3: Decision to block Skype

	ISP_B	
ISP_A	Block Skype	Do not block Skype
Block Skype	(L_A, L_B)	(H_A, l_B)
Do not block Skype	(l_A, H_B)	(h_A, h_B)

If both ISPs decide not to block Skype, they charge prices p_A^* and p_B^* and will earn profits $\pi_{ISP_A}(p_A^*)$ and $\pi_{ISP_B}(p_B^*)$, denoted as (h_A, h_B). However, if one of the ISPs decides to block Skype, it will be able to earn profits H_A or H_B;

1. ISP_A blocks Skype. In this situation, ISP_A is able to optimize its profits, given the price of its rival, in each market separately. As a result; $H_A \geq h_A$.[44]

2. ISP_B blocks Skype. In this situation, ISP_B will be able to maintain its profits in the voice market ánd steal the data market; it will set its price for data either at $P_A^* - \varepsilon$ or at P_D^M, depending on whether $P_D^M > p_A^*$. As a result, blocking Skype is always profitable for ISP_B.

As a result, for ISP_B, H_B is strictly larger than h_B. ISP_A is also better off when it blocks Skype (or blocking Skype is at least equally beneficial). To conclude, when an ISP is able to price discriminate, it is able to optimize its profits *given* the uniform price of its rival in each market separately, which is *at least* equally beneficial. Its rival then earns l_A or l_B, which is smaller than h_A or h_B.[45] However, if both ISPs decide to block Skype, they are in the situation that they both price discriminate and they will earn profits $\pi_{ISP_A} = L_A$ and $\pi_{ISP_B} = L_B$. Note that an ISP always wants to price discriminate if its rival price discriminates, as it is able to optimize its profits in each market separately, given the two prices of its rival. Thus, $L_A \geq l_A$ and $L_B \geq l_B$.

As one can easily see, the only Nash Equilibrium in pure strategies is (block Skype, block Skype) $= (L_A, L_B)$. In other words, the strategy to allow Skype is strictly dominated by the strategy to block Skype. As we have seen under section 8.1., if both ISPs price discriminate, prices are *ultimately* $p_{V_A} = \frac{t}{3}$, $p_{D_A} = 0$, $p_{V_B} = \frac{2t}{3}$ and $p_{D_B} = 0$ in equilibrium, leading to lower profits than in the uniform pricing situation. A solution to this problem may be to introduce an enforceable contract to ensure that the ISPs do not engage in blocking Skype. However, note

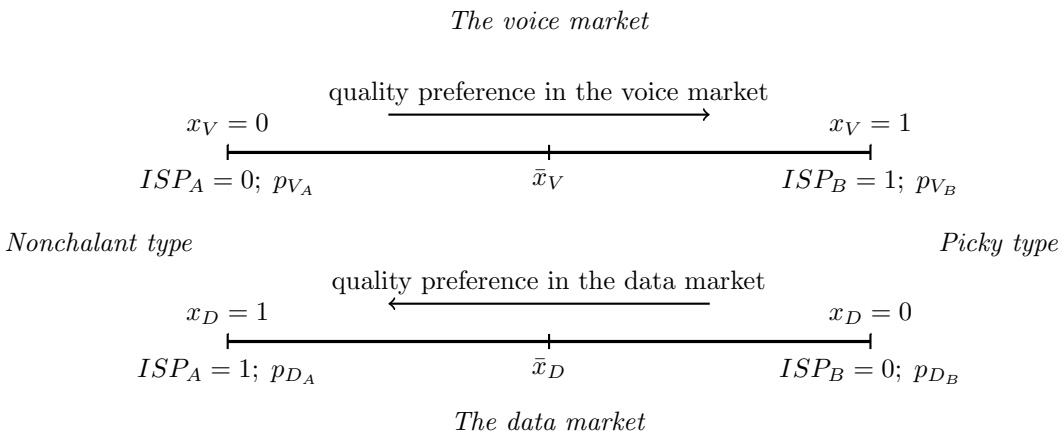
[44] Only if the monopoly price in the data market is equal to the optimal price in the voice market, charged by ISP_A in the voice market, given price P_B^*, $H_A = h_A$. In every other situation, $H_A > h_A$.
[45] Note that in case $p_D^M = p_A^*$, for ISP_B; $l_B = h_B$.

that the decision to block Skype would actually be conducive to welfare in this specific situation.

9 Quality advantage in the data market

In this chapter, the model of vertical differentiation is slightly adapted. As a result of a new technology, ISP_A is able to offer a higher level of quality for data services.[46] The magnitude of the quality advantage of ISP_A over its rival in the data market is described by t_D and I assume this parameter is equal to the magnitude of the quality advantage of ISP_B in the voice market, i.e. $t_D = t$. Consumers in the data market are homogeneously located along a linear line [0,1] according to their preference for the newest technique of data services. The *nonchalant type* - introduced in chapter 8 - who does not care about the quality of voice services, enjoys the newest data technique the most; however, the *picky type*, who requests the highest quality of voice services, does not care about this new data technology at all. The figure below shows a graphic overview of the competition in the two markets;

Figure 2: Competition on the interval [0,1] in the voice and data market



9.1 "One-sided" uniform pricing

Situation i: Price discrimination is possible:
Consumer i gets utility;

$$U_{V_i} = V_V - p_{V_A} \text{ and } U_{V_i} = V_V + x_{Vi}t - p_{V_B} \tag{1}$$

in the voice market from subscribing to the network of ISP_A and ISP_B respec-

[46] For example, one may think of G4 internet instead of G3.

tively. In the data market, it gets utility;

$$U_{D_i} = V_D + x_{Di}t - p_{D_A} \text{ and } U_{D_i} = V_{D_i} - p_{D_B} \tag{2}$$

from subscription to the network of ISP_A and ISP_B respectively. Similar to the calculations under section 8.1., ISP_A will set prices $p_{V_A} = \frac{t}{3}$ and $p_{D_A} = \frac{2t}{3}$ and ISP_B sets prices $p_{V_B} = \frac{2t}{3}$ and $p_{D_B} = \frac{t}{3}$ if price discrimination is possible. Both ISPs earn profits $\pi = \frac{5t}{9}$.

Situation ii) The introduction of Skype:
Again, we consider the introduction of Skype and assume, similar to the situation in the previous model, that only the consumers of ISP_B are able to use the highest quality of Skype.[47] As a result, price discrimination is not possible anymore for ISP_B; whereas in the previous situation ISP_B was able to charge consumers $p_{V_B} = \frac{2t}{3}$ and $p_{D_B} = \frac{t}{3}$, now consumers may use data for voice-purposes at price $\frac{t}{3}$. In contrast, ISP_A charges $p_{V_A} = \frac{t}{3}$ and $p_{D_A} = \frac{2t}{3}$ in a situation without Skype; although consumers of ISP_A are able to use data for voice-purposes as well, nobody would actually do this, since data is more expensive than voice. As a result, only ISP_A is still able to price discriminate between voice and data. I call this situation "one-sided" uniform pricing and consider the pricing strategies of the ISPs.

The profit functions are;

$$\pi_{ISP_A} = (\tfrac{-p_{V_A}+p_B}{t})p_{V_A} + (1 - \tfrac{-p_B+p_{D_A}}{t})p_{D_A} \tag{3}$$

$$\pi_{ISP_B} = (1 - \tfrac{2p_B}{t} + \tfrac{p_{D_A}}{t} + \tfrac{p_{V_A}}{t})p_B \tag{4}$$

The FOC gives the following reaction functions;

$$p^*_{V_A} = r_{V_A}(p_B) = \tfrac{p_B}{2} \tag{5}$$

$$p^*_{D_A} = r_{D_A}(p_B) = \tfrac{t+p_B}{2} \tag{6}$$

$$p^*_B = r_B(p_{V_A}, p_{D_A}) = \tfrac{t+p_{V_A}+p_{D_A}}{4} \tag{7}$$

[47] This assumption is plausible when Skype does not need the higher quality of data; i.e., it works perfectly fine with 3G internet and does not need 4G.

As one easily can see, the price charged by ISP_B is $p_B^* = \frac{t}{2}$. ISP_A will charge $p_{V_A}^* = \frac{t}{4}$ and $p_{D_A}^* = \frac{3t}{4}$. The profits of ISP_A and ISP_B are;

$$\pi_{ISP_A} = \underbrace{\frac{9t}{16}}_{\pi_{D_A}} + \overbrace{\frac{t}{16}}^{\pi_{V_A}} = \tfrac{10t}{16} \tag{8}$$

$$\pi_{ISP_B} = \underbrace{\frac{t}{8}}_{\pi_{D_B}} + \overbrace{\frac{3t}{8}}^{\pi_{V_B}} = \tfrac{t}{2} \tag{9}$$

To conclude, in this situation, ISP_B is worse off due to the introduction of Skype, but ISP_A is better off. However, this might not be the optimal pricing strategy for ISP_B. Another option for ISP_B is to ignore the data market and set the price for data equal to its optimal price for voice, namely $p_{V_B} = p_{D_B} = \frac{2t}{3}$. ISP_A anticipates on this pricing behavior of ISP_B and sets its prices at $p_{V_A} = \frac{t}{3}$ and $p_{D_A} = \frac{5}{6}t$. The profits of ISP_B and ISP_A are now;

$$\pi_{ISP_A} = \underbrace{\frac{25t}{36}}_{\pi_{D_A}} + \overbrace{\frac{t}{9}}^{\pi_{V_A}} = \tfrac{29t}{36} \tag{10}$$

$$\pi_{ISP_B} = \underbrace{\frac{t}{9}}_{\pi_{D_B}} + \overbrace{\frac{4t}{9}}^{\pi_{V_B}} = \tfrac{5t}{9} \tag{11}$$

One can clearly see that the latter pricing strategy is optimal for ISP_B. Also ISP_A is better off. As a result, in the situation that Skype is introduced and only ISP_A is able to price discriminate, prices are $p_{V_B} = p_{D_B} = \frac{2t}{3}$, $p_{V_A} = \frac{t}{3}$ and $p_{D_A} = \frac{5t}{6}$. The effect of price discrimination (and thus blocking Skype) compared to the one-sided uniform pricing situation on consumer welfare is unambiguously positive.

To conclude, whereas in the previous chapter was shown that the effects of price discrimination compared to uniform pricing can be unambiguously positive to consumer welfare if certain conditions hold, this model shows that price discrimination is also unambiguously beneficial to consumer welfare compared to the one-sided uniform pricing situation. Note that also in this model, both ISPs have "different strong" markets; as a result, ISP_A focuses on the data market and ISP_B focuses on the voice market.

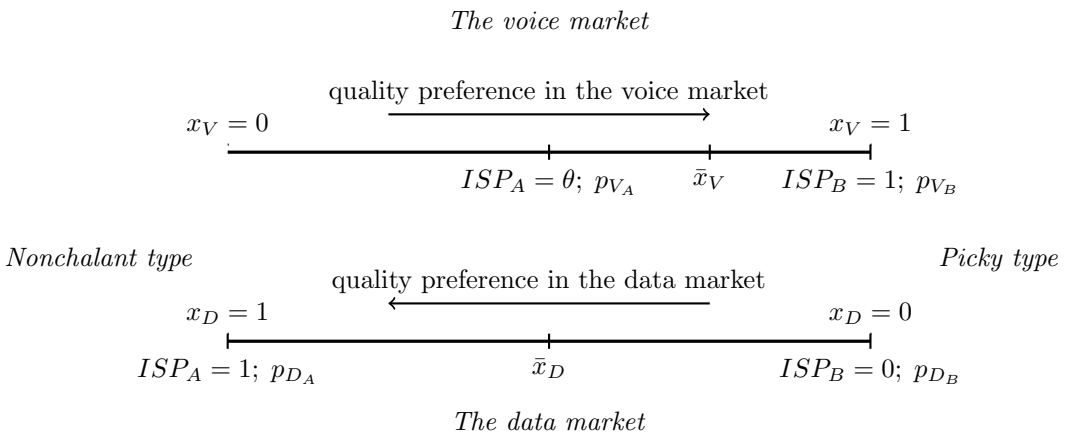
9.2 Incentives to block Skype

Also in this model it would be interesting to evaluate the incentives to block Skype. One may note that blocking Skype yields neither a benefit nor a loss for ISP_A; it is able to price discriminate anyway. However, for ISP_B, blocking Skype may be beneficial. If ISP_B is able to block Skype, it will still charge its optimal price for voice $p_{V_B} = \frac{2t}{3}$. However, in the data market, it will be able to optimize its profits, *given* the price for data of its rival, which is clearly advantageous to ISP_B. It sets its price for data now at $p_{D_B} = \frac{(\frac{5t}{6})}{2} = \frac{5t}{12}$. ISP_A responses to this new price of ISP_B by lowering its price for data; eventually, the equilibrium $(p_{D_A}, p_{D_B}) = (\frac{2t}{3}, \frac{t}{3})$ is reached. As one may notice, blocking Skype is again beneficial to consumer welfare.

9.3 Investment in the coverage of the network

In this last section, I assume that ISP_A has invested in its network coverage; although its coverage is still lower than ISP_B's, ISP_A is now located at $x = \theta$ with $0 < \theta < 1$. Similar to the previous model, ISP_A also has an advantage in the data market. The model can be shown by the following picture;

Figure 3: Competition in the voice and data market after the introduction of Skype.



Situation i: Price discrimination is possible:
When price discrimination is allowed, the ISPs will charge their optimal prices, given the prices of their rivals. In the voice market, the indifferent consumer is located at;

$$V_V - p_{V_A} + \theta x_{V_i} t = V_V - p_{V_B} + x_{V_i} t \leftrightarrow \bar{x}_V = \frac{-p_{V_A}+p_{V_B}}{t(1-\theta)} \tag{12}$$

As a result, ISP_A and ISP_B face demand functions for the voice market;

$$x_{ISP_A} = \bar{x}_V - 0 = \frac{-p_{V_A}+p_{V_B}}{t(1-\theta)} \tag{13}$$

$$x_{ISP_B} = 1 - \bar{x}_V = 1 - \frac{-p_{V_A}+p_{V_B}}{t(1-\theta)} \tag{14}$$

The FOC of the profit functions shows the reaction functions;

$$p^*_{V_A} = r_A(p_{V_B}) = \frac{p_{V_B}}{2} \tag{15}$$

$$p^*_{V_B} = r_B(p_{V_A}) = \frac{p_{V_A}+t(1-\theta)}{2} \tag{16}$$

As a result of ISP_A's investment in its network, prices for voice are now;

$$p_{V_A} = \frac{2t(1-\theta)}{6} \tag{17}$$

$$p_{V_B} = \frac{2t(1-\theta)}{3} \tag{18}$$

One may note that these prices for voice are lower than in the previous model for every value of θ smaller than one; the investment of ISP_A in its network coverage has increased competition in this market. For example, if $\theta = \frac{1}{2}$, prices are $p_{V_A} = \frac{t}{6}$ and $p_{V_B} = \frac{t}{3}$

In the data market, prices remain $p_{D_A} = \frac{2t}{3}$ and $p_{D_B} = \frac{t}{3}$, when price discrimination is possible.

Situation ii: The introduction of Skype:
Due to the introduction of Skype, consumers are able to use data for voice services. However, as one may recognize, the prices in the voice market are lower than the prices in the data market, which indicates that no rational consumer would use Skype. In other words, when the market for voice is more competitive than the market for data, and thus the prices in the market for voice are lower, the introduction of Skype has no effect on consumer behavior and the pricing strategy of the ISPs. ISPs will have no incentives to block Skype.

10 Conclusions and discussion

As we have seen, due to the increasing internet traffic and new types of data that require different traffic classes, the best-effort and end-to-end principles may become impracticable and new investments are required. ISPs may want to take measures to deal with congestion on their networks; they engage in network management, can introduce different levels of QoS and may even want to block certain content. They can also impose access fees to CPs and/or consumers. Regulators implement NN regulation to prohibit this behavior. According to proponents of NN regulation, the routing of internet traffic should be neutral and without interference. NN regulation would also contribute to innovation at the edge. Opponents argue that ISPs need to earn back their investments and NN regulation would actually hamper investments and innovations in network infrastructure.

From an economics point of view, one can distinguish the non-discrimination and zero-pricing rule. Many economics scholars have focussed on one of these pillars (or both) to investigate the (dynamic) effects of NN regulation. However, scholars vary widely in their emphasis; economics literature is still in an early stage and the (net) effects of NN regulation on welfare and innovation remain unclear. Although the possibility of network management can lead to anti-competitive behavior of ISPs, like foreclosure, I stress that it is important to identify the effects of NN regulation before regulators should intervene. The internet market is complex and is still evolving. Moreover, competition law may offer tools to prohibit and fight ant-competitive conduct of dominant ISPs.

Nonetheless, recent policy efforts have shown that NN regulation is high on the agenda of policy makers. The Netherlands was the first country in Europe to adopt NN regulation (this regulation came into force on January 1, 2013). On April 3 this year the European Parliament has voted to adopt a NN regulation proposal of the EC. According to the Dutch legislator, the main reason to adopt NN regulation the anti-competitive behavior of KPN. When taking a look at the Dutch NN regulation and the European proposal, the terms “separate services” and “specialised services” are at least remarkable.

In the second part of this research I evaluate the effect of an arbitrage opportunity between data an voice when end-users are able to use Skype; when Skype is introduced, ISPs may not be able to engage in price discrimination. However, the effects of price discrimination on consumer welfare and total welfare can be completely different in different market situations. In the monopoly situation, I show that price discrimination increases welfare if output increases. However, if output remains at the same level, the effect of price discrimination can be ambigu-

ous as the price for one good increases and the price for another good decreases. In the monopolistic model that is used in this research, the *net effect* of price discrimination is detrimental to welfare, when output does not increase.

In the duopolistic model that is introduced in chapter 8, price discrimination can actually unambiguously increase welfare for some parameter values. This result is caused by the asymmetry in the model; both ISPs have different "strong markets" as explained by Corts (1998). Although it is profitable for the ISPs if both refrain from price discrimination in this situation, the Prisoner's dilemma shows that both ISPs will always choose to price discriminate. In an adapted version of the oligopolistic model, when ISP_A obtains a quality advantage in the data market, it becomes clear that price discrimination is also unambiguously beneficial to consumer welfare compared to the so-called "one-sided" uniform pricing situation. Also in this situation, it is the dominant strategy for an ISP to block Skype in order to be able to price discriminate.

To conclude, there is actually no conclusive answer to the question whether NN regulation that prohibits an ISP from blocking Skype (when Skype is considered as an arbitrage opportunity) would contribute to welfare from an economics point of view. As shown in this research, in many situations, blocking Skype can actually (unambiguously) contribute to consumer welfare. In these situations it may therefore be recommended to allow ISPs to block Skype, or to let consumers pay for using Skype. I also have shown that ISPs have strong incentives to block Skype in the monopolistic and duopolistic situation.

Lastly, I would like to state that this NN debate shows that regulation is not always in step with economic theory. Although economics is very important, it shows that also legal and moral aspects play a large role in policy making.

Reference list

Armstrong, M. (2006) Competition in two-sided markets, *RAND Journal of Economics*, 37(3), pp. 668-691.

BEREC (2012) Differentiation practices and related competition issues in the scope of net neutrality, *Final Report BoR*, 12(132).

Caves, K.W. (2012) Modeling the welfare effects of net neutrality regulation: A Comment on Economides and Tåg, *Information Economics and Policy*, 24, pp. 288–292.

Corts, K.S. (1998) Third-Degree Price Discrimination in Oligopoly: All-Out Competition and Strategic Commitment, *The RAND Journal of Economics*, 29(2), pp. 306-323.

Chen, M.K., Nalebuff, B. (2006) One-way Essential Complements. *Cowles Foundation Discussion Paper* 1588, Yale School of Management, pp. 1-39.

Cheng, H.K, Bandyopadhyay, S., Guo, H. (2008) The Debate on Net Neutrality: A Policy Perspective, *Information Systems Research*, Forthcoming.

Choi and Kim (2010) Net neutrality and investment incentives, *The RAND Journal of Economics*, 41(3), pp. 446–471.

Danzon, P.M. (1998) The Economics of Parallel Trade, *PharmacoEconomics*, 13(3), pp. 293-304.

Duijvenvoorde, G.P., Knol, P.C.(2013) 'Connected Continent':Het voorstel voor een verordening inzake de Europese interne markt voor elektronische communicatie, *Telecommunicatie*, 10, pp. 352-363.

Economides, N., Tåg, J. (2012a) Network Neutrality on the Internet: A twosided Market Analysis. *Information Economics and Policy* 24, pp. 91–104.

Economides, N., Tag, J. (2012b) Modelling the welfare effects of network neutrality regulation: A response to Caves's comment *Information Economics and Policy*, 24, p. 293.

Economides, N., Tåg, J. (2011) Net Neutrality and Network Management Regulation: Quality of Service, Price Discrimination, and Exclusive Contracts, in *Research Handbook on Governance of the Internet* (2012). Available at *SSRN*, Working paper, *forthcoming version*. pp. 1-28

European Commission (2013) European single market for electronic communications, *COM(2013)0627*.

European Commission (2011) Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions: the open internet and net neutrality in Europe, *COM (2011) 222 Final*.

European Commission (2007) Commission Recommendation of 17 December 2007, 2007/879/EC, *L 344/65*.

European Parliamentary Research Service (EPRS), Briefing March 25, 2014, Net Neutrality in Europe, retrieved from *http://www.europarl.europa.eu/*.

Faulhaber, G.R. (2011) Economics of Net Neutrality: A Review. *Communications & Convergence Review*, 3, pp. 53-64.

FCC, 14-61, In the Matter of Protecting and Promoting the Open Internet, *Notice of Proposed Rulemaking (NPRM)* May 15, 2011.

Ganley, P., Allgrove, B. (2006) Net Neutrality: A User's Guide, *Computer Law & Security Report*, 22(2006). pp. 454-463.

Hahn, R., Wallsten, S. (2006) The Economics of Net Neutrality, *The Economists' Voice*, 3, pp. 1-7.

Holmes, T. J. (1989) The Effects of Third-Degree Price Discrimination in Oligopoly, *The American Economic Review*, 79(1), pp. 244–55.

Krämer, J., Wiewiorra, L., Weinhardt, C. (2013) Net Neutrality: A Progress Report, *Telecommunications Policy*, 37, pp. 794-813.

Krämer, J., Wiewiorra, L. (2009): Innovation Through Discrimination!? A Formal Analysis of the Net Neutrality Debate. *Working Paper, Karlsruhe Institute of Technology*.

Larouche, P. (2012) Five Neglected Issues about Net Neutrality, available at *SSRN*.

Larouche, P. (2011) Network Neutrality: The Global Dimension, *TILEC Discussion Paper*, available at *SSRN*, pp. 1-27.

Larouche, P., Cave, M. (2010) Net Neutrality and the Open Internet, A European academic perspective, *Centre on Regulation in Europe*.

Larouche, P., Cave, M., Collins, R., Eijk, N. van, Prosperetti, L., Streel, A. de, Valletti, T. (2009), Statement by European academics on the inappropriateness of imposing increased internet regulation in the EU. pp. 1-3.

Lee, R., Wu, T. (2009) Subsidizing creativity through netwok design: Zero-pricing and net neutrality, *Journal of Economic Perspectives*, 23(3), pp. 61-76.

Schmalensee, R., (1981) Output and Welfare Implications of Monopolistic Third-Degree Price Discrimination, *American Economic Review*, 71(1), pp. 242-247.

Schütt, F. (2010) Net Neutrality: A Survey of the Economic Literature, *TILEC Tilburg University*, available at *SSRN*.

Schumpeter, J.A., Nichol, A.J. (1934) Robinson's Economics of Imperfect Competition, *Journal of Political Economy*, 42(2), pp. 249-259.

Valletti, T., Reggiani, C. (2012) Net Neutrality and Innovation at the Core and at the Edge, *Economics Discussion Paper Series EDP-1202*, University of

Manchester.

Valletti, T.M., Estache, A. (1998) The Theory of Access Pricing: an Overview for Infrastructure Regulators, *The World Bank*.

Varian, H. (1985) Price Discrimination and Social Welfare, *The American Economic Review*, 75(4). pp. 870-875.

Wu, T. (2003) Network Neutrality, Broadband Discrimination, *SSRN Electronic Journal*, pp. 141-179.