Norwegian School of Economics

The Effects of Popcorn Time on Netflix in a Two–Sided Market

Masters in Business and Administration

Master Thesis - Economic Analysis

Matteo Blomberg Ghini

Supervised by

Hans Jarle Kind,

Bergen, Fall 2016

Abstract

My thesis discusses the effects on legal streaming agents of entry of free, but illegal, substitutes, in a two–sided video streaming market. Legal streaming agents rely on support from two very different, but inevitably linked, groups: studios and consumers, while their free counterparts rely on support only from consumers. As a result, the pricing decisions for legal streaming agents are far more complex than those of firms operating in regular single–sided markets and of firms operating in other two–sided markets.

I have used one model, with two setups, in order to examine how the payment–scheme between a paid streaming agent and the Studios affect key metrics as user distribution and platform utility. In the first setup, with a lump–sum transfer, I find that the effectiveness of anti–piracy investments increase utility for both the paid and the free platforms, and shift consumers towards the legal alternative. In the second setup, with a per–user transfer, I find that the free agent will capture the whole market, and no efforts taken by either the Studios or the paid streaming agent will change the user distribution. From this, I find that studios and paid streaming agents are much better off with lump–sum transfer.

Acknowledgements

I would like to thank my supervisor Professor Hans Jarle Kind for playing a crucial role throughout the writing process. It was in his lectures that I first encountered two–sided markets, and his input at various stages of the process has been invaluable and highly motivating.

I would also like to thank my brother Jonas Blomberg Ghini for helping me with how to illustrate the results in a suitable manner.

Bergen, December 2016

Matteo Blomberg Ghini

Contents

Chapter 1: Introduction

Not many industries have such a direct impact on people's lives as the media–industry. This ever–evolving, and borderline chaotic platform of profits and information has evolved a lot since the first Bibles were printed in the 15th century, and first photo was taken in the 19th century. Through innovations like radio and TV, the media industry evolved into mass media, but only as a one–to–many form of communication. With the Internet entering the public domain in the late 1990s, changes started to happen and one–to–one channels were finally possible. Stronger internet connections, faster computers and better software has allowed the broadcasting of TV to be personalised, and consumers can now freely choose what content they wish to indulge in, using so–called video streaming[1].

Today there are two main models for online video consumption. One legal model with services like Netflix and Hulu, and one pirated version, with (among other) Project Free TV, The Pirate Bay and Popcorn Time. These piracy–powered alternatives are free to use and not illegal as concepts, but rather indirectly illegal as they facilitates illegal activities. These services obtain their content by violation of copyright on commercially available work, making them highly competitive compared to the paid version, as they have no royalty charges[2].

In my thesis, Netflix will be used as a proxy to exemplify the legal industry while Popcorn Time will be used as a proxy to exemplify the illegal industry[3]. This is done to better conceptualise the market, facilitating understanding of the market and the effects at work.

[1] Streaming of video is on–demand content availability, where the user can choose what and when (s)he wants to watch something.

[2] `http://www.riaa.com/resources-learning/about-piracy/`

[3] Popcorn Time is no longer one service, with one app and one developer, but rather many different versions appearing to be the same program. There is also a new project based on Popcorn Time, called The Butter Project (`www.butterproject.org`), working in the same way, but changed to avoid legal issues. For simplicity all of these services will be treated as the same concept, and labelled "Popcorn Time".

Streaming copyright protected video–content through unlicensed services is not necessarily illegal, at least not in all countries. In Norway, the act of watching intellectual property that may have been illegally acquired is in itself not punishable, as long as it is not stored on the unit watching it[4]. Video streaming is defined by Idland, Øverby, and Audestad (2015, p. 3) as

"[...] one–way transmission of video signals over a data network, where the transmitted video can be viewed without completely downloading the data, so that the person may view the transmitted video on a computer, tablet, smartphone, television set or similar devices while the video is downloaded. For example, a streaming program may download the first ten seconds of the video file, store it (temporarily), and then start playing it. While the first part of the file is being played, the program is downloading the next 10 seconds of the file. The program does not store more than a little bit of the entire file; and once a part of the file is played, the previous part is deleted."

From this definition, not all video–streaming of copyright protected content is illegal, an obvious example is the video–giant YouTube. Popcorn Time is an open–source BitTorrent client using P2P file sharing and an integrated media player to mimic streaming; it downloads the file sequentially, stores and uploads it, all while allowing the user to watch it while it is downloading[5]. The storing and uploading element of the transaction, exploiting all users as a servers, allowing Popcorn Time to exhibit economies of scale (which will be further discussed later), is what makes it illegal. Popcorn Time does, like any other torrenting agent, allow for long–term storage of the files, but the defult setting is to stores files as a temporary file on your unit (e.g. computer, tablet, phone) and delete it when shutting down your unit[6].

With this in mind, my thesis will look into how different payment schemes between Netflix and film Studios (referred to as the Studios) will affect the distribution of users, and the utility of the platforms, in a two–sided market framework. Some of the elements this analysis will be built upon are willingness to pay, programming effort from the Popcorn Time developers, anti–piracy

[4] `http://itavisen.no/2015/02/23/det-er-lovlig-a-stromme-piratfilm-i-norge/`

[5] `http://www.tek.no/artikler/derfor-vet-vi-ikke-om-popcorn-time-er-lovlig/185505`

[6] `http://uk.pcmag.com/internet-products/10462/news/popcorn-time-is-like-netflix-for-pirated-movies`

investments and market size. From this I will also look into how the payment scheme affects the market outcome. These questions are warranted because, as I wish to demonstrate throughout my thesis, conventional economic reasoning might not apply here.

In recent years, many interesting articles have been published about piracy, with unexpected results. For instance, an article by Peitz and Waelbroeck (2006) concluded that under certain assumptions, for example if downloading is used for sampling of products, or if it expands the network–effects of a product, piracy could actually improve the profit for the producer. This is completely contrary to common belief, where piracy often is assumed to have unequivocally negative effects on profits.

What makes the streaming market so special? Why is it worth looking into? Being quite new, fast developing, not fully explored and two–sided, this market represents an exciting and challenging opportunity. Where most markets have a buyer and a seller, the "two–sided market" refers to something else. A two-sided market is defined by Evans (2002, p. 2) as *"[...] a market [where] there are two sets of customers who, in effect, need each other."* In the streaming market, Netflix competes with other streaming agents both for content licenses from the Studios and for users. The need to get both sides on board is what makes the market two–sided. Forcing the platforms to take network externalities into account influences their strategic decisions, leading them to act very differently from firms operating in traditional single–sided industries. In my thesis I will not look further into how the equilibrium changes with multiple legal and illegal services in the market — I will look at only one agent in each category.

Popcorn Time has been chosen as the proxy for the illegal industry because of their business model and motivation. Some of the pirating sites have income from advertising, like The Pirate Bay with pop-ups and banners, but Popcorn Time does not utilise any ads to earn money. In the article "Morality of Pirating Media" (Holbrook 2015) the developers of Popcorn Time says:

"We aren't sponsored by anyone, we don't have a paid team of people behind the project, we aren't a business, and we don't have any affiliations. We are a community. Just some people who are truly dedicated, spending well over forty hours a week to a couple hours or minutes a day.

Everyone contributes with the goal of making it amazing for everyone else. Every little bit makes us who we are. The thanks goes to every single contributor."

The goal for Popcorn Time is to improve the market and the offering to the consumer, adding a better service, not make a profit.

There are four concepts that need to be defined before pirating can be discussed; Peer–2–Peer (P2P), seeding, leeching and torrent. P2P is a network in which all machines are able to respond to requests of data and request data themselves, seeding is leaving data content available in the P2P network so that other people may request it, leeching is requesting (downloading) the available content in the P2P–network from a seed onto your own device where a torrent is the meta–data collection of all information needed to leech (obtain) a seed (file) in the P2P–network[7]. Bittorrent is the protocol that torrenting files and the process of torrenting are built upon.

The seeders of the piracy community does not make money from their efforts, and therefore the no–income system of Popcorn Time illustrates the relevant market in a good way[8]. The reason why Popcorn Time can survive without any revenue comes from how their streaming model and server system are built. With no material on their own servers, rather making use of the millions of torrents on the Internet (Zhang et al. (2011) identified more than 4.6 million unique torrents, with more than 38 000 trackers on just 5 sites[9]), they merely host a software that can utilise all this available content. As their source code is open source, it is not possible to shut it down either. Popcorn Time utilise something called Fork Programming, meaning that anyone with a copy of an existing version can start developing their own version independent of the original[10]. Because of this, new versions appear every now and then, making it virtually impossible to control or to find who is behind[11].

[7] Definitions obtained from `https://en.wikipedia.org/wiki/Glossary_of_BitTorrent_terms`.

[8] A Spanish study from 2010 found that 100 users of the Pirate Bay stood for about 75% of downloads and 66.6% of uploads making some money of it (Cuevas et al. (2010)), but the non–commercial users that uses Popcorn Time and Netflix for personal use have no financial stake in it.

[9] The study collected data over 9 months, from five (at the time) major torrent sites; Piratebay, BTMonster, Torrent Reactor, TorrentPortal and Mininova.

[10] `http://whatis.techtarget.com/definition/fork`

[11] `http://www.altcointoday.com/popcorn-time-shows-the-way-now-impossible-to-shut-down/`

I will group consumers into two main categories. The first group is those who pay for services like Netflix, and consume whatever content this service has a right to broadcast: they pay with money, and obey the law. The second category are those obtain content through illegal services. In my thesis the focus will be on the service(s) collectively defined as Popcorn Time. In this case, the service itself is free, hosting all pirated content, without concern for legality or copyright. The price here is paid in social and personal "capital", as users may face constraints, for both technical and ethical reasons, when obtaining illegal content. Such non–monetary costs may vary between individuals when knowingly not obeying the law, risking prison. In my thesis I will assume these costs to be the same for all consumers.

As some consumers do not know that their actions are actually illegal, the model will take into account the possibility for the Studios to do "quality investment", spreading knowledge about piracy being illegal, and that Popcorn Time is a part of this. My thesis regards this kind of investments as quality investments, as they improve the information quality of consumers: one example of this kind of investment is the "Piracy. It's a crime"–campaign, by the Motion Picture Association[12]. This thesis will not go into detail regarding how different approaches to this kind of campaign will affect the outcome. My thesis will only look into how the outcome of such investment will change the market outcome, based on the assumption that this has a real effect on the respective measures.

In my thesis only the Studios will do this kind of quality investments, as they own the content, and streaming is just one of many channels for distributing their content. Netflix do have a lot to gain from raising awareness around the severity of piracy, expanding their own market, but in my thesis I expect the streaming service not to take on this task themselves.

In this market, one might expect the consumers to multi–home, especially when the paid service does not include all available material[13]. Further, some consumers of the free alternative might actually wish to consume content legally, and therefore want to have a subscription to the legal

[12] `http://knowyourmeme.com/memes/piracy-its-a-crime`

[13] Multi–homing is connecting to multiple platforms simultaneously, instead of choosing one. The concept is further explained in the Litterateur chapter.

version to reduce the perceived personal social cost of "stealing" content. Nonetheless, I choose to preclude multi–homing from the model in my thesis. Multi–homing would on the other hand be an important contribution to the field, and a topic for future research.

The market also has a strong trend of using Virtual Private Network (VPN) for accessing geo–restricted content. For Netflix their catalogue differs a lot between different countries[14]. This has given birth to tools like Flixsearch, allowing users to find out which countries different content is available in[15]. This is called VPN–piracy, and Netflix works on ways to block it[16]. Nonetheless, this will not be further discussed in my thesis, as it is another branch of research. All users of Netflix will be treated as abiding the law, while the Popcorn Time users will be treated as breaking it.

Critical mass gives very different problems for the two sides of the market. Netflix, needing to be able to cover their operational costs in an efficient way and obtain some level of economies of scale, has a minimum critical mass n_{n}^{min}. At the same time, as they expand their user base the stress on the servers will increase and they will hit a maximum critical mass n_{n}^{max} before needing to reinvest in servers. The optimal level of subscriptions is therefore $n_{\mathrm{n}}^{*} \in [n_{\mathrm{n}}^{min}, n_{\mathrm{n}}^{max}]$.

For Popcorn Time, the problem is similar, but as they do not pay any royalties, for them the problems with a small user base are in their streaming model. Popcorn Time does not host any content themselves, all their activity goes through P2P hosting, where each user torrents the material they wish to consume. Accordingly, each existing user will benefit from one additional seeder (all users of Popcorn Time becomes seeders automatically) of material, as they will experience increased availability of content and better speed. These network economies provide intrinsic value for the users, being given a flawless consumer experience. As a consequence of this, the minimum critical mass, $n_{\mathrm{p}}^{\mathrm{min}}$, of Popcorn Time will depend on when they have enough users to provide a smooth and flawless experience. As earlier mentioned, a majority of the available content is provided by few (dedicated) uploaders, indicating that the minimum critical mass could be 0, as the marginal

[14]Norway has about a third of the content available in the US(`https://www.finder.com/netflix-usa-vs-world-content`).

[15]`https://flixsearch.io/`

[16]`https://torrentfreak.com/netflix-announces-crackdown-on-vpn-and-proxy-pirates-160114/`

content–contribution of additional users not necessarily is large. Because of the P2P model, there is no maximum mass of users that will set a cap on Popcorn Time. At the same time, Popcorn Time has a double–edged sword; even though the experience is improved, more users will also make the survival of the service more uncertain, as the industry–gain of taking them down also increases. Therefore, there will be an effective roof on how many users they should have, before their utility is decreasing. This roof will be attempted identified in the results. Therefore, the optimal level of user–mass is $n_{\mathrm{p}}^{*} \in [n_{\mathrm{n}}^{\mathrm{min}}, n_{\mathrm{n}}^{\mathrm{roof}}]$.

As work has been done on piracy in general and on two–sided markets, I am surprised to not find any work on these two topics combined, especially with one pay and one free actor. This has been a topic of debates since Napster started, in 1999, with free sharing of music[17].

The streaming market consists of many different platforms. Netflix is just one of many legal players in this market, and among others, Hulu[18] and Amazon Video[19]. Amazon Video is bundled with Amazon Prime, and HBO Go is bundled with some subscription from TV providers so their "user base" does not necessarily reflect their market share[20]. There are also some country specific players, like HBO Nordic[21] and Sky[22]. This makes it hard to say exactly how big the competitors of Netflix really are.

All these services operate more or less in the same fashion. They cost about the same, with all services in the range around USA $10/per month, and the difference lies in what content they provide access to. There are services that allow for rent/purchasing, like iTunes, but my thesis will only focus on the pure streaming services.

[17] https://www.theguardian.com/music/2013/feb/24/napster-music-free-file-sharing

[18] Being much smaller than Netflix with only 12 million users (http://www.thewrap.com/hulu-is-slowing-hits-12-million-subscribers-versus-netflixs-81-million/), only in the US.

[19] With about 54 million users, not exclusively to video-service, but Amazon Prime in total (not possible to separate), only available in the USA (http://www.investors.com/news/amazon-com-has-more-u-s-streaming-subscribers-than-netflix/).

[20] https://order.hbonow.com/nowvsgo

[21] HBO Nordics is a service designed by HBO to target Norway, Sweden, Denmark and Finland (http://in.reuters.com/article/us-netflixinc-scandinavia-idINBRE87E0JL20120815).

[22] from Italy (https://skystreaming.org/canali).

The reason why only two services are chosen to represent the two types of actors in this market comes from the fact that the illegal service has access to all content (as it acquires it without taking royalties or copyright into account); it will have all content available on all legal services on top of much more. Therefore, I expect Popcorn Time to have close to 100% of available content. The analysis will be replicable for any and all streaming–services operating in this market. When stripping down their offers, not to include multiple users per subscription, offline capabilities and other tweaks that might differentiate the services, their core offering to the consumer is the same: access to digital video content trough streaming. As I will only focus on the core of their product, services are similar enough not to be differentiated. The model can also be considered to allow for multiple services (the share of available content and user fee would increase, but theoretically no difference), but in my thesis I will consider on a market with only one agent.

After starting up in 2007, Netflix reached 75 million subscriptions in Q4 2015[23]. With more than 10 million users of Popcorn Time after a little more than a year[24] both services are huge, and have considerable effects on the market[25].

For the remainder of my thesis, I will first give an overview of the most important literature in Chapter 2. After this, Chapter 3 will define the model used for the analysis, divided into sections for Consumers, Platforms and Film Studios. Chapter 4 will be split into the analysis of lump–sum and per–user charges from Studios to Netflix, illustrating some results, before critic of the model. Lastly, Chapter 5 will wrap up the thesis with some concluding remarks.

[23] `http://www.statista.com/statistics/250934/quarterly-number-of-netflix-streaming-subscribers-worldwide/`

[24] `http://www.dn.no/magasinet/2015/09/07/1606/Popcorn-Time/inside-popcorn-time--the-worlds-fastest-growing-piracy-site`

[25] `http://www.theverge.com/2015/10/23/9600576/popcorn-time-history-timeline` — time line for the development of Popcorn Time.

Chapter 2: Literature Review

Although two–sided markets in recent years have been analysed quite extensively, resulting in a mature field with comprehensive literature, very little attention has been given to the streaming market, with the case of pirated versus legal agents next to unmentioned.

In this review, I start by briefly introducing the seminal literature on two–sided markets, on which my thesis is built. I will from this proceed to introduce some of the work done on the development of free software and why open source software can emerge, although there are massive opportunity costs for the contributors. Finally I will look into the extent to which existing literature addresses the implications of illegal actors in two–sided market.

2.1 Two–Sided Markets

Rochet and Tirole (2006) summarised the development in the field of two–sided markets since publishing their first article on the subject in 2002. In their initial article Rochet and Tirole (2002) used the interchange fees from credit card markets to exemplify two–sided markets, but within only a few years it became evident that the same framework could describe other interesting markets, and the media market has been the object of study in many articles. Despite being published over a decade ago, Rochet and Tirole (2006) is still a point of reference within two–sided markets, and I will focus on this work for the overview of the model.

The two–sidedness of the media market comes as a result of the interdependence and need for two groups to join the platform to reap full benefit. Newspapers, radio–stations and TV–channels all need to provide their advertisers with sufficient audience. By offering a product the audience want to consume, they ensure that the size of the audience is worthwhile for the advertisers. One of the main differences between media–markets and many other two–sided markets, are the externalities. On platforms such as dating–sites and credit–card companies the other side of the market experiences positive externalities as the opposite side grows; more users increases number of possible matches on dating sites; while for credit cards, a customer see a higher value of obtaining a credit card as more shops accepts the card, while shops sees a higher value of accepting a card as more customers have it. Most advertisers unquestionably increase their utility as the number of consumers increases and their reach expands, but consumers do not necessarily have the same opinion towards ads. Whether the externalities are positive or negative is an empirical question, and has been debated for a long time without any clear answer[26].

In classical two–sided market analyses, competition is defined through one of three models: Hotelling, representative consumer and Salop. The three models suit different objectives, and describe different competitive situations, as their features differs, to some extent, from each other. Which is better depends on the market conditions one wishes to model.

The Hotelling framework was introduced by Hotelling (1929), and models a duopoly situation with horizontal differentiation as standard, although the model allows for multiple firms and more complex competition. This will not be further discussed in my thesis, as I will look at two firms.

The differentiation in the Hotelling framework can be interpreted as physical position on a line through a city, ideological position on a political spectrum, or differentiation along any of a large number of other dimensions. With consumers uniformly distributed along the interval, they incur a "transportation cost" when they need to move along the line, consuming a product that is not identical to their preferences. This cost can either be physical transport, having to walk all the way to the store, or voting for a party not fully agreeing with your own political view. This transport can be thought of as a compromise, where a clash of position and preference is resolved by choosing the lesser of two evils. Standard Hotelling presumes perfectly inelastic demand, with

[26]The literature is split, with articles such as Kaiser and Song (2009) concluding that in the German market, advertising might have a positive effect on demand for both TV and certain magazines depending on their market. Bogart (1989) concludes similarly using simple linear demand (monopoly), without taking potential endogeneity into account. Peitz and Valletti (2008) on the other hand concludes that the degree of channel differentiation and the disutility–level of commercials will influence the outcome. Correspondingly Anderson and Coate (2005) finds that the externalities of commercials for U.S. TV consumers most likely are negative. From this it is evident that the true direction of the effect is disputed, and one cannot conclude.

only relative prices having implications for the distribution of consumers between the platforms. This assumption is called single–homing, where each side of the market connect with exactly one platform. Multi–homing, on the other side, is connecting with multiple platforms, allowing access to larger parts of the other side, to increase surplus.

The representative consumer framework normalises the population, scaling the whole market to be represented by a single consumer. In papers like Kind, Nilssen, and Sørgard (2009) the consumer chooses how much time to spend on the different media products, or aggregated what fraction of the population watching a given channel at a given time. One limitation to this framework, evident from Godes, Ofek, and Sarvary (2009), is that it does not take into account heterogeneity among consumers of the media product, expecting everyone to have the same utility from consuming the same content. As a response to this critique Kind, Nilssen, and Sørgard argue that the framework is not ideal for the full market, but rather for a segment, making heterogeneity a more likely assumption. Despite this limitation, the framework is extensively used, and very popular in the literature.

The last of the three, Salop circular city framework, defines the market as a circle, with the firms distributed along the periphery, and consumers "travelling" (comparable to that of Hotelling) among the firms to their best match. This makes Salop a good tool for entry–analysis and optimal number of firms in the market, complimenting the fixed–number prerequisite of Hotelling. For more information on Salop Circular City, see Salop (1979) or Choi (2006). This framework will not be further discussed in my thesis.

A main difference between one– and two–sided markets comes from the pricing strategy. Two sided markets have three functions compared to regular markets (Evans (2009) page 5): (1) facilitate easier exchange (e.g. eBay, NASDAQ), (2) build audiences, making it easier for the other side to reach possible matches (e.g. Google, news) and (3) provide shared resources to reduce cost for both groups (e.g. Windows, PlayStation). This makes two–sided markets into games of strategic interactions, where platforms simultaneously needs to take both sides into account when establishing the market equilibrium. As described in Ludwig (2000), cross–financing allows media–providers to finance content for consumers, by selling advertising (selling access to their user base). This will not be possible for all two–sided markets, but for streaming agents' banners and consumer–patterns can be a cross–financing source, allowing lower prices and higher consumer surplus. This skewed price structure has been dedicated to unobserved network externalities in the market, allowing the platform to strategically attract the two sides of the market to seem more interesting for the other side[27].

For the pricing in two–sided markets, Peitz and Valletti (2008) found an interesting result, when they allowed for negative prices for one side of the market — in their article, the buyers. When analysing the transition from Free–To–Air to Pay–TV the equilibrium profit is independent from volume of advertising, indicating that increases in revenue from sales will correspondingly reduce the content prices they can charge users, in effect cancelling each other out. They further predict total differentiation, with the platform located at the extremes of the Hotelling line, either fully ad–funded and free, or fully financed by fees without ads.

The nuisance parameter of advertising will decide the size of the advertising market in the model[28]. With increasing nuisance, it is evident that the channel with the lowest amount of advertising will capture users. The model does, on the other hand, not take economic surplus into account, as the surplus of the advertisers are not included in the model. In the case where TV is Free–To–Air, Peitz and Valletti (2008) come to an exactly opposite conclusion from that in Pay–TV. The marginal effect on revenue from selling ads has no (nuisance) effect, only increased revenues from sales, leading to overprovision of advertising in the Free–To–Air model compared to social optimum. The article further discusses how transportation cost affects the outcome, concluding that increased transportation cost will reduce the differentiation, as it becomes too costly to be located too far away from your competition, as you lose too many users.

They conclude, not surprisingly, that neither Pay–TV nor Free–To–Air produces a socially optimal equilibrium. Under Pay–TV there is too little advertising (as value for the advertisers are not taken into account when setting the level) and too much differentiation, while for Free–To–Air the result

[27] This fact has been duly proven in, among others, the work of Rochet and Tirole (2006) and Caillaud and Jullien (2003).

[28] Nuisance is to what extent consumers experience disutility from having to consume ads.

depends on the transportation cost and the nuisance parameter. These results show that the regime in which a service operate affect the outcome and what effect different choices has on the end result. For the legal streaming market, substituting both Free–To–Air and Pay–TV, it is important to remember that the advertisers might lose (depending on the nature of the streaming service) an important channel to reach consumers, and steps must be taken to ensure an outcome as close to social optimum as possible, also for the advertisers. These possible steps will not be further discussed in my thesis. Nor will advertising in the streaming market be further discussed, as this is outside the scope of my thesis.

Another aspect that could affect the price structure in a two–sided market according to Rochet and Tirole (2003), is the presence of marquee buyers[29] and multi–homing. Marquee buyers can best be considered an asset, as they attract players to the other side, allowing for increased price on the other side, and therefore result in higher market power. The power can originate from non-negligible switching cost, or proprietary rights. In markets consisting of more than one platform, multi–homing occurs when player(s) on either side of the market choose to connect to multiple platforms. When a player connects to only one platform, this i defined as single–homing. There are three cases to consider: (1) both groups multi–home, (2) one group multi–home and one group single–home and (3) both groups single–home. Case (1), where both groups multi–home, might be not be very common, because when all members of side A has joined all platform, members on side B need not join more than one platform to reach all agents on the other side. Exactly how multi– vs single–homing will affect the market has been discussed, and the seminal literature has yet to conclude on anything. Armstrong (2006) finds (in Proposition 4) that in a competitive bottleneck model the multi–homing side ends up being "exploited" and single–homing side ends up "aggressively" targeted by the platforms[30]. For the streaming market, the producers single–homes, selling their content to only one service. This forces consumers to multi–home using

[29]Marquee buyers are defined as "buyers generating a high surplus on the seller side"(Rochet and Tirole (2003, p. 24).

[30]Competitive bottleneck, defined on page 2 of Armstrong and Wright (2007), arise when differentiation only accrue on one side of the market (say buyers), forcing an equilibrium where the other side (say the sellers) has to multi–home. The platform (the stores) will then compete for the single–homing buyers, forcing their prices down, while the multi–homing sellers has to pay for it.

multiple services in order to gain access to content.

Dietl, Lang, and Lin (2013) discuss the welfare and profit effects in a two–sided market, with one free (with ads) and one paid (without ads) media provider. Their model is divided into two setups, pay–per–click and lump–sum transfers from advertisers to the free platform. Their analysis shows that the free media platform generates higher profits when the free media platform adopts a lump–sum fee than when it charges a pay–per–click fee to advertisers, while the pay media platform generates lower profits when the free media platform adopts a lump–sum charge. This comes from the fact that advertisers pay a higher price and the volume is higher in the case of lump–sum for the free media. The paid media on the other hand will experience a lower subscription fee, but demand increases enough to compensate for this. As this analysis looks into the streaming industry, it will utilise the conceptual thoughts and some ideas from Dietl, Lang, and Lin as a benchmark on how to conduct the analysis.

Rasch and Wenzel (2013) use a two–sided market analysis with operational systems (such as Microsoft Windows) as the platform, customers wanting as much software as possible on their platform, and software developers wanting as many customers as possible on the platforms they develop on. The platform(s) must then set their prices (or subsidies) such that their own profit(s) are maximised, by attracting the right amount of developers and users. They further argue how piracy and software protection influence the cross–group externalities. With more piracy, the software developers lose revenue from decreasing sales, assuming that a pirate would pay for it otherwise[31]. At the same time, the software platform increases in value for the consumer, indicating that piracy with cross–financing might not purely have negative consequences, even though it might reduce the short–term profits. This will be further discussed in Section 2.3. My thesis will only use the insights from this as a background for modelling–purposes.

The general model of my thesis has been inspired by well–known literature on two–sided markets, among others Rochet and Tirole (2003), Armstrong (2006) and Rochet and Tirole (2006). Consistently, all these articles' price structures are heavily dependent on indirect network externalities between groups of users. Even though piracy might be negative for the direct revenues of the con-

[31] Note that, as discussed later on, this assumption is not strictly correct, illustrated in Smith and Telang (2009).

tent providers, it might increase sales of merchandise and/or awareness around the concept. For example, studies shows how piracy of music might lead to increased sales of concert tickets, and indirectly increase revenues[32]. Therefore, piracy in a two–sided market is not necessarily negative for the profit–maximising producer.

2.2 Open Source Software

Standard working situations consist of employees selling labour for compensation. Salaries are the exchange allowing the employers to directly manage the efforts of their employees. How does this change when the workforce no longer is paid? How do you explain the efforts of (more or less) skilled programmers in open source software development, when many easily could get monetary compensation for their efforts in other (commercial) projects?

Lerner and Tirole (2005) tries to explain this by adapting a standard framework from labour economics. They motivate their choice with the fact that open source software developers face a variety of benefits and costs, just as any other worker. Many contributors on open source projects forgo monetary compensation for their work, or in other ways have an (alternative) cost of contributing. On the other hand, there is several short– and long–term benefits that may counter these costs. One of many is the intrinsic pleasure it may provide the programmer with, working on a project whose outcome they themselves need, or simply to get their name on widely spread software. Furthermore, as they improve their skills, the contribution may improve future performance in paid work, or in other cases contributions may signal to future employers. When tested, the fact that a programmer contribute to an open source software project (tested for the Apache project, reported in Lerner and Tirole (2005, p. 105)) does not itself lead to higher salaries, but individuals with higher positions in the Apache organisation enjoy higher salaries from their everyday job, regardless of whether their work involves Apache programing, compared to others in the Apache organisation.

[32]As shown by Gayer and Shy (2006) and backed up by Peitz and Waelbroeck (2006).

The seminal work does not offer any empirical or proven explanation of what actually motivates the contributors of open source software. Among others, Haruvy, Wu, and Chakravarty (2005) finds that corporate intentions, with higher expected future salary as a main component, are important drivers for open source contributions. Lakhani and Von Hippel (2003) on the other hand, finds main motivation to be personal need to solve their own specific programming needs, while Lakhani, Wolf, et al. (2002) in a Boston Consulting Group survey finds that intellectual stimulation and improving skills are the main drivers for contributors. These three studies diverge quite a lot in their conclusions, indicating a level of uncertainty with respect to the true motivation.

Idland, Øverby, and Audestad (2015) look into the competition between legal and illegal video streaming services, using Netflix and Popcorn Time as proxies for the two sides. In their simulations they find that timing of entry is one of the most important factors for the success of the illegal actor. With timing they are referring to how developed the legal service is prior the entry of the illegal competitor, as this determines how well the illegal service ends up performing. Popcorn Time can experience growth either as a result of churning from Netflix, or independent decisions of users[33]. Therefore, a larger Netflix user–base before the entry of Popcorn Time, leading to (in absolute terms) more users churning, will result in a larger user–base for Popcorn Time. Idland, Øverby, and Audestad further state that network effects are among the most influential factors when users choose legal versus illegal services, comparing critical mass with roof point, to predict the effect on the growth of the illegal service. They also find that P2P provides a far better end–result compared to client–server for the users when the market becomes large enough. In my thesis I will not look into timing as a parameter of success, but will draw on this general insight.

The consensus in the market seems to be that downloading and piracy is hurting the movie industry, and that as long as downloading exists, the legal industry will suffer. As co–chairman of Fox Filmed Entertainment, Jim Gianopulos[34], puts it,

"We can't compete with free. That's an economic paradigm that doesn't work."

[33]Churning is the act of convincing users to change service after first adopting the other one.

[34]Quoted by Smith and Telang (2009), on page 1.

Smith and Telang (2009) tested this statement, using sales data from Amazon[35], broadcasting on television and downloading[36]. Their analysis focus on how broadcasting of movies changes sales, with a hypothesis that showing a movie on TV would reduce sales. Beside this, they analysed the effect of availability of the movies shown on TV on BitTorrent, and how this affected DVD–sales. When testing this, Smith and Telang finds no significant evidence that availability of movies on BitTorrent sites at the time of airing on TV hurt DVD–sales. This might seem counter–intuitive, but the authors explain this as caused by the market consisting of two separate groups of consumers — those willing and those unwilling to pay for content. It would be pure speculations discussing how the situation would be without piracy, and if it is true that the group buying never would download while the group downloading would never buy, the value of focusing on piracy is limited. That being said, there is no empirical evidence of a clear–cut division between the two groups, and my model assumes all consumers chooses based on subjective valuation, and maximisation of expected utility.

2.3 Illegal actors in two–sided markets

Rasch and Wenzel (2015) analyse how the piracy problem differs for prominent and non–prominent software in two–sided markets[37]. With examples from the markets of gaming and phone–applications, Rasch and Wenzel (2015), much like Rasch and Wenzel (2013), describe the problem of piracy and how this might affect profit for developers and platforms in the markets. For some markets, like the one for phone–applications, the piracy rates are as high as 90% constituting a tremendous problem[38]. At the same time, Rasch and Wenzel (2015, p. 2), report that a study by the Yankee Group and Skyhook from 2011, investigating the impact of app piracy on 75 Android developers,

[35]As other sales channels might not carry a full selection of all material, focus has been set to Amazon.

[36]Tracking seeders, leechers and total number of downloads from BitTorrent pages like The Pirate Bay.

[37]Prominent and non–prominent software are distinguished by level of consumer knowledge. Prominent software is known to the consumers prior to choosing which platform to join, by virtue of which it influences the decision of what platform to join.

[38]`https://www.theguardian.com/technology/appsblog/2012/jul/23/dead-trigger-android-free-piracy`

revealed that 27% consider piracy a “huge problem” and another 26% consider it “somewhat of a problem”, indicating that remaining 47% of the developers experience no problem with piracy.

The main findings of Rasch and Wenzel (2015) is that the more popular the prominent software is, the more likely it is to be pirated, but, contrary to conventional wisdom, additional software protection will not necessarily benefit the producers of this software. The model allows developers to multi–home, while users single–home. One of the main findings of the article is that software protection and piracy will affect the developer very differently depending on their software being prominent or not, owing to their pricing strategy in the two cases. With prominent software, the platforms have an incentive to subsidise developers, and these results holds even when the developers are distributed continuously along an interval from least to most prominent — the more prominent developers will gain more from reduction in software protection, as the increase in piracy will induce higher value from the platform and thus a transfer of money from platforms to developers. There will be different effects at hand, but piracy might increase the user–base of a platform enough for the platform to compensate the developers for the piracy. In this case, piracy contributes to platform’s competing for prominent developers. This effect, from lower software protection only holds for the prominent developers, and thus higher software protection will be positive for the non–prominent developers. That being said, the whole model builds on the condition that platforms can observe which applications are prominent and non–prominent. This might not be so easily done, in practice giving rise to non–observable effects.

Gramstad (2016) analyses how optimal pricing strategies change when a proprietary software developer faces competition from free–of–charge open source software, in the presence of network–externalities and software piracy. Referring (on page 2) to the 2011 BSA Global Piracy study, the author states that an estimated 42% of all software used in 2011 was pirated, arguing that not only are profits affected by the massive downloading, but also the structure of the industry itself will be changed. For all products with externalities and user–scalability, where knowledge on how to use and understanding of the system is of importance, the number of users with prior knowledge of your product is very important to “win” the market. This leads many commercial firms to set their prices so that critical mass of users is not attainable for the open source software, a strategy called “network strategic pricing”. This allows the commercial firms to take a much larger share, at the expense of open–source products.

The presence of piracy makes "network strategic pricing" more likely, both because the size of the user–base increases and because piracy already drives the price down, so the increase in quantity sold of the commercial product, relatively speaking, is less costly for the firm[39].

Gramstad's model has three types of software; legal (Windows, bought), illegal (Windows, pirated) and open source (Linux, obtained for free). There are two types of consumers, new and old. The old have already chosen their platform, and will stay there, while the new consumers have to choose which platform to join. When not taking network externalities into account, the model predicts the open source platform becoming much larger than the commercial one, as it is free and legal. On the other hand, when both externalities and piracy are taken into account, the number of old users of the commercial alternative compared to its critical mass affects the outcome — if the externalities are large enough, network strategic pricing will be observed (to outperform the open source alternative)[40]. These results are affected by the quality of copies, and therefore how good of an alternative the pirated software actually is. Gramstad (2016) also find that reduced piracy will reduce the price, as the critical mass needed stays the same, but fewer use it, and price must be reduced to obtain the critical mass.

The software– and the movie industry are very different, but at the same time, some of the same logic can be applied. The concept of "critical mass" for the entertainment industry is not necessarily clear nor applicable, none the less, as Smith and Telang (2009) concludes there are two different groups — those willing and those unwilling to pay — the piracy might just increase the

[39]This argument builds on the logic that reduced price will increase quantity, but as price already is reduced to counter the effects of piracy, parts of the reduction needed to win against open–source software already has been taken, therefore the additional loss is lower, while the gain from weaker competition, because of the network strategic pricing, stays the same.

[40]Critical mass is the smallest number of users a platform can have to maintain a self–sustaining development, or in other words, the tipping point where externalities are sufficiently large to have an effect.

attention and hype of a movie so that more of those willing to buy a movie will acquire it[41]. So the lost revenue is, in actuality, not as large as the theoretical earnings lost to piracy of the specific content.

[41]One can argue that this mass will depend on how much each member is willing to pay, and it would rather be a "critical earnings" level, but including this will greatly complicate the model, without touching the general area of interest.

Chapter 3: The Model

In this section I wish to model the streaming market in a theoretical two–sided Hotelling framework, to illustrate effects of endogenous and exogenous parameters on consumer distribution and platform utility.

The model will take into account three types of agents: consumers (users), platforms and Studios. The platforms will be one paid client (labelled Netflix) and one free (but illegal) client (labelled Popcorn Time). Netflix charges a premium for access to its content, while Popcorn Time gives it for free.

Since the streaming market is not completely developed yet, with a still–expanding user base, it is not possible to identify the platform competition to be of a pure Hotelling fashion. This makes a compelling argument for finding other ways to identify competitive systems to better capture the market dynamics. Studies as that done by Devletoglou in 1965 built upon an uneven distribution of population, based on the general clustering of opinions we observe in the world, as Li et al. (2013) found. In the streaming market, it can be argued that most consumers probably find themselves in the middle, not dedicated to either legal or illegal alternatives, as personal attitude towards illegal acquisition of digital content is itself an opinion the individual need to form for themselves. In my thesis I will not attempt to model this, but rather build on conventional Hotelling competition.

3.1 Consumers

I set the number of consumers to be $\theta \in \mathbb{R}^+$, being uniformly distributed along the unit interval. Consumers are modelled with unit demand, wanting either 0 or 1 unit, and I assume that the intrinsic value of consuming either services is sufficiently large to ensure complete market coverage, where all consumer choose one of the two services. Netflix and Popcorn Time are located at the extremes of the interval with Netflix (denoted by n) at 0 and Popcorn Time (denoted by p) at 1.

The model has linear transportation cost $t \in \mathbb{R}^+$ with horizontal differentiation, where t best can be considered as a differentiation parameter. The lower the t value is, the closer substitutes are the two services.

For the consumer located at $x \in [0, 1]$, the utility function from consuming media content from Netflix is

$$u_{\mathrm{n}} = \delta_{\mathrm{n}} v - S_{\mathrm{n}} - tx, \qquad u_{\mathrm{n}} \in [0, \infty\rangle \tag{3.1}$$

where $S_{\mathrm{n}} \in \mathbb{R}^+$ is the subscription fee for Netflix. $v \in \mathbb{R}^+$ is the value of consuming all available content in the world, while the δ_{n}[42]$(\in [0, 1])$ term defines how much of the possible content is available on Netflix.

The utility function from consuming media content from Popcorn Time is

$$u_{\mathrm{p}} = E(H) - \gamma(I) - t(1 - x), \qquad u_{\mathrm{p}} \in [0, \infty\rangle \tag{3.2}$$

where $\gamma(I)$ is the effect of anti–piracy investments (further discussed in Section 3.3) and $E(H)$ is defined as the utility from using Popcorn Time, increasing in hours spent on development by the developers (further discussed in the Section 3.2, under Popcorn Time).

As all content on Netflix can, and in close to all cases will, be copied, or with other methods, be made available on pirating alternatives such as Popcorn Time, the content on Popcorn Time will always be higher than Netflix[43]. I will assume that the content on Popcorn Time is high, and close to 100%, and therefore not incorporate this further into my model.

The marginal consumer, obtained by finding the indifferent consumer with the same value from both services, when utility from Netflix (from Equation 3.1) and from Popcorn Time (from Equation 3.2) is equal, will be located in

$$x = \frac{1}{2} + \frac{1}{2t}\left[v\delta_{\mathrm{n}} - S_{\mathrm{n}} - E(H) + \gamma(I)\right]. \tag{3.3}$$

[42] This formulation is based on an article on Green Consumerism, (Eriksson 2004).

[43] On average it takes about one hour from a show has aired before it is piratable (`https://www.quora.com/How-much-time-does-it-take-for-a-new-episode-of-any-TV-series-to-arrive-on-torrents-just-after-its-release-on-tv`).

With a market size of θ, multiplying x with the market size results in the demand for each of the two services being,

$$n_{\mathrm{n}} = \frac{\theta}{2t}\left[t + v\delta_{\mathrm{n}} - S_{\mathrm{n}} + \gamma(I) - E(H)\right], \qquad n_{\mathrm{n}} \in [0, \theta] \tag{3.4}$$

$$n_{\mathrm{p}} = \frac{\theta}{2t}\left[t + E(H) - v\delta_{\mathrm{n}} + S_{\mathrm{n}} - \gamma(I)\right] \qquad n_{\mathrm{p}} \in [0, \theta] \tag{3.5}$$

where $n_{\mathrm{p}} = \theta - n_{\mathrm{n}}$.

3.2 Platforms

The media platforms provide access to the content for consumers. The consumers want access to the material they wish to consume, and experience increasing utility with greater selection, according to their utility.

For Netflix the profit is given by,

$$\pi_{\mathrm{n}} = S_{\mathrm{n}} n_{\mathrm{n}} - \delta_{\mathrm{n}}\beta, \tag{3.6}$$

where $S_{\mathrm{n}} n_{\mathrm{n}}$ is the income of Netflix and $\delta_{\mathrm{n}}\beta$ is the royalty transfer the Studios impose on Netflix for access to a part δ_{n} of their content. $\beta \in \mathbb{R}^{+}$ is the payment–scheme from Netflix to the studios for access to all content weighted for the content part (δ_{n}) Netflix choose to host. β is R_{n} in the lump–sum case of Regime A, and β is $r_{\mathrm{n}} n_{\mathrm{n}}$ in the per–user case of Regime B. For more information, see Section 3.3.

For the utility function of Popcorn Time, a programming team commented

"The first goal for Popcorn Time is to make the best viewing experience for all our users, and the other is to make the safest watching experience so all our users can fulfil the first goal without getting in trouble"[44].

Because of this, the success, or utility, of Popcorn Time, w_{p}, will be increasing with how good the

[44] This if from the team behind Time4Popcorn, one of many versions, (`https://torrentfreak.com/popcorn-time-has-millions-of-users-140709/`).

program is $(E(H) = (\psi H - \lambda))$ and negatively correlated with user share:

$$w_{\text{p}} = (\psi H - \lambda)\left[1 - \frac{n_{\text{p}}}{\theta}\right] \qquad w_{\text{p}} \in \mathbb{R}^{+}, \tag{3.7}$$

where $H \in \mathbb{R}^{+}$ is how many hours the programmers choose to put into developing Popcorn Time, n_{n} is the user mass of Netflix (further discussed in Section 3.1) and θ is the market size. As mentioned earlier, Popcorn Time operates without a profit function, as they have no income. As a community, no–one is in charge, and there is therefore no overall utility or centralised decision on how much time to put into it. Therefore, each individual programmer choose for themselves how much effort (measured in hours, H) to put into it, programming new features like automatic language–detection, subtitles and so on. All of this is captured by the term $E(H) = (\psi H - \lambda) \in \mathbb{R}^{+}$, where $\frac{\lambda}{\psi}$ is the initial time spent needed to develop the basic model of the program. I model it as a linear relationship between hour spent and how good the program becomes. This is modelled such that this developer–utility is falling with larger market share, as the potential industry–gain from targeting Popcorn Time is increasing as Popcorn Time has a growing market share. Therefore, my thesis will model the developer–utility to be decreasing with user share, making their trade–off between making the optimal service for themselves, and attracting too much attention.

For Netflix the utility is the same as their profit, as that is what they are maximizing. The utility function of Netflix, w_{n}, will depend on number of users (n_{n}), subscription fee (S_{n}) and their pay–out to the studios ($\delta_{\text{n}}\beta$);

$$w_{\text{n}} = n_{\text{n}} S_{\text{n}} - \delta_{\text{n}}\beta \qquad q_{\text{n}} \in \mathbb{R}^{+}. \tag{3.8}$$

3.3 Film Studios

For the studios, maximising profits is maximising return on investment for their films. From this, I get their utility function to be,

$$u_{\text{s}} = \delta_{\text{n}}\beta - \alpha - I, \qquad u_{\text{s}} \in \mathbb{R}^{+} \tag{3.9}$$

where u_{s} is the studio's utility, $\delta_{\text{n}}\beta$ is the pay–out they get from Netflix, α is their production cost and I is investments they can make to increase awareness around the fact that Popcorn Time is illegal.

Consumer awareness of the illegality of Popcorn Time, γ, is governed by the effectiveness of investments, I, by the studios, in anti–piracy investments. An expression for this relationship is given by

$$\gamma(I) = \Delta + \kappa I, \qquad \gamma(I) \in \mathbb{R}^{+} \tag{3.10}$$

where Δ is the initial level of awareness, and κ is the marginal effect on consumer awareness and legislation (lobbying) per unit of capital invested by the studios. For the analysis, $\gamma(I)$ will be treated as one expression, and not as composed by individual elements. This way, the analysis will only consider the out come of these kinds of investments, not how much or how investments are spent. This is because how one can invest in anti–piracy investments are outside the scope of my thesis. I define γ such that $\frac{\mathrm{d}\gamma(I)}{\mathrm{d}I} \geq 0$ indicating that an increased level, I, in anti–piracy investment will increase the extent to which the consumers associate Popcorn Time with being illegal and investments in lobbying will lead to stricter legislation. This is in accordance with the finding of Coyle et al. (2009, p. 1032) under "Legal Considerations".

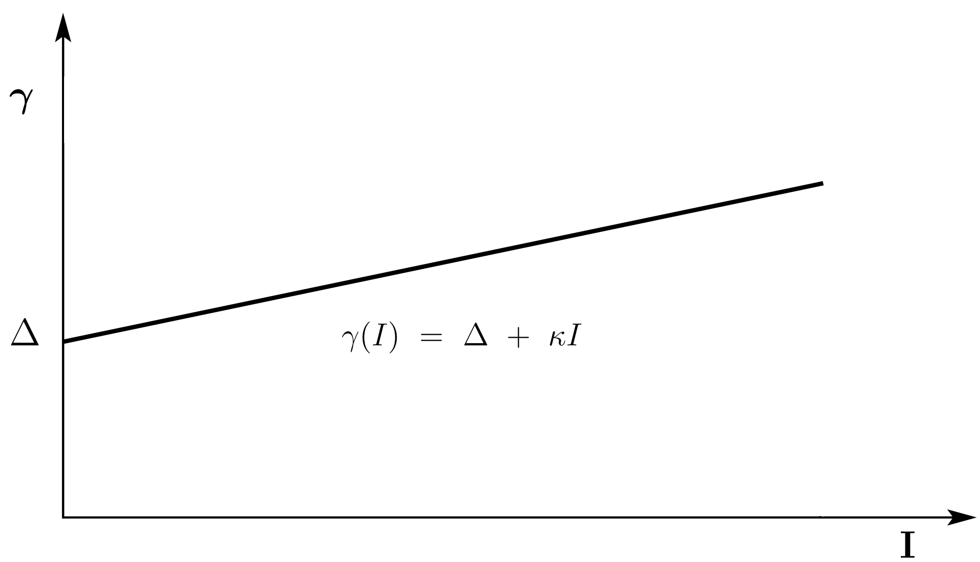

Figure 3.1: Linear development of consumer awareness of the fact that Popcorn Time is illegal, because of anti–piracy investments.

The effect of anti–piracy investments, $I \in \mathbb{R}^{+}$, is given by $\gamma(I)$ (from by Equation 3.10) and can be either increasing or constant. If increasing ($\kappa > 0$) the marginal effect of additional investments are as effective regardless of how much has already been put into it. On the other had if it is constant ($\kappa = 0$), investment will have no marginal effect. In my model the term $\gamma(I)$ is treated as being linearly increasing, assuming each additional unit invested in increased awareness is as efficient as the last one.

I have chosen to compile the fear of prosecution and illegal actions in the term $\gamma(I)$. The Studios have two types of anti–piracy investments they can undergo: campaigns and lobbying. Campaigns will spread the knowledge that Popcorn Time is illegal, increasing the perceived loss consumers experience, as they now knowingly takes part in illegal activities. Not all consumers will care sufficiently about breaking the law, but might still experience some sort of subjective social cost of doing so. Additionally, I have not included any specific variable for the fear of prosecution, due to the low chances of actually being caught. Less than 0.00583% of all pirates in the US were prosecuted in 2009, and even less faced legal action (Holbrook (2015, p. 11)). The second alternative for the Studios, is investments in lobbying. Lobbying is used to strengthen laws, as they were in Sweden in 2009, where the increased fear of being prosecuted reduces pirating substantially, with a 40% drop over–night in internet traffic, mostly attributed to reduced downloading (Adermon and Liang (2014, p. 2))[45]. My thesis will not distinguish between the effect of investment in anti–piracy campaigns focus on consumers versus legislative authorities, and will refer to them as "anti–piracy investments". I will assume the best measures are chosen at any given time, making it a linear relationship, as shown in Figure 3.1.

As the term $\gamma(I)$ reflects effect of anti–piracy investments, I would expect it to be decreasing in population size (θ), as Diffusion of responsibility comes into play, and therefore, the single consumer to a lesser extent feel affiliation to the loss of the producers of content, when they acquire the content through illegal means[46].

With increasing fear of prosecution, fewer people take part in the network, reducing the availability of content on illegal streaming services (Adermon and Liang (2014)). All illegal content must be

[45] As the laws are not enforced, the fear decreases, and the old levels of downloading are resumed.

[46] Defined by Kassin et al. (2013) as a sociopsychological phenomenon whereby a person is less likely to take responsibility for action or inaction when others are present.

seeded by someone in the P2P network and therefore, increased fear leads to reduced available content. Popcorn Time, being dependent on the torrents supporting it, will observe a drop in available content when subjective social cost increases. I will disregard this effect, and not try to model it is my thesis.

There are other revenue streams for the studios, like cinema, DVD and Blu–ray sales, sponsoring and so on. As including these only makes the analysis unnecessarily complicated, I will disregard all other sources of revenue for the studios, except the payment from Netflix, $\delta_{\mathrm{n}}\beta$. This way α is interpreted as the part of total revenue that streaming is expected to cover.

From Equation 3.1 I have the consumer utility function of Netflix, given by among other the v parameter, defined as being the value a consumer experience when consuming all available content. At the same time, the studios set a value α that streaming is supposed to cover. As α represent the studio expected value of the same content as the consumers value to v, one should expect the two parameters to be aligned in equilibrium. The studios will observe how their content is received in the market, and on the basis of this re–evaluate the potential value of content to align with the consumer valuation, according to standard adjusted net asset method[47]. With this as an expectation, $\alpha = \alpha(v)$. As the consumer valuation cannot be directly changed by the studios, the value of α will be taken as given, and not further discussed in this thesis.

[47]A business valuation procedure used in acquisition accounting that changes the stated values of a company's assets and liabilities to reflect its current fair market values (`http://www.investopedia.com/terms/a/adjusted-net-asset-method.asp`).

Chapter 4: Analysis and Results

In this chapter, equilibrium is reached when both Netflix and Popcorn Time are choosing their best action, given the action of the other, maximising their own utility. Netflix has a content cost, $\delta_{\mathrm{n}}\beta$, according to their payment–scheme with the Studios and sets their subscription fee to maximise their revenue given this. This scheme can be either a lump–sum (Regime A) or a per–user–fee (Regime B). For simplicity the Studios, and the content they provide, is treated as one single entity. This is an unrealistic assumption and simplification, but solving the model with multiple and heterogeneous Studios is outside the core of my thesis.

In my model I assume that all consumers consume the same amount of content, and that all content has the same value. This is not a probable assumption, but the heterogeneity of the consumers is outside the scope of my thesis and will therefore be excluded.

The superscript, X^{A} for variable X in Regime A and X^{B} for variable X in Regime B, will define which regime the variable is describing.

4.1 Regime A: Lump–Sum Studio Charges

In Regime A, the royalty transfer, β, is a fixed lump–sum transfer from Netflix to the Studios, making $\beta = R_{\mathrm{n}}$, where R_{n} is the lump–sum pay–out from Netflix to the Studios, exogenously given. From Equations 3.4 and 3.5 I have

$$n_{\mathrm{n}} = \frac{\theta}{2t}[t - (\psi H - \lambda) - S_{\mathrm{n}} + \gamma(I) + v\delta_{\mathrm{n}}], \tag{4.1}$$

$$n_{\mathrm{p}} = \frac{\theta}{2t}[t + (\psi H - \lambda) + S_{\mathrm{n}} - \gamma(I) - v\delta_{\mathrm{n}}]. \tag{4.2}$$

Inserting this into the utility function of Popcorn Time from equation 3.7 and Netflix from equation

3.8, with $\beta = R_{\text{n}}$, I get,

$$w_{\text{p}}^{\text{A}} = (\psi H - \lambda)\left(1 - \frac{1}{2t}[t + (\psi H - \lambda) + S_{\text{n}} - \gamma(I) - v\delta_{\text{n}}]\right), \tag{4.3}$$

$$w_{\text{n}}^{\text{A}} = S_{\text{n}}\frac{\theta}{2t}[t - (\psi H - \lambda) - S_{\text{n}} + \gamma(I) + v\delta_{\text{n}}] - R_{\text{n}}. \tag{4.4}$$

The analysis will be conducted in two stages. Stage One will be to maximise the utility of Netflix (w_{n}^{A}) with respect to available content ($\delta_{\text{n}}^{\text{A}}$). In Stage Two, the utility of Netflix (w_{n}^{A}) will be maximised with respect to the subscription fee (S_{n}^{A}) and the utility of Popcorn Time (w_{p}^{A}) will be maximised with respect to the number of hours programmers put into it (H^{A}). I will solve it using backwards deduction, starting with Stage Two, then proceeding with Stage One.

Stage Two, Regime A

To find S_{n}^{A} and H^{A}, I maximise w_{n}^{A} subject to S_{n}^{A} and w_{p}^{A} subject to H^{A}. For Netflix, maximising revenue means having as high a user fee as possible, while considering the reduction in user mass as the fee increases. For Popcorn Time, the utility is increasing with hours spent, but so is their user mass, which in turn decreases the utility. Therefore, Popcorn Time developers will want to consider the user fee of Netflix, to maximise their own utility without obtaining too large of a market share. The results from Stage Two are,

$$S_{\text{n}}^{\text{A}} = \frac{t}{3} + \frac{\gamma(I)}{3} + \frac{v\delta_{\text{n}}}{3}, \tag{4.5}$$

$$H^{\text{A}} = \frac{1}{\psi}\left[\frac{t + \gamma(I) + v\delta_{\text{n}}}{3} + \lambda\right]. \tag{4.6}$$

For the consumer distribution I get

$$n_{\text{n}}^{\text{A}} = \frac{\theta}{6t}(t + \gamma(I) + v\delta_{\text{n}}), \tag{4.7}$$

$$n_{\text{p}}^{\text{A}} = \frac{\theta}{6t}(5t - \gamma(I) - v\delta_{\text{n}}). \tag{4.8}$$

See Appendix A, under "Calculations of Stage Two" for detailed calculations of these outcomes.

Further on, for Stage One of the analysis, the objective will be to maximise $w_{\mathrm{n}}^{\mathrm{A}}$ from Equation 4.4 subject to $\delta_{\mathrm{n}}^{\mathrm{A}}$. As the royalty transfer Netflix pay depend on the share of content they decide to host, they maximise utility by minimising content level, while taking into account the reduction in user mass as the content level decreases.

Stage One, Regime A

I now maximise $w_{\mathrm{n}}^{\mathrm{A}}$ from Equation 4.4, with respect to δ_{n}, to solve $S_{\mathrm{n}}^{\mathrm{A}}(\delta_{\mathrm{n}})$, $H^{\mathrm{A}}(\delta_{\mathrm{n}})$, $n_{\mathrm{n}}^{\mathrm{A}}(\delta_{\mathrm{n}})$ and $n_{\mathrm{p}}^{\mathrm{A}}(\delta_{\mathrm{n}})$. The result of Stage One is,

$$\delta_{\mathrm{n}}^{\mathrm{A}} = \frac{9tR_n}{v^2\theta} - \frac{t}{v} - \frac{\gamma(I)}{v}. \tag{4.9}$$

From this, I calculate consumer distribution, Netflix user fee and equilibrium effort of Popcorn Time programmers to be

$$n_{\mathrm{n}}^{\mathrm{A}} = \frac{3R_n}{2v} \tag{4.10}$$

$$n_{\mathrm{p}}^{\mathrm{A}} = \frac{\theta}{6t}\left(6t - \frac{9tR_{\mathrm{n}}}{v\theta}\right) \tag{4.11}$$

$$S_{\mathrm{n}}^{\mathrm{A}} = \frac{t}{3} + \frac{\gamma(I)}{3} + \frac{v}{3}\left[\frac{9tR_n}{v^2\theta} - \frac{t}{v} - \frac{\gamma(I)}{v}\right] = \frac{3tR_n}{v\theta} \tag{4.12}$$

$$H^{\mathrm{A}} = \frac{1}{\psi}\left[\frac{t + \gamma(I) + \left(\frac{9tR_n}{v^2\theta} - \frac{t}{v} - \frac{\gamma(I)}{v}\right)v}{3} + \lambda\right] = \frac{1}{\psi}\left[\frac{3tR_n}{v\theta} + \lambda\right]. \tag{4.13}$$

See Appendix A, under "Calculations of Stage One" for detailed calculation of these outcomes.

From these results, one of the first insights is the fact that anti–piracy investments has no effect on consumer distribution, equilibrium effort level of Popcorn Time programmers or Netflix user fee. The only parameter these investments affect is the content availability on Netflix, which it in turn only affect in a negative way. This comes from how the model is set up. As the anti–piracy investments increase, the social cost of using Popcorn Time increases. This reduces the utility for Popcorn Time users and increases the utility for Netflix users. Correspondingly, Netflix can reduce their content share, thus saving costs, without losing any users. As Netflix reduces content correspondingly to the increase in anti–piracy investment, the effect on users is cancelled out — social cost increases as the content share on Netflix decreases, making this a zero sum game. Anti–piracy investments can therefore be considered as monetary transfers from the Studios to Netflix in this model, not affecting consumer distribution, equilibrium effort level of Popcorn Time programmers or Netflix user fee. On the other hand, if there are no anti–piracy investments to "make up" for a reduction in content, users will expect a lower fee. This is consistent with the results of Goyanes (2014), which found a positive effect of content availability on willingness to pay.

The next observation from these results, is the fact that increasing royalty transfer, R_{n}, will increase the market share of Netflix. The best explanation I have for this is that increasing the royalty transfer has an effect on how using Popcorn Time is regarded. As this cost increases, it represent a situation where the Studios are more dependent on streaming–revenue to cover their costs, thereby increasing social pressure, making Netflix a more desirable service. Eres, Louis, and Molenberghs (2016) found that people are more willing to steal an intangible (torrenting content) versus a tangible (as the DVD of the same content would be) good. With increasing royalty transfer, larger parts of the Studios revenues comes from streaming and streaming becomes a more "tangible" good — not in the sense user can feel it, but as the revenue stream increase in importance, using Popcorn Time instead of Netflix harms the Studios in a more direct way. This increases the feeling of guilt, and is in accordance with the results of my model.

4.2 Regime B: Per–User Studio Charges

In Regime B, the royalty transfer, β, is a per–user transfer from Netflix to the Studios for each Netflix user, making $\beta = r_{\mathrm{n}} n_{\mathrm{n}}$. With a per–user charge, Netflix no longer has any economies of scale with increasing consumer–base $n_{\mathrm{n}}^{\mathrm{B}}$[48]. I have user–mass of Netflix from Equation 3.4 and for

[48] http://www.investopedia.com/terms/e/economiesofscale.asp

Popcorn Time from Equation 3.5,

$$n_{\mathrm{n}} = \frac{\theta}{2t}\left[t + v\delta_{\mathrm{n}} - S_{\mathrm{n}} + \gamma(I) - (\psi H - \lambda)\right], \tag{4.14}$$

$$n_{\mathrm{p}} = \frac{\theta}{2t}\left[t - v\delta_{\mathrm{n}} + S_{\mathrm{n}} - \gamma(I) + (\psi H - \lambda)\right]. \tag{4.15}$$

Inserting this into the utility function of Popcorn Time from equation 3.7 and Netflix from equation 3.8, with $\beta = r_{\mathrm{n}} n_{\mathrm{n}}$, I get,

$$w_{\mathrm{n}}^{\mathrm{B}} = S_{\mathrm{n}} n_{\mathrm{n}} - \delta_{\mathrm{n}} r_{\mathrm{n}} n_{\mathrm{n}}, \tag{4.16}$$

$$w_{\mathrm{p}}^{\mathrm{B}} = (\psi H - \lambda)\left(1 - \frac{n_{\mathrm{p}}}{\theta}\right). \tag{4.17}$$

The analysis will be conducted in two stages. Stage One will be to maximise the utility of Netflix ($w_{\mathrm{n}}^{\mathrm{B}}$) with respect to available content ($\delta_{\mathrm{n}}^{\mathrm{B}}$). In the second stage the utility of Netflix ($w_{\mathrm{n}}^{\mathrm{B}}$) will be maximised with respect to subscription fee ($S_{\mathrm{n}}^{\mathrm{B}}$) and the utility of Popcorn Time ($w_{\mathrm{p}}^{\mathrm{B}}$) with respect to the hours (H^{B}) invested by the developers of the service. I will solve this using backwards deduction, starting with Stage Two, then proceeding with Stage One.

Stage Two, Regime B

To find $S_{\mathrm{n}}^{\mathrm{B}}$ and H^{B}, I maximise $w_{\mathrm{n}}^{\mathrm{B}}$ subject to $S_{\mathrm{n}}^{\mathrm{B}}$ and $w_{\mathrm{p}}^{\mathrm{B}}$ subject to H^{B}. For Netflix, maximising revenue would be having as high a user fee as possible, while considering the reduction in user mass as the fee increases. For Popcorn Time, the utility is increasing with hours spent, but so is their user mass, which in turn decreases their utility. Therefore, Popcorn Time developers will want to consider the user fee of Netflix, to maximise their own utility without obtaining too large of a market share.

The results from Stage Two are,

$$S_{\mathrm{n}}^{\mathrm{B}} = \frac{t}{3} + \frac{\gamma(I)}{3} + \frac{\delta_{\mathrm{n}}}{3}(2r_{\mathrm{n}} + v), \tag{4.18}$$

$$H^{\mathrm{B}} = \frac{1}{\psi}\left(\frac{t + \gamma(I) - \delta_{\mathrm{n}}(r_{\mathrm{n}} - v)}{3} + \lambda\right). \tag{4.19}$$

For the consumer distribution I get,

$$n_{\mathrm{p}}^{\mathrm{B}} = \frac{\theta}{6t}(5t - \gamma(I) + \delta_{\mathrm{n}}(r_{\mathrm{n}} - v)), \tag{4.20}$$

$$n_{\mathrm{n}}^{\mathrm{B}} = \frac{\theta}{6t}(t + \gamma(I) + \delta_{\mathrm{n}}(v - r_{\mathrm{n}})). \tag{4.21}$$

See Appendix B, under "Calculations of Stage Two" for detailed calculation of the outcomes.

Further, for Stage One of the analysis, the objective will be maximise $w_{\mathrm{n}}^{\mathrm{B}}$ from Equation 4.16 subject to $\delta_{\mathrm{n}}^{\mathrm{B}}$. As the royalty transfer Netflix pay depend on the share of content they decide to host, they maximise utility by minimising content level, while taking into account the reduction in user mass as the content level decreases.

Stage One, Regime B

I will now maximise $w_{\mathrm{n}}^{\mathrm{B}}$ from Equation 4.16, with respect to $\delta_{\mathrm{n}}^{\mathrm{B}}$, to solve $S_{\mathrm{n}}^{\mathrm{B}}(\delta_{\mathrm{n}})$, $H^{\mathrm{B}}(\delta_{\mathrm{n}})$, $n_{\mathrm{n}}^{\mathrm{B}}(\delta_{\mathrm{n}})$ and $n_{\mathrm{p}}^{\mathrm{B}}(\delta_{\mathrm{n}})$. From these calculations I get,

$$\delta_{\mathrm{n}}^{\mathrm{B}} = \frac{t + \gamma(I)}{r_{\mathrm{n}} - v}. \tag{4.22}$$

From this, I calculate Netflix user fee, equilibrium effort of Popcorn Time programmers and consumer distribution to be

$$S_{\mathrm{n}}^{\mathrm{B}} = \frac{r_{\mathrm{n}}(t + \gamma(I))}{r_{\mathrm{n}} - v}, \tag{4.23}$$

$$H^{\mathrm{B}} = \frac{\lambda}{\psi}. \tag{4.24}$$

$$n_{\mathrm{n}}^{\mathrm{B}} = 0, \tag{4.25}$$

$$n_{\mathrm{p}}^{\mathrm{B}} = \theta. \tag{4.26}$$

See Appendix B, under "Calculations of Stage One" for detailed calculation of these results.

In the calculations I find the user distribution to be $n_{\mathrm{n}}^{\mathrm{B}} = 0$ and $n_{\mathrm{p}}^{\mathrm{B}} = \theta$, indicating Popcorn Time will capture the whole market if the Netflix has per–user royalty transfers, regardless of anti–piracy investments from the Studios and content– and fee–changes by Netflix. The equilibrium effort level for Popcorn Time developers is as low as the model allow, making the most basic version possible of Popcorn Time[49]. As Popcorn Time obtains the whole market one of two scenarios has happened: (1) Netflix has too little content, so no consumer consider them a viable option, (2) Netflix is too expensive, so no consumer consider the service worth the cost. As Netflix no longer may vary their user fee freely, it is bound by the minimum level of the per–user charge (r_{n}) the scenario where Netflix is too expensive is most likely to have happened. Compared to the lump–sum case Netflix no longer obtain any economies of scale, which in Regime A allowed a reduction in user fee with increasing market size. Because Netflix is so expensive it falls out of the market, Popcorn Time will (even with the most basic version of the program) capture the whole market. It can be argued that Popcorn Time developers could increase their utility by not developing their software, if effort comes at a cost. But, as the model assumes both services to appear in equilibrium, the decision not to produce lies outside the solution space of my model.

4.3 Results

I will now compare some of the results from Regime A and B, to better examine the difference between the two regimes. The two regimes cannot be directly compared, as the levels of parameters might be different, especially in equilibrium. That being said, under some assumptions it will still be possible to interpret how, and why some, seemingly equivalent changes has so different effects.

[49] As $E(H) = \psi H - \lambda$ a H value of $\frac{\lambda}{\psi}$ makes $E(H) = 0$, which is the lowest effort Popcorn Time developers can exert.

Utility of the Studios

The Studio–utility, u_s^A and u_s^B, is defined in Equation 3.9. For the two regimes the utility functions are,

$$u_\mathrm{s}^\mathrm{A} = \delta_\mathrm{n} R_\mathrm{n} - \alpha - I = \left(\frac{9tR_\mathrm{n}}{v^2\theta} - \frac{t}{v} - \frac{\gamma(I)}{v}\right) R_\mathrm{n} - \alpha - I, \tag{4.27}$$

with $\delta_\mathrm{n}^\mathrm{A}$ from equation A.22 and,

$$u_\mathrm{s}^\mathrm{B} = \delta_\mathrm{n} r_\mathrm{n} n_\mathrm{n} - \alpha - I = \frac{t + \gamma(I)}{r_\mathrm{n} - v} r_\mathrm{n} \cdot 0 - \alpha - I = -(\alpha + I), \tag{4.28}$$

with $\delta_\mathrm{n}^\mathrm{B}$ from equation B.25 and n_n^B from equation B.26.

For the same level of production costs (α) and invested capital in anti–piracy efforts (I) in both regimes, it is evident that $u_\mathrm{s}^\mathrm{A} \geq u_\mathrm{s}^\mathrm{B}$, indicating that the Studios are better off in Regime A, when asking for a lump–sum rather than per–user royalty transfer from Netflix. This coincides with the best–case scenario for Netflix, as they do not get any users in Regime B. From this I draw the conclusion that, as it is Netflix and the Studios together determining royalty scheme, Regime A will be preferred to Regime B. As mentioned in the calculations of Regime B, the model does not provide sufficiently large set of possibilities to predict a result in a satisfactory manner, as the modelling assumes Popcorn Time has to be developed. Therefore the results of the utility–comparison of the two regimes does not necessarily survive empirical testing.

As Regime A is the only regime with a positive surplus to the Studios, I will look into how changes in the consumer valuation will affect the utility of the Studios.

$$\frac{\partial u_\mathrm{s}^\mathrm{A}}{\partial v} = \left(\frac{-18tR_\mathrm{n}}{v^3\theta} + \frac{t}{v^2} + \frac{\gamma(I)}{v^2}\right) R_\mathrm{n} = \frac{R_\mathrm{n}}{v^2}\left(t + \gamma(I) - \frac{18R_\mathrm{n}}{v\theta}\right) \tag{4.29}$$

For Studio utility to be increasing in valuation of content, $(t + \gamma(I))v\theta > 18R_\mathrm{n}$ has to hold. This indicates that transportation costs, anti–piracy investments, consumer valuation of content and total number of consumers has to be sufficiently large compared to the transfer from Netflix to the Studios, otherwise, an increased consumer valuation will reduce studio utility. Rationally argued, a high transfer from Netflix to the Studios could lead to a higher user fee, which in turn reduces the equilibrium level of Netflix users. On the other hand, higher content value would allow higher user fee without reducing market share, which in turn would allow for higher lump–sum transfer from Netflix to the Studios. The Studios must restrain themselves when demanding royalties from Netflix — their royalty transfer must be balanced compared to the utility Netflix gives the users. If I postulate an idea that the lump–sum transfer from Netflix to the Studios, R_{n}, has to be linked to user valuation, v, and how many users there are in the market, θ, and call $\frac{R_{\mathrm{n}}}{v\theta} = \omega$, I get $\frac{t+\gamma(I)}{18} > \omega$. ω can here be interpreted as a ratio, which cannot be too high for users to participate.

Another take on this problem would be to resume the discussion from Regime A, on how anti–piracy investments can be considered a monetary transfer from the Studios to Netflix, and an optimal response to this could be for Studios not to invest in anti–piracy measures. For this to happen, differentiation between the services has to be sufficiently large, otherwise consumers would change service. The partial derivative of content share on Netflix with respect to differentiation parameter is,

$$\frac{\partial \delta_{\mathrm{n}}^{\mathrm{A}}}{\partial t} = \frac{9R_{\mathrm{n}}}{v^2\theta} - \frac{1}{v} = \frac{1}{v}\left(\frac{9R_{\mathrm{n}}}{v\theta} - 1\right), \tag{4.30}$$

and that the expression for partial derivative of Studio utility with respect to users content valuation to be positive only if $(t+\gamma(I))v\theta > 18R_{\mathrm{n}}$ holds. It makes intuitive sense that higher valuation of content would increase utility, as this would allow for higher revenues. If this holds, the partial derivative of content share will be negative, if $t > 1$, as $\left(\frac{9R_{\mathrm{n}}}{v\theta} - 1\right)$ leads to

$$\frac{9R_{\mathrm{n}}}{v\theta} < 1 \Rightarrow 9R_{\mathrm{n}} < v\theta \tag{4.31}$$

which must hold as $v\theta$ is larger than $18R_{\mathrm{n}}$. Therefore, increasing the differentiation parameter will reduce the content on Netflix. This can be rationalised as increasing differentiation will lead to consumers having a stronger connection to their platform — the cost of switching increases. Therefore, as Netflix wishes to minimise content (costs) to maximise revenue, increased differentiation will lead to less available content. This is accordance with the findings of Grossman and Shapiro (1984) where increased differentiation allows for a positive profit. In my thesis, if Netflix and Popcorn Time becomes heterogeneous enough, the user mass of Netflix will no longer consider Popcorn Time a viable option. Netflix can then increase the user fee, increasing their profits, without loss of user mass.

Effect of Consumer Valuation on User Fee

The effect of changing valuation of content on user fee is very different in the two regimes, leading to very different outcomes.

$$\frac{\partial S_{\mathrm{n}}^{\mathrm{A}}}{\partial v} = -\frac{3tR_{\mathrm{n}}}{v\theta}, \tag{4.32}$$

$$\frac{\partial S_{\mathrm{n}}^{\mathrm{B}}}{\partial v} = \frac{r_{\mathrm{n}}(t+\gamma(I)}{(r_{\mathrm{n}}-v)^2}. \tag{4.33}$$

In the lump–sum regime, user fee is negatively correlated with content valuation, and Netflix will reduce their fee to obtain higher market shares. In the per–user regime, user fee is positively correlated with content valuation, and Netflix will increase their fee to increase their revenue per user. The difference between these two regimes, is whether or not the service can benefit from economies of scale. In the per–user regime, Netflix no longer has the opportunity to reduce their fee to obtain market shares. This makes the Netflix user fee much higher in the per–user regimes, forcing them out of the market. No longer being able to decide the optimal fee level from the market, but rather having to take the royalty transfer as the minimum, deprives Netflix of adaptability. Under Regime A, the lump–sum transfer sets a lower bound on the user fee, $S_{\mathrm{n}} \geq \frac{R_{\mathrm{n}}}{n_{\mathrm{n}}}$, as cost must be covered. This bound is decreasing in user mass, and allows Netflix much more flexibility when it comes to adapting the fee.

Illustrations of equilibrium levels

To illustrate some of the effects, I have plotted the effect of different parameters on the distribution of consumers and utility for the platforms. As the model concludes that the whole market will be allocated to Popcorn Time in Regime B, all illustrations will be representations of Regime A.

To better highlight the effects at hand, I have scaled all figures so that the intervals $[0,1]$ on the x–axis and $[0,1]$ on the y–axis are scaled linearly, while the intervals $\langle 1,\infty]$ on the x–axis and $\langle 1,\infty]$ on the y–axis are scaled logarithmically. This is done to better illustrate the effects at low levels. Because of this, the graphs have breakpoints whenever they cross 1 on either axes, but this is due to the projection — the functions themselves are continuous.

For Figure 4.1 I will see how the consumer distribution is affected by changes in effort by the programmers behind Popcorn Time for different levels of user fee for Netflix.

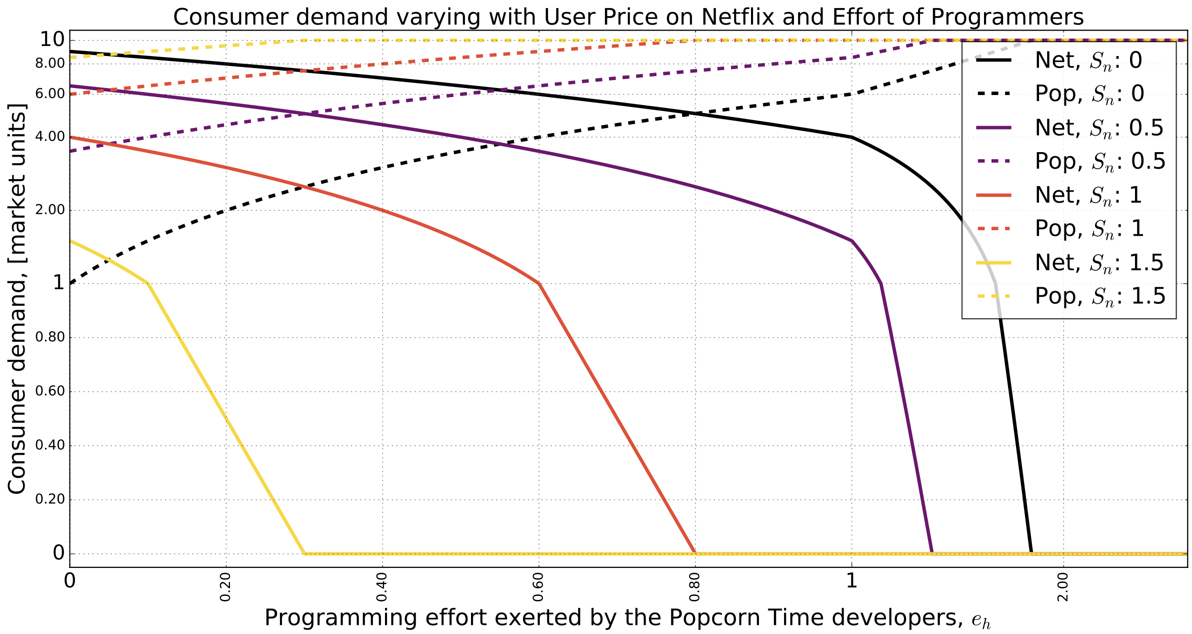

Figure 4.1: With consumer valuation set to 1, Netflix having 80% of available content, transportation cost set to 1, market size at 10 and the effect of anti–piracy investments is set to 0, with effort of Popcorn Time programmers varying for different levels of Netflix user fee.

Figure 4.1 shows a general trend — higher effort from the programmers behind Popcorn Time increases the user–mass of Popcorn Time, and higher user fee for Netflix will increase the user–mass of Popcorn Time. On the other hand, a quite interesting result is the fact that even if Netflix is free with a high amount of content, they will not conquer the whole market — Popcorn Time will obtain users either way.

Lower Netflix user fee will allow for higher programming effort without Popcorn Time obtaining higher market shares, increasing the utility of the programmers. In other words — the programmers behind Popcorn Time will set their effort in accordance with the Netflix user fee. Therefore, it can be considered such that the Popcorn Time programming team wishes to minimise how many users they have, and with lower user fee they can produce a better program without obtaining a higher user–mass. If Netflix is relatively cheap, compared to the value of their content, the effort from the programmers must be very high before Popcorn Time starts obtaining market shares. This was the case with the development of the Norwegian Bit–torrent network NorBits in the mid–2000s[50]. As their user–mass was very small (partly because of internal rules — invite as only entry method among other) the service grew, and no–one targeted them, allowing the site to host more or less all available content. Already in 2008 NorBits had over 10 000 unique files[51], and thousands of users. All this was possible by hiding from the police in a small closed network.

In Figure 4.2 I will illustrate the importance of content–availability is on the consumer distribution.

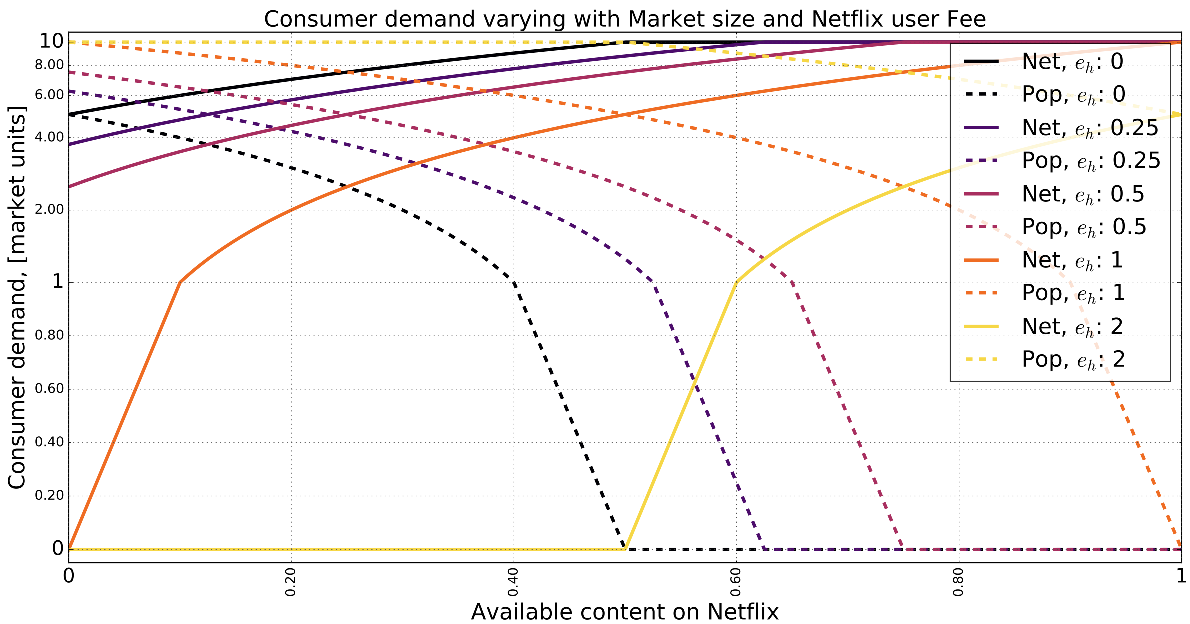

Figure 4.2: With consumer valuation set to 2, the transportation cost is set to 1, effect of anti–piracy investments is set to 1 and user fee set to 1, with varying content availability on Netflix for different levels of effort from the programmers of Popcorn Time.

From Figure 4.2 I get that even though many effects seem to be important, the share of available content seems to overshadows the effects of all these — when Netflix has a low amount of content Popcorn Time will capture market shares no matter how low the user fee is. From any starting point in the market, a very efficient approach to solving the piracy problem would be to expand the

[50] http://www.nettavisen.no/2216310.html

[51] http://itavisen.no/2008/05/07/norbits-pirat-snakker-ut/

amount of available content on legal services, to “drown” the illegal alternatives. Comparable to the development in the movie–industry the past decades, one can draw parallels to the development in the music–industry in the same period. From this, a possible basis for comparison for Netflix, is Spotify. Aguiar and Waldfogel (2015) concludes that in the music industry, streaming agents pay less than pure sales, but the overall effect ends up being revenue–neutral because of decreased illegal consumption. It has been argued, however, that movies are single–consumption goods, where the user does not wish to consume the same content more than once, rendering this argument from the music industry invalid. Either way, content–availability is of importance for Netflix, to capture large market shares. As argued by Piotr and Danny (2009), availability is an important driver for illegal consumption, indicating that the lack of access is itself a reason why consumers choose the illegal alternative.

Further Figure 4.2 show how Netflix has decreasing user mass with increasing programming effort from the Popcorn Time developers. With the most basic program (effort set to 0), the developers behind Popcorn Time themselves obtain no utility from the program, while too high effort (compared to user fee) will capture too large market shares, yet again depleting utility of the programmers. For medium levels of programming effort, the two services can coexist. Popcorn Time does not want to many users, and will be better of as content share of Netflix is increasing.

In Figures 4.3 and 4.4, I will show how variations in user fee affects the utility of Netflix and Popcorn Time. In these two figures, I will test this distribution for different levels of royalty transfer market size. Other values in the model, like anti–piracy investment and consumer valuation changes between the figures to highlight the effects in each figure. This is done to ensure that the effect under examination are explicit and within the possible outcomes reported in the figures.

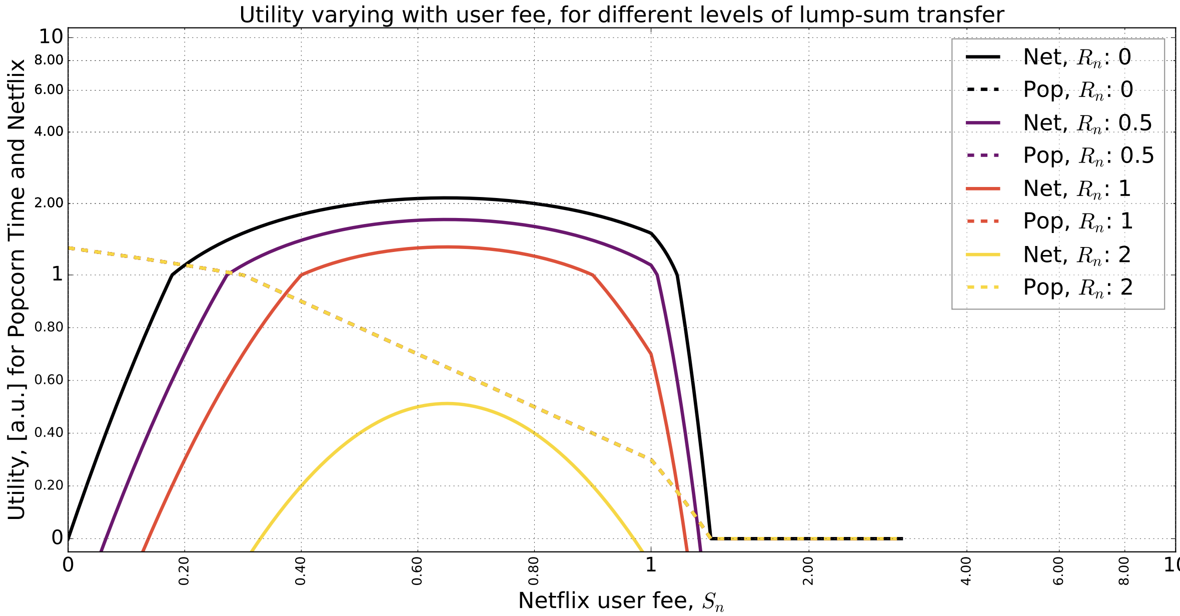

Figure 4.3: With consumer valuation set to 2, Netflix having 80% of available content, there are 10 people in the market, effort of programmers set to 2 and the effect of anti–piracy investments is set to 0.7, with Netflix user fee varying for different levels of royalty transfers.

In Figure 4.3 Netflix user fee varies for different levels of royalty transfers from the Studios to Netflix. As the figure clearly indicates, there is an optimal level of user fee for Netflix, at about 0.65 here. Regardless of the royalty transfers' size, this seems to be at more or less the same level. This optimal level comes from the fact that royalty transfers are not taken into account in Stage Two of the maximisation, rendering the level irrelevant for the optimal user fee. Therefore increases in the royalty will only serve to reduce the utility of Netflix.

The figure shows how Netflix has a diminishing market share with increasing user fee (indicated by the gradual decrease in Popcorn Time utility), levelling their utility at zero when the whole market is captured by Popcorn Time. As the only way the royalty transfers affect Popcorn Time is through user–mass, the utility of Popcorn Time is not affected by the level of these charges directly. The effect happens through the increased Netflix user fee, making Netflix so expensive no one chooses it anymore.

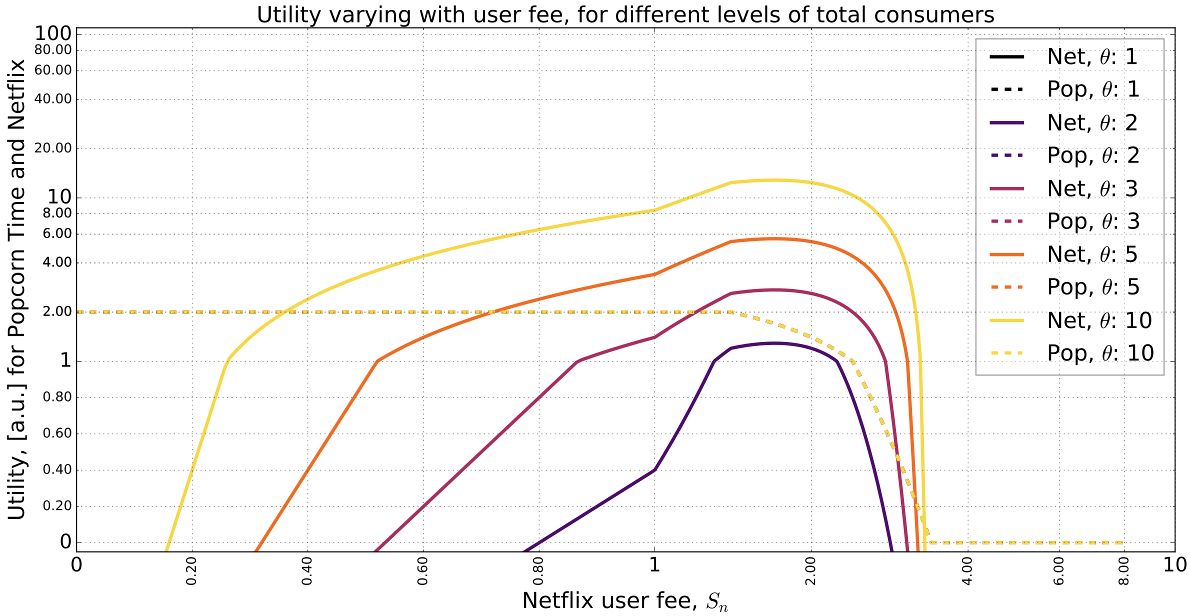

Figure 4.4: With consumer valuation set to 3, Netflix having 80% of available content, anti–piracy investments set to 2, programming effort set to 2, royalty transfers at 2 and transportation cost at 1, with Netflix user fee varying for different levels of market size.

In Figure 4.4. Popcorn Time has market–size independent utility, as their fare of being caught is depending on market share. For Netflix on the other hand, as they have fixed (royalty) costs to cover, they need either higher user fee or a larger market to be able to obtain profits. Netflix also have the same user fee as the optimal level for all market sizes, in this representation, with these parameters, about 1.6, just about the same level where Popcorn Time starts obtaining market shares. At this point, marginally increasing the user fee will no longer be able without losing too many users, and optimal solution is found.

The general trend when increasing the user fee for Netflix, regardless if it is tested for different levels of anti–piracy investments, market size, royalty transfers or effort of Popcorn Time programmers, is the sudden drop in utility at a certain level of user fee. This is the point at which utility of Popcorn Time surpasses that of Netflix, and Netflix no longer obtain enough users to cover their fixed (royalty) costs. In all scenarios, there will be an optimal fee for Netflix to charge, diminishing in programming effort and royalty transfers, increasing in population size and anti–piracy investments. These results are in accordance with standard supply and demand theory in economics.

Lastly, in Figure 4.5, I will show how variations in programming effort from the Popcorn Time developers affect the utility of Netflix and Popcorn Time.

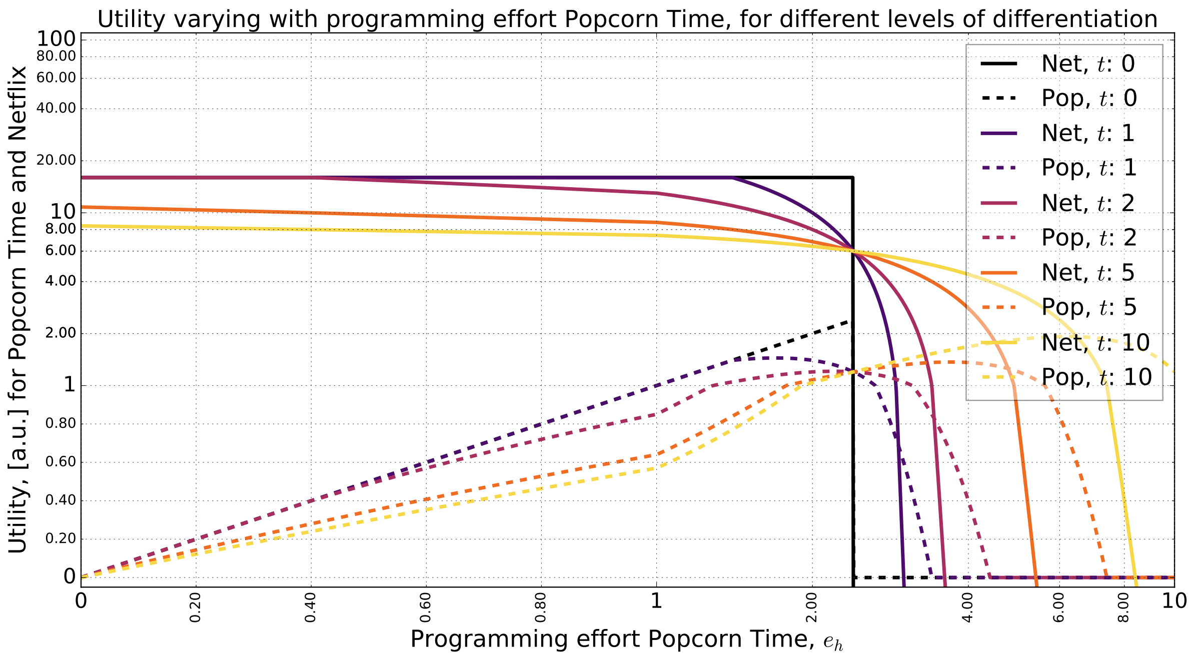

Figure 4.5: With consumer valuation set to 3, Netflix having 80% of available content, anti–piracy investments set to 2, user fee set to 2, market size set to 10 and royalty transfers at 5, with Popcorn Time programming effort varying for different levels of service differentiation.

The first conclusion drawn from Figure 4.5 is that with no differentiation between the two services — t is zero — the market is perfectly segmented between the services. Netflix obtains the whole market up until effort of programmers reach a "swap–level", after which Popcorn Time takes the whole market. As the differentiation increases, utility for Netflix falls for all levels of programming effort up until the "swap–level", where the value of Popcorn Time exceeds that of Netflix, and market share of Popcorn increases. After this point both services are better off with higher differentiation. From this I draw the conclusion that for low levels of effort Popcorn Time will be better off with low differentiation, while for higher levels of effort, Popcorn Time will be better off with higher differentiation.

The result that increased content availability increases utility is consistent with the study by Goyanes (2014), when testing willingness to pay (comparable to utility) against content availability. In their study, Goyanes finds a positive effect between willingness to pay and content availability, much like my model predicts also in the streaming market — which intuitively makes sense, as content is what the consumer pays to access. Higher differentiation will divide the market towards a situation where the two services take half the population each. From this we can draw the conclusion that if Netflix is struggling, differentiation will be a possibility to obtain safe market sharing. Predicting this kind of development is outside the scope of this model, and will therefore be pure speculations, and not further discussed in my thesis.

4.4 Critique of the Model

There are some calculations in the model that does not make sense, where the model just does not do a good job modelling the actual market dynamic. Some reasons for this might come from the fact that the modelling is not perfect — it is very unlikely that the effort invested by the Popcorn Time developers results in a linear increase in program–utility, regardless of how much has been put into it already. This is indirectly taken into account by having the utility of the programmers being negatively dependent on their share of the total user–mass (which in turn is dependent on the effort of the programmers). Nonetheless, the modelling of programmers' effort is probably among the weakest points of the analysis.

Building on the weak point of effort, the utility of the Popcorn Time developers is only negatively affected by increased user–mass, but empirically the developers comment themselves that "*the amount of love and thankfulness we've received from our millions of users since is [our motivation]. This is what keeps us going*"[52]. From this, it is evident that a more intricate relationship between the utility of the developers and the number of users are needed to better predict the market of Popcorn Time.

[52] http://cordcutting.com/interview-the-popcorn-time-se-team/

Another problem, related to the aforementioned issue with Popcorn Time's utility function depending on $(1 - \frac{n_{\text{p}}}{\theta})$ is the fact that if Popcorn Time takes the whole market their utility is 0. Popcorn Time can obtain full market coverage if the Netflix user fee is out of proportion, there is not enough anti–piracy investments or if the Studios simply go for a per–user charge as in Regime B. Although the model predicts Popcorn Time to take the whole market, it is unlikely that the utility of the Popcorn Time developers actually ends up being zero. From this, it seems that the model does not predict well in corner solutions.

The model does not take into account any way for Netflix to directly do anti–piracy investments, which in turn makes them unable to influence the consumers' perception of legality. Including this would allow for the model to better predict the market, and would therefore be a valuable extension for future research.

To regime B the most damaging flaw is the fact that the model predicts 100% of the market to Popcorn Time, regardless of any action Netflix takes, a result that cannot hold. This is a major issue when commenting on the effects and outcomes of the whole regime. As this payout scheme works in the music streaming industry, where Spotify pays out 70% of their user fee directly to the artists, as reported in Ranaivoson, Iglesias, and Vondracek (2013, p. 209). A key difference between these two services is that Spotify pays according to number of streams, not content–availability in itself. This changes the market, making it hard to predict the differences. It could still be an interesting topic for further research, expanding the model with a Regime C, where Netflix paid royalties to the Studios according to how many minutes of content has been streamed, like Spotify does.

A critique to the model as a whole is how the social costs are modelled, and how it expects all users of Popcorn Time to contribute equally. This is most most likely not the case. An additional consumer will not necessarily be willing or able to upload content because of lacking skills, not having content that is sought after or simply because the consumer does not wish to do so.

As is evident from the critic, the model has some flaws, that being said, it is possible to draw some general insight from the model, summarised in the Conclusion.

Chapter 5: Conclusion

The main purpose of my thesis has been to investigate whether regular two–sided market models can be applied to an industry with one illegal (and free) platform and one legal (and paid) platform. This is motivated by the observation that illegal alternatives keeps growing although anti–piracy laws are reinforced, with increasing severity and certainty of penalty. The analysis has looked into how a free Bit–Torrent streaming software with integrated media player (conceptualised with Popcorn Time) affects the market of a paid streaming service (conceptualised with Netflix), in a two–sided market with different payment schemes for the paid service. I find this to be a justifiable question when looking at how recent research into two–sided markets has shown that traditional economic intuition falls short.

My thesis argues how the competition in this market is principally different from regular markets, and that failure to take this into account can result in decreased profits and lower overall utility for all parties involved. To the best of my knowledge there has been no research done on two–sided markets with one illegal free actor and one legal paid actor prior to my thesis. To begin filling this research gap, I develop a model of competition between a pay streaming agent and a free streaming agent in a two–sided market.

Legal streaming agents rely on support from two very different, but inevitably linked groups: studios and consumers. At the same time, they are in competition not only with other legal streaming agents offering similar products, but also the illegal market, offering more content at no financial (but rather a personal "conscience") cost to the user. This leads to strategic decisions being far more complex compared to conventional and single–sided markets.

The two regimes discussed in the analysis, Regime A and B, differ in only one aspect — the monetary transfer from Netflix to the Studios. In Regime A Netflix pays a lump–sum royalty fee for access to the content regardless of user–mass, while in Regime B Netflix pays a per–user fee.

The model predicts that anti–piracy investments will have a positive effect on the utility of Netflix users, but Netflix will use this effect to reduced content availability, to increase their own revenue. When anti–piracy investments increases, the relative value of Netflix increases as well, but the content reduction removes the effect on consumer distribution. This makes anti–piracy investments a monetary transfer from the Studios to Netflix.

The Studios control two parameters — anti–piracy investments and royalty charges to Netflix. In market equilibrium the Studios will align the size of the royalty charges, and how large anti–piracy investments they endure, to maximise their own profit. As Popcorn Time has a "roof" on optimal investment, with diminishing return on invested programming effort, the model predicts a result where both services may coexist.

My analysis shows that for median–situation, with variables within reasonable and possible values, the market is shared between the two services. The results of my analysis indicate, in accordance with the results of Smith and Telang (2009), two separate consumer groups — those willing and those not willing to pay. My analysis does, however, show that if there are no anti–piracy investments, the illegal alternative will capture the whole market if content share on Netflix is sufficiently low. This can be seen as an argument for increased content on the streaming services, so that the illegal market can be suffocated, much like Aguiar and Waldfogel (2015) argues Spotify has done to downloading of music.

For Netflix, the outcome differs fundamentally between the payment schemes. As per–user charges lead to 0 users, their preferred scheme is, by far, A, where they get a part of the market. Lump–sum is also the best situation for the Studios, as their utility here is higher, regardless of the level of anti–piracy investments. From this, it is evident that the model predicts Regime A as the market outcome.

Chapter 6: References

Adermon, Adrian and Che–Yuan Liang (2014). "Piracy and music sales: The effects of an anti–piracy law". In: *Journal of Economic Behavior & Organization* 105, pp. 90–106.

Aguiar, Luis and Joel Waldfogel (2015). *Streaming Reaches Flood Stage: Does Spotify Stimulate or Depress Music Sales?* Tech. rep. National Bureau of Economic Research.

Anderson, Simon P and Stephen Coate (2005). "Market provision of broadcasting: A welfare analysis". In: *The review of Economic studies* 72.4, pp. 947–972.

Armstrong, Mark (2006). "Competition in two–sided markets". In: *The RAND Journal of Economics* 37.3, pp. 668–691.

Armstrong, Mark and Julian Wright (2007). "Two–sided markets, competitive bottlenecks and exclusive contracts". In: *Economic Theory* 32.2, pp. 353–380.

Bogart, Leo (1989). *Press and public: Who reads what, when, where, and why in American newspapers*. Psychology Press.

Caillaud, Bernard and Bruno Jullien (2003). "Chicken & egg: Competition among intermediation service providers". In: *RAND journal of Economics*, pp. 309–328.

Choi, Jay Pil (2006). "Broadcast competition and advertising with free entry: Subscription vs. free–to–air". In: *Information Economics and Policy* 18.2, pp. 181–196.

Coyle, James R et al. (2009). ""To buy or to pirate": The matrix of music consumers' acquisition–mode decision–making". In: *Journal of Business Research* 62.10, pp. 1031–1037.

Cuevas, Ruben et al. (2010). "Is content publishing in BitTorrent altruistic or profit–driven?" In: p. 11.

Devletoglou, Nicos E (1965). "A dissenting view of duopoly and spatial competition". In: *Economica* 32.126, pp. 140–160.

Dietl, Helmut, Markus Lang, and Panlang Lin (2013). "Advertising pricing models in media markets: Lump–sum versus per–consumer charges". In: *Information Economics and Policy* 25.4, pp. 257–271.

Eres, Robert, Winnifred R Louis, and Pascal Molenberghs (2016). "Why do people pirate? A neuroimaging investigation". In: *Social neuroscience*, pp. 1–13.

Eriksson, Clas (2004). "Can green consumerism replace environmental regulation?—a differentiated–products example". In: *Resource and energy economics* 26.3, pp. 281–293.

Evans, David S (2002). "The antitrust economics of two–sided markets". In: *Available at SSRN 332022*.

— (2009). "Two–sided market definition". In: *MARKET DEFINITION IN ANTITRUST: THEORY AND CASE STUDIES, Forthcoming*.

Gayer, Amit and Oz Shy (2006). "Publishers, artists, and copyright enforcement". In: *Information Economics and policy* 18.4, pp. 374–384.

Godes, David, Elie Ofek, and Miklos Sarvary (2009). "Content vs. advertising: The impact of competition on media firm strategy". In: *Marketing Science* 28.1, pp. 20–35.

Goyanes, Manuel (2014). "An empirical study of factors that influence the willingness to pay for online news". In: *Journalism Practice* 8.6, pp. 742–757.

Gramstad, Arne Rogde (2016). "Piracy in commercial vs. open–source software competition". In: *Open–Source Software Competition (March 7, 2016)*.

Grossman, Gene M and Carl Shapiro (1984). "Informative advertising with differentiated products". In: *The Review of Economic Studies* 51.1, pp. 63–81.

Haruvy, Ernan, Fang Wu, and Sujoy Chakravarty (2005). *Incentives for Developers' Contributions and Product Performance Metrics in Open Source Development: An Emprical Exploration*. Indian Institute of Management.

Holbrook, Matthew (2015). "Morality of Pirating Media". In:

Hotelling, Harold (1929). "Stability in Competition". In: *The Economic Journal* 39.153, pp. 41–57.

Idland, Elisabeth, Harald Øverby, and Jan A Audestad (2015). "Economic Markets for Video Streaming Services: A Case Study of Netflix and Popcorn Time". In: *Norsk Informatikkonferanse (NIK)*.

Kaiser, Ulrich and Minjae Song (2009). "Do media consumers really dislike advertising? An empirical assessment of the role of advertising in print media markets". In: *International Journal of Industrial Organization* 27.2, pp. 292–301.

Kassin, S et al. (2013). "Social psychology (2 nd Canadian ed.) Toronto". In: *ON: Nelson*.

Kind, Hans Jarle, Tore Nilssen, and Lars Sørgard (2009). "Business models for media firms: Does competition matter for how they raise revenue?" In: *Marketing Science* 28.6, pp. 1112–1128.

Lakhani, K and Eric Von Hippel (2003). “How open source software works:“free” user–to–user assistance”. In: *Research policy* 32.6, pp. 923–943.

Lakhani, K, Bob Wolf, et al. (2002). “The boston consulting group hacker survey”. In:

Lerner, Josh and Jean Tirole (2005). “The economics of technology sharing: Open source and beyond”. In: *The Journal of Economic Perspectives* 19.2, pp. 99–120.

Li, Lin et al. (2013). “Consensus, polarization and clustering of opinions in social networks”. In: *IEEE Journal on Selected Areas in Communications* 31.6, pp. 1072–1083.

Ludwig, Johannes (2000). “The essential economic problem of the media: Working between market failure and cross–financing”. In: *The Journal of Media Economics* 13.3, pp. 187–200.

Peitz, Martin and Tommaso M Valletti (2008). “Content and advertising in the media: Pay–tv versus free–to–air”. In: *international Journal of industrial organization* 26.4, pp. 949–965.

Peitz, Martin and Patrick Waelbroeck (2006). “Piracy of digital products: A critical review of the theoretical literature”. In: *Information Economics and Policy* 18.4, pp. 449–476.

Piotr, Stryszowski and Scorpecci Danny (2009). *Piracy of digital content*. OECD Publishing.

Ranaivoson, Heritiana, Maria Iglesias, and Anna Vondracek (2013). “Costs of Licensing for Online Music Services: An Explanatory Analysis for European Services, The”. In: *Mich. St. U. Coll. L. Int'l L. Rev.* 21, p. 665.

Rasch, Alexander and Tobias Wenzel (2013). “Piracy in a two–sided software market”. In: *Journal of Economic Behavior & Organization* 88, pp. 78–89.

— (2015). “The impact of piracy on prominent and non–prominent software developers”. In: *Telecommunications Policy* 39.8, pp. 735–744.

Rochet, Jean–Charles and Jean Tirole (2002). “Cooperation among competitors: Some economics of payment card associations”. In: *Rand Journal of economics*, pp. 549–570.

— (2003). “Platform competition in two–sided markets”. In: *Journal of the European Economic Association* 1.4, pp. 990–1029.

— (2006). “Two–sided markets: a progress report”. In: *The RAND journal of economics* 37.3, pp. 645–667.

Salop, Steven C (1979). “Monopolistic competition with outside goods”. In: *The Bell Journal of Economics*, pp. 141–156.

Smith, Michael D and Rahul Telang (2009). "Competing with free: the impact of movie broadcasts on DVD sales and internet piracy 1". In: *mis Quarterly* 33.2, pp. 321–338.

Zhang, Chao et al. (2011). "Unraveling the bittorrent ecosystem". In: *Parallel and Distributed Systems, IEEE Transactions on* 22.7, pp. 1164–1177.

Appendices

Appendix A: Calculations for Regime A

Calculations of Stage Two, Regime A

First, to find $S_{\mathrm{n}}(a_{\mathrm{p}})$ and $a_{\mathrm{p}}(S_{\mathrm{n}})$, I maximise $w_{\mathrm{n}}^{\mathrm{A}}$ with respect to S_{n} and $w_{\mathrm{p}}^{\mathrm{A}}$ with respect to a_{p}.

I got the utility of Netflix, given by

$$w_{\mathrm{n}}^{\mathrm{A}} = n_{\mathrm{n}} S_{\mathrm{n}} - \delta_{\mathrm{n}} \beta \tag{A.1}$$

from Equation 3.8 where $\beta = R_{\mathrm{n}}$ in regime A.

When differentiating $w_{\mathrm{n}}^{\mathrm{A}}$ with respect to S_{n}, I get,

$$\frac{\partial w_{\mathrm{n}}}{\partial S_{\mathrm{n}}} = n_{\mathrm{n}} + \frac{\partial n_{\mathrm{n}}}{\partial S_{\mathrm{n}}} S_{\mathrm{n}} = 0 \tag{A.2}$$

Which is,

$$\frac{\partial w_{\mathrm{n}}}{\partial S_{\mathrm{n}}} = \frac{\theta}{2t}\left[tv\delta_{\mathrm{n}} - S_{\mathrm{n}} + \gamma(I) + (\psi H - \lambda)\right] + \frac{\theta}{2}\frac{-1}{t} S_{\mathrm{n}} = 0 \tag{A.3}$$

and I multiply it by $\frac{2t}{\theta}$, yielding,

$$S_{\mathrm{n}} = \frac{t + v\delta_{\mathrm{n}} - (\psi H - \lambda) + \gamma(I)}{2} = S_{\mathrm{n}}(H). \tag{A.4}$$

For Popcorn Time I get the utility, w_{p}, from Equation 3.7, to be,

$$w_{\mathrm{p}} = (\psi H - \lambda)\left[1 - \frac{n_{\mathrm{p}}}{\theta}\right]. \tag{A.5}$$

When differentiating w_{p} with respect to H I get,

$$\frac{\partial w_{\mathrm{p}}^{\mathrm{A}}}{\partial H} = \psi\left[1 - \frac{n_{\mathrm{p}}}{\theta}\right] + (\psi H - \lambda)\frac{\delta n_{\mathrm{p}}}{\delta H}\frac{-1}{\theta} = 0 \tag{A.6}$$

which, when multiplying with $\frac{2t}{\psi}$ on both sides, gives,

$$2t - t - (\psi H - \lambda) - S_{\mathrm{n}} + \gamma(I) + v\delta_{\mathrm{n}} - (\psi H - \lambda) = 0, \tag{A.7}$$

where I move the term with H to the right side, yielding,

$$(\psi H - \lambda) = \frac{t - S_{\mathrm{n}} + \gamma(I) + v\delta_{\mathrm{n}}}{2}, \tag{A.8}$$

which can be rearranged such that,

$$H = \frac{1}{\psi}\left[\frac{t - S_{\mathrm{n}} + \gamma(I) + \delta_{\mathrm{n}}}{2} + \lambda\right] = H(S_{\mathrm{n}}). \tag{A.9}$$

Having both $S_{\mathrm{n}}(H)$ and $H(S_{\mathrm{n}})$, substituting the exression of H from Equation A.8 into S_{n} from Equation A.4 gives,

$$S_{\mathrm{n}} = \frac{t}{2} + \frac{v\delta_{\mathrm{n}}}{2} - \frac{1}{2}\left[\frac{t}{2} - \frac{S_{\mathrm{n}}}{2} + \frac{\gamma(I)}{2} + \frac{v\delta_{\mathrm{n}}}{2}\right] + \frac{\gamma(I)}{2}. \tag{A.10}$$

When multiplying both sides by 4, I get

$$4S_{\mathrm{n}} = 2t + 2v\delta_{\mathrm{n}} + S_{\mathrm{n}} - \gamma(I) - v\delta_{\mathrm{n}} + 2\gamma(I), \tag{A.11}$$

which ends up giving,

$$S_{\mathrm{n}} = \frac{t}{3} + \frac{\gamma(I)}{3} + \frac{v\delta_{\mathrm{n}}}{3}. \tag{A.12}$$

From this I can solve H, getting,

$$H = \frac{1}{\psi}\left[\frac{t - (\frac{t}{3} + \frac{\gamma(I)}{3} + \frac{v\delta_{\mathrm{n}}}{3}) + \gamma(I) + \delta_{\mathrm{n}}}{2} + \lambda\right] \tag{A.13}$$

which can be solved by multiplying both the numerator and denominator by 3, such that it will be 6 in the denominator, yielding,

$$H = \frac{1}{\psi}\left[\frac{t + \gamma(I) + v\delta_{\mathrm{n}}}{3} + \lambda\right], \tag{A.14}$$

which again implies that

$$(\psi H - \lambda) = \left[\frac{t + \gamma(I) + v\delta_{\mathrm{n}}}{3}\right]. \tag{A.15}$$

With the results of H and S_n, I calculate the consumer distribution to be

$$n_{\mathrm{n}} = \frac{\theta}{2}\left[\frac{3t + 3v\delta_{\mathrm{n}} - t - \gamma(I) - V\delta_{\mathrm{n}} - t - \gamma(I) + 3\gamma(I)}{3t}\right] = \frac{\theta}{6t}(t + \gamma(I) + v\delta_{\mathrm{n}}), \tag{A.16}$$

where I have multiplied the numerator and denominator with 3 to simplify the calculations.

For Popcorn Time the user mass will be,

$$n_{\mathrm{p}} = \frac{\theta}{2}\left[\frac{3t + t + \gamma(I) + V\delta_{\mathrm{n}} + t + \gamma(I) + v\delta_{\mathrm{n}} - 3v\delta_{\mathrm{n}} - 3\gamma(I)}{3t}\right] = \frac{\theta}{6t}(5t - \gamma(I) - v\delta_{\mathrm{n}}), \quad \text{(A.17)}$$

also this after multiplying numerator and denominator inside the brackets by 3. With these results, I will carry on to Stage One of the optimisation.

Calculations of Stage One, Regime A

Given H, S_{n}, n_{n} and n_{p}, I will now maximise the utility of Netflix given how much content they provide on their service (δ_{n});

$$w_{\mathrm{n}}^{\mathrm{A}} = n_{\mathrm{n}}S_{\mathrm{n}} - \delta_{\mathrm{n}}R_{\mathrm{n}}. \quad \text{(A.18)}$$

First I derive $w_{\mathrm{n}}^{\mathrm{A}}$ with respect to δ_{n}:

$$\frac{\partial w_{\mathrm{n}}^{\mathrm{A}}}{\partial \delta_{\mathrm{n}}} = \frac{\partial S_n}{\partial \delta_{\mathrm{n}}}n_{\mathrm{n}} + S_{\mathrm{n}}\frac{\partial n_{\mathrm{n}}}{\partial \delta_{\mathrm{n}}} - R_{\mathrm{n}} = \frac{v}{3}n_{\mathrm{n}} + S_{\mathrm{n}}\frac{\theta}{6t}v - R_{\mathrm{n}} = 0. \quad \text{(A.19)}$$

When fulfilling this, I get,

$$\frac{v}{3}\frac{\theta}{6t}[t + \gamma(I) + v\delta_{\mathrm{n}}] + \frac{1}{3}(t + \gamma(I) + v\delta_{\mathrm{n}})\frac{\theta}{6t}v = 0, \quad \text{(A.20)}$$

which I multiply with $\frac{18t}{v\theta}$, yielding,

$$t + \gamma(I) + v\delta_{\mathrm{n}} + t + \gamma(I) + v\delta_{\mathrm{n}} - \frac{18t}{v\theta}R_{\mathrm{n}} = 0, \quad \text{(A.21)}$$

which can be rearranged into,

$$\delta_{\mathrm{n}} = \frac{9tR_{\mathrm{n}}}{v^2\theta} - \frac{t}{v} - \frac{\gamma(I)}{v}. \quad \text{(A.22)}$$

From this, I calculate H, S_{n}, n_{n} and n_{p}, not no longer dependent on δ_{n}.

With n_{n} from Equation A.16, and δ_{n} from Equation A.22, user mass of Netflix is,

$$n_{\mathrm{n}} = \frac{\theta}{6t}\left(t + \gamma(I) + v\left(\frac{9tR_{\mathrm{n}}}{v^2\theta} - \frac{t}{v} - \frac{\gamma(I)}{v}\right)\right) = \frac{\theta}{6t}\left(\frac{9tR_{\mathrm{n}}}{v\theta}\right) = \frac{3R_{\mathrm{n}}}{2v}. \quad \text{(A.23)}$$

With n_{p} from Equation A.17, and δ_{n} from Equation A.22, user mass of Popcorn Time is,

$$n_{\mathrm{p}} = \frac{\theta}{6t}\left(5t - \gamma(I) - v\left(\frac{9tR_{\mathrm{n}}}{v^2\theta} - \frac{t}{v} - \frac{\gamma(I)}{v}\right)\right) = \frac{\theta}{6t}\left(6t - \frac{9tR_{\mathrm{n}}}{v\theta}\right). \tag{A.24}$$

The equilibrium consumer fee, with S_{n} from Equation A.12 and δ_{n} from Equation A.22, will be given by,

$$S_{\mathrm{n}} = \frac{t}{3} + \frac{\gamma(I)}{3} + \frac{v}{3}\left[\frac{9tR_{\mathrm{n}}}{v^2\theta} - \frac{t}{v} - \frac{\gamma(I)}{v}\right] = \frac{3tR_{\mathrm{n}}}{v\theta}, \tag{A.25}$$

and the equilibrium effort of Popcorn Time developers, with H from Equation and δ_{n} from Equation A.22, will be given by,

$$H = \frac{1}{\psi}\left[\frac{t + \gamma(I) + \left(\frac{9tR_{\mathrm{n}}}{v^2\theta} - \frac{t}{v} - \frac{\gamma(I)}{v}\right)}{3} + \lambda\right] = \frac{1}{\psi}\left[\frac{3tR_{\mathrm{n}}}{v\theta} + \lambda\right]. \tag{A.26}$$

Appendix B: Calculations for Regime B

Calculations of Stage Two, Regime B

First, to find S_{n} and H, I will maximise $w_{\mathrm{n}}^{\mathrm{B}}$ subject to S_{n} and $w_{\mathrm{p}}^{\mathrm{B}}$ subject to H. I got the utility of Netflix given by,

$$w_{\mathrm{n}}^{\mathrm{B}} = n_{\mathrm{n}} S_{\mathrm{n}} - \delta_{\mathrm{n}} \beta, \tag{B.1}$$

from Equation 3.8 with $\beta = r_{\mathrm{n}} n_{\mathrm{n}}$ in Regime B.

When differentiating $w_{\mathrm{n}}^{\mathrm{B}}$ with respect to S_{n}, I get,

$$\frac{\partial w_{\mathrm{n}}^{B}}{\partial S_{\mathrm{n}}} = n_{\mathrm{n}} + \frac{\partial n_{\mathrm{n}}}{\partial S_{\mathrm{n}}} S_{\mathrm{n}} - r_{\mathrm{n}} \delta_{\mathrm{n}} \frac{\partial n_{\mathrm{n}}}{\partial S_{\mathrm{n}}} = 0 \tag{B.2}$$

when calculating this, I get,

$$\frac{\theta}{2t}[t + v\delta_{\mathrm{n}} + \gamma(I) - S_{\mathrm{n}} - (\phi H - \lambda)] - \frac{S_{\mathrm{n}}\theta}{2t} + \frac{r_{\mathrm{n}}\delta_{\mathrm{n}}\theta}{2t} = 0 \tag{B.3}$$

which I multiply by $\frac{2t}{\theta}$ and rearrange into,

$$S_{\mathrm{n}}(H) = \frac{t}{2} + \frac{\gamma(I)}{2} - \frac{\psi H - \lambda}{2} + \frac{\delta_{\mathrm{n}}(r_{\mathrm{n}} + v)}{2}. \tag{B.4}$$

For Popcorn Time I get the utility, w_{p} from Equation 3.7, as

$$w_{\mathrm{p}} = (\psi H - \lambda)\left(1 - \frac{n_{\mathrm{p}}}{\theta}\right). \tag{B.5}$$

When differentiating w_{p} with respect to H, I get,

$$\frac{\partial w_{\mathrm{p}}}{\partial H} = \psi\left[1 - \frac{n_{\mathrm{p}}}{\theta}\right] + (\psi H - \lambda)\frac{-\psi}{2t} = 0, \tag{B.6}$$

$$\psi\left(1 - \frac{1}{2t}(t + (\psi H - \lambda) + S_{\mathrm{n}} - \gamma(I) - v\delta_{\mathrm{n}})\right) - (\psi H - \lambda)\frac{\psi}{2t} = 0, \tag{B.7}$$

which I multiply by $\frac{2t}{\psi}$, leading to,

$$2t - t - (\psi H - \lambda) - S_{\mathrm{n}} + \gamma(I) + v\delta_{\mathrm{n}} - (\psi H - \lambda) = 0, \tag{B.8}$$

which can be rearranged to have H on left hand side:

$$(\psi H - \lambda) = \frac{1}{2}(t - S_{\mathrm{n}} + \gamma(I) + v\delta_{\mathrm{n}}), \tag{B.9}$$

or, also,

$$H = \frac{1}{\psi}\left(\frac{1}{2}(t - S_{\mathrm{n}} + \gamma(I) + v\delta_{\mathrm{n}}) + \lambda\right). \tag{B.10}$$

Using $S_{\mathrm{n}}(H)$ from equation B.4 and $H(S_{\mathrm{n}})$ from B.10, inserting them into each other, gives the unconditional equilibrium level of them both, using the expression for H from Equation B.9. Multiplying S_{n} by 2 gives,

$$2S_{\mathrm{n}} = t + \gamma(I) - \frac{1}{2}(t - S_{\mathrm{n}} + \gamma(I) + v\delta_{\mathrm{n}}) + \delta_{\mathrm{n}}(r_{\mathrm{n}} + v). \tag{B.11}$$

Multiplying both sides by 2, and rearranging the terms gives,

$$S_{\mathrm{n}} = \frac{t}{3} + \frac{\gamma(I)}{3} + \frac{\delta_{\mathrm{n}}}{3}(2r_{\mathrm{n}} + v). \tag{B.12}$$

Using this expression for S_{n} in $H(S_{\mathrm{n}})$ gives

$$H = \frac{1}{\psi}\left(\frac{1}{2}\left(t - \left[\frac{t}{3} + \frac{\gamma(I)}{3} + \frac{\delta_{\mathrm{n}}}{3}(2r_{\mathrm{n}} + v)\right] + \gamma(I) + v\delta_{\mathrm{n}}\right) + \lambda\right) \tag{B.13}$$

which can be multiplies by 3 in both numerator and denominator and rearranged giving,

$$H = \frac{1}{\psi}\left(\frac{2t + 2\gamma(I) - 2r_{\mathrm{n}}\delta_{\mathrm{n}} + 2v\delta_{\mathrm{n}}}{6} + \lambda\right) = \frac{1}{\psi}\left(\frac{t + \gamma(I) - \delta_{\mathrm{n}}(r_{\mathrm{n}} - v)}{3} + \lambda\right). \tag{B.14}$$

This can be rearranged to give,

$$(\psi H - \lambda) = \frac{1}{3}(t + \gamma(I) - \delta_{\mathrm{n}}(r_{\mathrm{n}} - v)). \tag{B.15}$$

Using the calculation of H from Equation B.15 and S_{n} from Equation B.12 in the consumer distribution gives,

$$n_{\mathrm{n}} = \frac{\theta}{2t}\left[t + v\delta_{\mathrm{n}} - \left(\frac{t}{3} + \frac{\gamma(I)}{3} + \frac{\delta_{\mathrm{n}}}{3}(2r_{\mathrm{n}} + v)\right) - \frac{1}{3}(t + \gamma(I) - \delta_{\mathrm{n}}(r_{\mathrm{n}} - v)) + \gamma(I)\right], \tag{B.16}$$

which can be rearranged into,

$$n_{\mathrm{n}} = \frac{\theta}{6t}(t + \gamma(I) + \delta_{\mathrm{n}}(v - r_{\mathrm{n}}). \tag{B.17}$$

For Popcorn Time I get,

$$n_{\rm p}=\frac{\theta}{2t}\left(t+\frac{1}{3}[t+\gamma(I)-\delta_{\rm n}(r_{\rm n}-v)]+\frac{t}{3}+\frac{\gamma(I)}{3}+\frac{\delta_{\rm n}}{3}(2r_{\rm n}+v)-v\delta_{\rm n}-\gamma(I)\right), \tag{B.18}$$

which can be rearranged into,

$$n_{\rm p}=\frac{\theta}{6t}(5t-\gamma(I)+\delta_{\rm n}(r_{\rm n}-v)) \tag{B.19}$$

With these expressions for H, $S_{\rm n}$, $n_{\rm n}$ and $n_{\rm p}$ I will proceed to Stage One of the maximisation.

Calculations of Stage One, Regime B

With H, $S_{\rm n}$, $n_{\rm n}$ and $n_{\rm p}$, I will now maximise the utility of Netflix given how much content they provide on their service ($\delta_{\rm n}$);

$$w_{\rm n}^{\rm A}=n_{\rm n}S_{\rm n}-\delta_{\rm n}r_{\rm n}n_{\rm n}. \tag{B.20}$$

First I derive $w_{\rm n}^{\rm B}$ with respect to $\delta_{\rm n}$:

$$\frac{\partial w_{\rm n}^{\rm B}}{\partial\delta_{\rm n}}=\frac{\partial S_n}{\partial\delta_{\rm n}}n_{\rm n}+S_n\frac{\partial n_{\rm n}}{\partial\delta_{\rm n}}-r_{\rm n}n_{\rm n}-\delta_{\rm n}r_{\rm n}\frac{\partial n_{\rm n}}{\partial\delta_{\rm n}}=0. \tag{B.21}$$

This gives,

$$\frac{2r_{\rm n}+v}{3}n_{\rm n}+\frac{1}{3}(t+\gamma(I)+\delta_{\rm n}(2r_{\rm n}+v))\frac{\theta}{6t}(v-r_{\rm n})-r_{\rm n}n_{\rm n}-\delta_{\rm n}r_{\rm n}\frac{\theta}{6t}(v-r_{\rm n})=0. \tag{B.22}$$

First I see that the third term ($r_{\rm n}n_{\rm n}$) also appears in the first term ($\frac{2r_{\rm n}+v}{3}n_{\rm n}$), and merge the two. I then multiply both sides by $\frac{18t}{\theta}$ and rearrange it into,

$$(v-r_{\rm n})(t+\gamma(I)+\delta_{\rm n}(v-r_{\rm n})+(t+\gamma(I)+\delta_{\rm n}(2r_{\rm n}+v)(v-r_{\rm n})-3\delta_{\rm n}r_{\rm n}(v-r_{\rm n})=0, \tag{B.23}$$

which I will multiply by $\frac{1}{v-r_{\rm n}}$, which can be rearranged into,

$$2t+2\gamma(I)+2v\delta_{\rm n}+\delta_{\rm n}r_{\rm n}-3\delta_{\rm n}r_{\rm n}=0 \tag{B.24}$$

giving,

$$\delta_{\rm n}=\frac{t+\gamma(I)}{r_{\rm n}-v}. \tag{B.25}$$

From this, I can calculate consumer distribution, equilibrium effort of Popcorn Time developers and equilibrium consumer fee for Netflix.

With n_{n} from Equation B.17, and δ_{n} from Equation B.25, together with $v - r_{\mathrm{n}} = -(r_{\mathrm{n}} - v)$, user mass of Netflix is,

$$n_{\mathrm{n}} = \frac{\theta}{6t}\left[t + \gamma(I) + \left(\frac{t + \gamma(I)}{r_{\mathrm{n}} - v}\right)(v - r_{\mathrm{n}})\right] = \frac{\theta}{6t}(t + \gamma(I) + -t - \gamma(I)) = 0. \tag{B.26}$$

With n_{p} from Equation B.19, and δ_{n} from Equation B.25, the user mass of Popcorn Time is given by,

$$n_{\mathrm{p}} = \frac{\theta}{6t}\left[5t - \gamma(I) + \left(\frac{t + \gamma(I)}{r_{\mathrm{n}} - v}\right)(r_{\mathrm{n}} - v)\right] = \frac{\theta}{6t}6t = \theta \tag{B.27}$$

For the equilibrium effort of Popcorn Time developers, with H from Equation and δ_{n} from Equation B.25 I get,

$$H = \frac{1}{\psi}\left[t + \gamma(I) - \frac{t + \gamma(I)}{r_{\mathrm{n}} - v}(r_{\mathrm{n}} - v) + \lambda\right] = \frac{\lambda}{\psi}. \tag{B.28}$$

The equilibrium consumer fee, with S_{n} from Equation B.12 and δ_{n} from Equation B.25, will be given by,

$$S_{\mathrm{n}} = \frac{1}{3}\left[t + \gamma(I) + \frac{t + \gamma(I)}{r_{\mathrm{n}} - v}(2r_{\mathrm{n}} + v)\right] = \frac{1}{3}\left[(t + \gamma(I))\left(1 + \frac{2r_{\mathrm{n}} + v}{r_{\mathrm{n}} - v}\right)\right], \tag{B.29}$$

$$S_{\mathrm{n}} = \frac{1}{3}\left[(t + \gamma(I))\left(\frac{r_{\mathrm{n}} - v + r_{\mathrm{n}} + v}{r_{\mathrm{n}} - v}\right)\right] = \frac{r_{\mathrm{n}}(t + \gamma(I)}{r_{\mathrm{n}} - v}. \tag{B.30}$$