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Net Neutrality in the Content Provision and Internet Service Provision Markets

İçerik Sağlayıcı ve İnternet Servis Sağlayıcı Pazarında Ağ Tarafsızlığı

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ABSTRACT

Relaxing net neutrality in the form of introducing termination fees and its welfare effects are considered in a model of imperfect complements. The equilibrium of the game between the internet service provider (ISP) and the content provider (CP) yields welfare-maximizing termination fees that depend on the relative size of the ISP's and the CP's own-price effects and the cross-price effects. Only when the ISP's own price effect is relatively high compared to that of the CP's, along with high cross price effects, such a fee should be allowed. On the other hand, when the CP's own price effect is relatively high compared to that of the ISP's, along with high cross price effects, mergers are expected and are likely not harmful to social welfare. Telecommunication regulators may find the results useful in their net neutrality decisions.

Keywords: Net neutrality, Termination fee, Waterbed effect
JEL Classification: L13, L51, L86

ÖZ

İnternet servis sağlayıcı ve içerik sağlayıcı arasındaki eksik tamamlayıcılık ilişkisini modelleyerek ağ tarafsızlığının uygulanması ve uygulanmaması gereken ekonomik şartları belirledik. Oyun teorisi yöntemleri ile bulduğumuz dengede, sosyal faydayı maksimize eden erişim ücretinin, model parametreleri olan fiyat etkileri ve çapraz fiyat etkilerine bağlı olduğunu ortaya çıkardık. Sadece servis sağlayıcının kendi fiyat etkisinin içerik sağlayıcınınkinden büyük ve çapraz fiyat etkisinin görece yüksek olduğu durumlarda, ağ tarafsızlığının gevşetilip, erişim ücretine izin verilmesi gerektiği sonucunu bulduk. Eğer içerik sağlayıcının kendi fiyat etkisi servis sağlayıcınınkinden büyükse ve çapraz fiyat etkisi görece yüksekse, bu durumda şirket birleşmelerinin gerçekleşeceğini ve sosyal faydaya zarar vermeyeceğini model çözümünden öngördük. Bulduğumuz sonuçlara dayanarak telekomünikasyon regülasyon kurumları ülkelerindeki internet servis sağlayıcı ve içerik sağlayıcıya ait kendi fiyat etkisi ve çapraz fiyat etkisi bilgilerini kullanarak ağ tarafsızlığı konularında alacakları kararlarını değerlendirebilirler.

Anahtar kelimeler: Ağ tarafsızlığı, Sonlandırma ücreti, Su yatağı etkisi
JEL Sınıflaması: L13, L51, L86

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1. Introduction

On May 18, 2022, an appellate court in South Korea, the Seoul High Court, saw a case between a content provider (CP), Netflix, and an internet service provider (ISP), South Korea Broadband (SKB), which concerned payments from content providers to internet service providers. These payments violated the principle of net neutrality (NN), a principle that is currently debated all around the world (Krämer, Wiewiorra, & Weinhardt, 2013). For many CPs, net neutrality in the sense that CPs shall not pay termination fees, has been seen as the engine of growth of internet content (Njoroge, Ozdaglar, Stier-Moses, & Weintraub, 2014).[1,2]

The date January 1, 1983 is widely accepted as the official birthday of the Internet when all computers started using the same language, called "Transfer Control Protocol/Internetwork Protocol (TCP/IP)" (Leiner et al., 2009). Since then, the internet has in its essence been distributing desired content to consumers. By 2022, these internet-connected computers have evolved into touch-screen laptops, lightweight high-resolution-display tablets, foldable/rollable smart phones and other smart-wearables such as virtual reality glasses by Oculus, a Meta Platforms Inc (formerly known as Facebook) company. The content evolved from academic output to throughput-hungry products produced by movie and TV-series content-streaming firms like Netflix, online gaming companies such as Activision Blizzard, short video-clips-on-demand platform like Google's YouTube and many more.

1 We use terminology like NN and termination fee just because the telecom industry uses them as such, however, it is important to note that more suitable terms can be found to explain the economic nature of this principle such as "Net Rationality" instead of NN and Access Rent or Access Fee instead of termination fee. Indeed, there are no neutral parties in the debate of who shall actually pay for the cost of ISP infrastructure expansions due to CP-induced bottlenecks the end users, the CP or the ISP. All of these players in this strategic environment are rational economic agents.

2 The termination fee itself has nothing to do with termination but has a lot to do with "congestion." ISPs have limited "pipes" through which to allow the "flow" of data. If a certain kind of CP, like a video streamer, exhausts the ISP's resources, i.e., filling up the majority of the pipe, and if the ISP is forced to expand their pipes due to this congestion, then is it fair for them to ask the CP to share the cost? One such Net Rationality decision can be based on imposing the social welfare maximizing access rent under the telecom regulator's directive. From this point on, we go back to the well recognized terms, NN and termination fee.

The distribution channel itself has evolved from a network of copper lines to millions of miles of fiber cables, giant ISPs like Verizon, content delivery networks such as Akamai and various commercial agreements among ISPs such as peering,[3] transit,[4] and mobile termination rates.[5]

Considering the production, distribution and consumption aspects of the Internet, it is a perfect focus area for economics research. Especially, after the concept of net neutrality entered the stage, the debates around who pays who is an active area of research (Wu, 2003). Our article fills a gap in modeling the economic relation between the CPs and ISPs explicitly by accounting for the imperfect complementarity between these services and provides insights for the regulation of the termination fees, i.e., payments from the CPs to the ISPs. Our choice of the phrase "termination fee" is due to commonly used telecommunication industry referral to the specific state in a call setup flow, when the calling party establishes the signaling link with the called party. To this end, it is critical to understand the recent developments in ISP and CP relationships in the market. One of the recent mergers shed considerable light on this issue.

In February 2014, about a year after Comcast, an ISP, acquired NBC Universal. A CP, Netflix agreed to pay an undisclosed amount to co-locate its content delivery servers inside Comcast's network. Prior to this contract, Netflix was using Cogent's content delivery network services to reach its customers in Comcast's network. Content delivery networks reduce the backbone or transit fees of the ISPs by caching such frequently watched videos.[6] The caching also provides faster access to the content. Cogent and Comcast had a peering agreement from which

[3] Peering refers to an agreement between internet service providers to provide access to each others' customers free of charge (Norton, 2001).

[4] Transit refers to an agreement between a smaller internet service provider and a larger one where the smaller one pays the larger based on megabit per second per month (Norton, 2001).

[5] Mobile termination rate (MTR) is a fee that the mobile operator where the voice call has originated pays to the mobile operator where the voice call is terminated and only applies if an originating operator is different from the terminating operator (Wright, 1999).

[6] Caching refers to the "temporary storage" of video and other content like web sites to be accessed, which is faster than going to the original source each time (Li, Xu, Schaar, & Li, 2016).

they had a mutual benefit. Cogent got the payment from content providers and invested in its servers and the algorithm to cache the right content. As the Netflix traffic grew, Comcast asked Cogent for extra payment for the unbalanced traffic, that is, more traffic flowing downstream than upstream.[7] Netflix users in Comcast networks started experiencing buffering and low-quality videos, which led to Netflix signing the server co-location deal with Comcast bypassing Cogent. Just after a few weeks of the deal, Netflix's CEO, Reed Hastings complained about the high bargaining power of the ISPs, Comcast in this case, and called all ISPs to follow a "strong net neutrality rule," which meant no payment can be demanded from the content providers by the ISPs (Russell, 2014). Indeed, as if net neutrality is not complicated enough, there is the weak versus strong net neutrality debate to spice things up (Gans, 2015). Weak net neutrality refers to treating all data equally (and non-discriminatory fees are possible), whereas strong net neutrality refers to content providers not having to pay ISPs interconnection fees. In this article, we unravel the mechanism behind strong net neutrality by modeling the ISP and the CP markets and the strategic interactions therein.

In this article, we explore the significance of the termination fee, t, in a more realistic scenario compared to the academic studies that have been conducted so far. We do this by modeling the level of complementarity while leaving the market structure simple enough at both the ISP and CP levels to keep the focus on the welfare effects of t. With this article, we show that the termination fee that a CP pays to an ISP can be an important tool for the National Telecommunications Regulation Authority, henceforth the regulator to maximize total welfare and consumer welfare. As such, to our knowledge, this analysis fills an important gap in the literature.

1.1. Literature Review

The literature is generally concerned with the total surplus maximizing termination fee under different market and demand structures between the ISP

[7] Downstream is the direction from the CP to the ISP. In our context, upstream is the direction from the Comcast network towards the Cogent network. This kind of data flow occurs when the end-users of an ISP create content, which is demanded by the end-users of other ISPs.

and the CP. In a seminal paper in this regard, Greenstein, Peitz and Valetti (2016), henceforth GPV, discuss the relationship between the subscription fees of the ISP and the CP and the termination fee in the context of the net neutrality debate. GPV's basic result is the irrelevance of the termination fee. Therefore, GPV model's irrelevance result is not very insightful in terms of regulating the termination fee. In particular, GPV obtain an extreme version of the "waterbed effect" in a model of perfect complements, where all of the termination fee is passed on to the consumers by the ISP.[8] As all ISPs carry content and as all CPs need some form of an ISP, the GPV model of perfect complementarity and the take-it-or-leave-it offer to the consumer may not at first seem inappropriate. However, the nature of the NN debate and the drastic differences between video streaming as content and visiting web sites for different purposes warrant a separate analysis of the ISP-CP relationship in the context of home-based video streaming. In this context, given that the ISPs have other services than just delivering video streaming over their network and the CPs have other channels that they can reach consumers, this assumption of perfect complementarity is highly unrealistic, if not misleading. While GPV acknowledge that their model has many missing elements, they do not consider the possibility of an imperfect complementarity as one of them. In our article, we fill this gap by introducing an imperfect complementarity, which renders various plausible outcomes that explain what we see in the industry. Moreover, with our model, we are able to suggest optimal termination fees, which brings back the possibility and implications of regulating the termination fee.

Another one of the acknowledged missing elements by GPV is the existence of competitors in the ISP market. The same applies to the CP markets, and the literature has papers addressing both issues. Calzada and Tselekounis (2018), henceforth CT, study the welfare implications of net neutrality and termination fees in the context of a model with two CPs and one ISP. Different from the GPV model, the ISP and the CPs are not complements as the ISP has base revenues

[8] The waterbed effect is defined as "a situation in which pressure on one side of the market leads to a corresponding change in prices on the other side of the market" (Greenstein, Peitz, & Valetti, 2016).

from selling to the whole customer base in a Hotelling model. In other words, as long as the market is covered wholly, which is the case of interest in CT's paper, there is no impact of the ISP's price on either the CP's demand as this price cancels out in utility calculations. In the CT model, the CPs agree to put links in each other's web pages for consumers to jump from one web page to the other. This introduces a parameter a_i which denotes the advertisement time to which the consumer is exposed and helps increase the referring CP_i's profit function. Furthermore, CP_i's profit also depends on *f*, per-unit termination fee that CP_i pays to the ISP, D_i and D_{ji}, the number of visitors it gets directly or through CP_j, and the similarity and the number of attributes such as news, pictures, videos it offers. In this model, CT find that the ISP costs are related to the termination fees in that if the costs are low then the ISP sets a low termination fee to incentivize the CPs to improve their linked content. Finally, CT show that the optimal *t* coincides with the equilibrium *t* when the ISP costs are either too low or too high. As such, they suggest regulation of the termination fee only at the intermediate levels.

Bourreau and Lestage (2019), henceforth BL, deviate from GPV by modeling the ISP and the CP markets as different from monopoly, similar to the CT paper. As opposed to the CT study, the BL paper assumes oligopolistic competition between ISPs while the CPs have a monopolistically competitive market structure. There are two ISPs, one integrated, the other not, and the integrated one provides last mile connectivity to the other and charges a fee, *for* access. The profit functions of the ISPs depend on their marginal costs (c, c_n, c_d), the access fee (a), ISP subscriptions (q_A, q_B) and the number of the CPs connecting to each ISP (n_A, n_B). The BL paper models imperfect complementarity implicitly as the quantity of the content provider *i*, q_i, is a function of the prices of ISPs, however, 1) there is no price charged directly to end-users, which we are interested in analyzing as we observe that pricing is an important strategy for Netflix, 2) even if we consider the price charged to advertisers as relevant, it is a constant price, β_s, which is introduced as an externality.

The analysis includes (per CP) termination fees determined by the ISP as well as the regulatory body, as such, the model is not directly comparable with models where the termination fee is per subscriber. Nevertheless, it is useful to note that BL's findings imply that the access prices are inversely related to the termination fees, as opposed to the common suggestion that the access fees should be low to encourage CP entry. Finally, BL suggest that their model does not include the dynamic issues that pertain to the interaction of net neutrality and capacity investments.

While the CT and BL papers introduce competition at the ISP and CP levels respectively, neither paper explicitly models the level of complementary between the products which our article aims to do abstracting from the complications arising from market structures.

In all these papers and in general, the welfare criterion is the total surplus as in our article. Moreover, the termination fee is restricted to be non-negative in general, but in our article, we explore negative termination fees, which means the ISP "pays" to the CP, which can be interpreted as pressure towards a merger between the ISP and the CP or towards an ISP launching its own CP. All these possibilities are observed in the market as discussed above.

In parallel with their (ex post regulation) mandates, competition authorities are primarily concerned with protecting consumer surplus, for example in Turkey, the EU, and the United States.[9] On the other hand, (ex ante) regulatory agencies such as the Turkish Information Technologies and Communication Authority (ITCA or BTK in Turkish) and United States Federal Communications Commission (FCC) need to consider the total surplus as well. Our model sheds light both on the consumer surplus and the producer surplus separately and hence, their sum, the total surplus (social welfare) as a result of the introduction of a termination fee from a CP to an ISP.

The main potential benefit of our article to the national and the global economy is to help with net neutrality policy decisions so as to maximize the total

[9] Some exceptions include Australia and Canada, where, competition authorities focus on total surplus (Katsoulacos, Metsiou, & Ulph, 2016).

surplus by considering the overall benefits of an improved model of CP, ISP, and end-user interaction.

Some examples for the ISPs are Comcast/Xfinity in the United States and Turk Telekom/TTNet or Turkcell/Superonline in Turkey. There are about 3000 ISPs with varying subscriber coverage capabilities in the United States alone. In the wider definition of a CP, there are hundreds of thousands of entities that create content which is consumed by the end-users. In fact, some of the end-users themselves are content providers. For the sake of simplicity, we narrow the definition of a CP down to a paid streaming video on demand (SVOD) provider for entertainment purposes. There are about 300 SVOD providers in the United States. We let the end-users be the consumers of the CPs and ISPs. ISPs are an important gateway for the CPs to reach the end-users.

Before delving into the details, the market structure as in the CT or BL papers, a fundamental intermediate step in the regulation of the termination fees needs to be addressed. That step is the analysis of the CP and ISP relationship as imperfectly complementary services in the context of the termination fees determined by the regulator. Our hypothesis is that the total surplus (social welfare) maximizing t, depends on the own and cross price elasticities between the ISP and the CP. In particular, the socially optimal t could be positive (from the CP to the ISP) or negative (the ISP to the CP) depending on the level of complementarity. This hypothesis is in stark contrast to the GPV result of the irrelevance of t, while we confirm the waterbed effect that is also present in all the papers we discuss above. Next, we introduce the background to the net neutrality debate.

1.2. Net Neutrality Debate

Ever since its first appearance in Wu (2003), Net Neutrality (NN) has been a subject of hot debate between the ISPs and CPs. Regulatory Authorities tend to favor one or the other based on political reasons rather than sound economic reasoning. This is because there are sizeable pros and cons for each side of the story.

1.2.1. Definition of net neutrality

The phrase "net neutrality" policy refers to internet service providers (ISPs) treating all data that flows through them with equal priority and payment consideration. The weak and strong NN definitions we have discussed above have been introduced in the literature but have not been adopted by too many, therefore, we use NN to refer to the strong NN definition. Historically, this principle has been deemed by some, Gans (2015) the single-most effective factor in the current proliferation of innovations and digital economy via this medium. However, others argue that the idea goes against the principles required for a market economy to be efficient because some relevant markets are prohibited from emerging with their own price.[10] Examples of such markets who cannot emerge thanks to the NN principle include the markets for capacity (infrastructure for data transfer). For example, if the NN principle was to be eliminated, the prominent CPs like Netflix or YouTube would be able to pay more to the ISP than a "ma-and-pa" CP. Some argue that this would suppress innovation.

Indeed, ISPs try to explore the boundaries of net neutrality with creative ideas to achieve financial gains. Policy makers and regulators evaluate the impact of each method of stretching the boundaries of net neutrality. Some of these methods' impact are straightforward thanks to similar experiences gained from other industries, however many of the cases prove very difficult to estimate in the long run. Therefore, net neutrality provides plenty of opportunities for economic analysis.

1.2.2. Content provider's (CP) point of view

Content providers charge a subscription fee which allows the end-user access to the content. By the nature of their business, CPs would rather not pay any termination fee to the ISPs in order to reach the end-user. This is viewed as their basic right under the net neutrality argument. CPs claim that having no termination fee reduces the barrier to entry for CPs and creates the opportunity for more innovation.

[10] The First Fundamental Theorem of Welfare Economics states that when all the relevant markets are present and when they are all perfectly competitive, the equilibrium outcome is (Pareto) efficient. This suggests that, other things being equal, restrictions on relevant markets to emerge is welfare reducing.

1.2.3. Internet service provider's (ISP) point of view

Internet service providers also charge a subscription fee but for limited data buckets. If the contracted bucket is surpassed by the end-user then the end-user is expected to pay more or suffer the consequences such as throttled access (lower throughput would be frustrating to try to watch a Netflix movie, for example, which requires relatively high throughput) to the internet or disconnection from the internet all together until the next payment cycle starts. ISPs claim that they have made huge investments in the infrastructure and would therefore welcome the idea of charging a termination fee to the CPs as well. This point puts the ISPs in the anti-strong net neutrality camp. With the extra revenue, they claim, they can manage congestion by making more infrastructure investments for the increasing data volumes, provide faster service and foster innovation. If indeed a termination fee is irrelevant as Greenstein, Peitz and Valetti (2016) suggested, then we would not see such ISP behavior. We do not study the concept of congestion in this article but see Economides and Hermalin (2012) and Economides (2015) for more analysis.

1.2.4. The Regulators' point of view

Regulators usually sit on the fence and do not intervene with the termination fee because of its complex nature (Clark, 2007). In this article, we prove that doing so is at least not in the best interest of the total surplus or, in some cases, the consumer surplus.

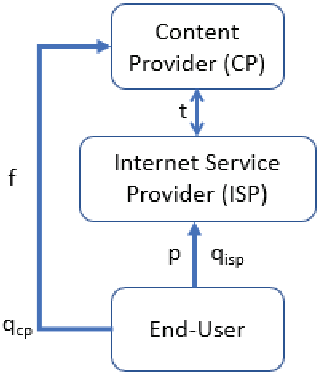
2. The Model

2.1. The CP and the ISP Markets

2.1.1. Preliminaries

Consider a market with one representative CP (paid video streaming service provider, e.g., Netflix, BluTV) and one representative ISP serving the home with fixed broadband access (e.g., Comcast, Turk Telekom). These representative firms save us from the complications that the differing market structures can introduce to our analysis, they allow us to focus on the welfare effects of a termination fee.[11] The demand structure is such that the CP and the ISP are imperfect complements allowing ISPs and CPs to have different quantities demanded in equilibrium. This approach complies better with market realities as ISPs have other uses than just video streaming access and such CPs have multiple vehicles to reach consumers such as mobile networks as opposed to fixed networks which we consider to be *the ISP* that serves the end-users at home. As such, in our model, while the termination fee is a cost component for the CP, it is not directly a price component for the ISP, introducing a strategic element for the equilibrium prices, quantities, and welfare.

Figure 1. Vertical Levels in CP (upstream) and ISP (downstream) Market



In Figure 1, the notation is as follows:

f: the monthly subscription fee, the end-user pays the CP for video content

p: the monthly subscription end-user pays ISP for internet access (not limited to video content)

[11] It may be expected that neutrality can only be discussed when we talk about multiple CPs. We use a representative CP to simplify the model in order to show the impact of cross and own price effects on the best outcome. Moreover, the imperfect complementarity between the home-based video-streaming services and fixed broadband access already implies the presence of substitutes such as other content providers and other ISPs such as the Mobile Network Operators.

t: the termination fee per CP user that the CP pays the ISP (t > 0) or the ISP pays the CP (t < 0) for access

q_{isp}: the demand for ISP subscriptions

q_{cp}: the demand for CP subscriptions

In Figure 1, we observe that both the ISP and the CP are paid separately, *p* and *f* respectively by the consumers in compliance with the industry practice. Moreover, the CP pays the ISP a termination fee, *t*. We call it the termination fee to be consistent with the literature, for the reasons mentioned earlier, but note that our model allows for t < 0 also. The possibility of a negative *t* enables us to model various methods of monetary or non-monetary payments including the observed mergers and acquisitions between ISPs and CPs. Specifically, if the model solution yields a negative *t* where the industry profits are maximized, we interpret this as a tendency or pressure towards a merger. Finally, this model allows us to find the termination fee that maximizes the total surplus, which is our main goal.

2.1.2. Demand structure

I next present the demand structure that models the imperfect complementarity. (Singh and Vives, 1984)

$$q_{isp} = a_1 - b_{11}.p - b.f \quad (1)$$

$$q_{cp} = a_2 - b.p - b_{22}.f \quad (2)$$

where a_1, a_2, b, b_{11}, b_{22} are all positive following from the assumptions on the underlying utility function, $q_{isp} > 0$ is the demand for ISP and $q_{cp} > 0$ is the demand for CP, and $p > 0$ and $f > 0$ are the subscription fees (prices).[12] The parameter *b* represents the cross-price effect between the two goods.

[12] This demand function follows from the utility function of the representative consumer. $u(q_1, q_2) = \alpha_1 q_1 + \alpha_2 q_2 - \frac{1}{2}(\beta_1 q_1^2 + 2\gamma q_1 q_2 + \beta_2 q_2^2) - \sum_{i=1}^{2} p_i q_i$, where $\alpha_i > 0, \beta_i > 0, i = 1,2,$ $\beta_1\beta_2 - \gamma^2 > 0$, and $\alpha_i\beta_j - \alpha_j\gamma > 0, i \neq j, i = 1,2.$ These assumptions imply $a_i, b, b_{ii} > 0, i = 1,2.$ The existence of competitive numeraire sector with a continuum of consumers of the same type ensures no income effects and allows partial equilibrium analysis (Singh & Vives, 1984).

The Slutsky matrix in a demand system with two goods is symmetric and negative semi definite regardless of the rationality axiom, that is, whether the demand is based on preferences or a weak axiom of revealed preferences. (Mas-Colell, Whinston, & Green, 1995).[13] Negative semi definiteness implies that the product of own price effects is stronger than the product of cross price effects.

$$S = \begin{bmatrix} \frac{dq_{isp}}{dp} & \frac{dq_{isp}}{df} \\ \frac{dq_{cp}}{dp} & \frac{dq_{cp}}{df} \end{bmatrix} = \begin{bmatrix} -b_{11} & -b \\ -b & -b_{22} \end{bmatrix} \tag{3}$$

A negative semi definiteness implies

$-(-b_{11}) \geq 0, -(-b_{22}) \geq 0$ and $b_{11}b_{22} - b^2 \geq 0$

Note that, $b_{11}b_{22} - b^2 \geq 0$ implies $4b_{11}b_{22} - b^2 \geq 0$, a property we use throughout this article.

The above demand structure lends itself to game theoretic modeling in the presence of an exogenous termination fee.

2.1.3. The Nash equilibrium of the game

In this simultaneous game, the players are the ISP and the CP, the strategy spaces are positive real numbers for prices, i.e., *p* and *f*, and the payoffs are the profit functions of the ISP and the CP. The payoff functions represent the above demand structure as well as the role of the termination fee:

$\Pi_{isp} = (p - c_{isp})q_{isp} + t.q_{cp} - F_{isp}$
$\Pi_{cp} = (f - t - c_{cp})q_{cp} - F_{cp}$

[13] Definition of NSD: An NxN matrix M is negative semi definite if $z^TMz \leq 0$ for all $z \in R^n$. There are alternative characterizations for symmetric matrices. In particular, if M is a 2x2 symmetric matrix, then negative semi definiteness is characterized as $-(-b_{11}) \geq 0, -(-b_{22}) \geq 0$ and $b_{11}b_{22} - b^2 \geq 0$.

where F_{isp} and F_{cp} are fixed costs.

Note that the ISP's profits depend on both firms' quantities. Moreover, *t* acts just like a constant marginal cost for the CP, but the same is not true for the ISP.

In addition to the demand parameters discussed above, we have the cost parameters in the profit functions, the constant marginal costs and the fixed costs of the ISP and the CP, denoted by c_{isp}, F_{isp}, c_{cp}, and F_{cp}, which are all positive. The constant marginal cost assumption is typical in these models (Calzada & Tselekounis, 2018). When it comes to fixed costs, both the ISP and the CP have significant fixed costs (Mitra & Sridhar, 2018).

I next proceed to find the Nash equilibrium. The ISP's best response function is yielded by profit maximization with respect to its price *p*, given the price of CP and all the other parameters:

$$\frac{d\pi ISP}{dp} = a_1 - 2b_{11}.p - b.f + b_{11}.c_{isp} - b.t = 0 \tag{4}$$

This first order condition, which is linear in its argument, therefore, yielding a linear best response function, ensures profit maximization when the second order condition is negative, which readily holds:

$$\frac{d^2\pi ISP}{dp^2} = -\, 2b_{11} < 0 \tag{5}$$

Next, we proceed with the CP's best response function. The first order condition is:

$$\frac{d\pi CP}{df} = a_2 - b.p - 2b_{22}.f + b_{22}.c_{cp} + b_{22}.t = 0 \tag{6}$$

Similarly, the CP's second order condition also readily holds:

$$\frac{d^2\pi CP}{df^2} = -\, 2b_{22} < 0 \tag{7}$$

The Nash equilibrium is found where the best response functions intersect:[14]

$$p^* = \frac{A_1 + B_1 c_{isp} + C_1 c_{cp} + D_1 t}{D} \tag{8}$$

where, $D = 4b_{11}b_{22} - b^2$ and

$$A_1 = 2a_1 b_{22} - a_2 b$$

$$B_1 = 2b_{11}b_{22}$$

$$C_1 = -bb_{22}$$

$$D_1 = -4bb_{22}$$

$$f^* = \frac{A_2 + B_2 c_{isp} + C_2 c_{cp} + D_2 t}{D} \tag{9}$$

where,

$$A_2 = -a_1 b + 2a_2 b_{11}$$

$$B_2 = -b_{11}b$$

$$C_2 = 2b_{11}b_{22}$$

$$D_2 = 2b_{11}b_{22}^2 + b^2 b_{22}$$

Equilibrium quantities directly follow from the demand functions.

$$q_{isp}^* = \frac{A_3 + B_3 c_{isp} + C_3 c_{cp} + D_3 t}{D} \tag{10}$$

where,

$$A_3 = 2a_1 b_{11} b_{22} - a_2 b b_{11}$$

$$B_3 = -b_{11}^2 b_{22} + b_{11} b^2$$

$$C_3 = -b_{11} b b_{22}$$

$$D_3 = b(b_{11}b_{22} - b^2)$$

[14] Any set of values for {b, b_{11}, b_{22}} that results in D = 0 will make p* and f* undefined, hence no solution.

$$q_{cp}^* = \frac{A_4 + B_4 c_{isp} + C_4 c_{cp} + D_4 t}{D} \quad (11)$$

where,

$$A_4 = -a_1 b b_{22} + 2a_2 b_{11} b_{22}$$

$$B_4 = -b_{11} b b_{22}$$

$$C_4 = -2b_{11} b_{22}^2 + b_{11} b b_{22}$$

$$D_4 = -2b_{22}(b_{11} b_{22} - b^2)$$

Both the ISP and the CP's first order conditions (hence their best-response functions) are dependent on *t*, which is an exogenous parameter determined by the regulatory agency in our model.

2.1.4. Comparative statics with respect to the termination fee

As can be seen from the equilibrium, all the demand parameters, cost parameters and the termination fee are present in the equilibrium. This result contrasts with the perfect complements model of GPV where *t* is irrelevant. Proposition 1 and 2 summarize these results.

Proposition 1: Equilibrium prices and equilibrium quantities are linear in *t*.

Proof:

As can be seen from the equilibrium price above given by (8),

$$p^* = \frac{A_1 + B_1 c_{isp} + C_1 c_{cp} + D_1 t}{D}$$

where,

$$\frac{D_1}{D} = \frac{-4b_{22} b}{4b_{11} b_{22} - b^2} < 0 \quad (12)$$

since $\frac{D_1}{D}$ is a constant given the parameter values. Similarly, as can be seen from the equilibrium values given by (9)-(11) for f^*, q_{isp}^*, q_{cp}^*, respectively, the coefficients of *t* are all constant given the parameter values.

Q.E.D.

This linearity is expected because *t* is a termination fee per CP subscriber. The linearity lends itself to a discussion of the range of *t* when positive prices are assumed as required by the demand structure of the implications of *t*'s impact on prices.

Proposition 2: In equilibrium, the ISP price decreases with *t* (waterbed effect), $dp^*/dt < 0$, the CP prices increase with *t*, $df^*/dt > 0$, the ISP quantities increase with *t*, $dq^*_{isp}/dt > 0$, and the CP quantities decrease with *t*, $dq^*_{cp}/dt < 0$.

Proof:

See (8)-(11) for

$$\frac{dp^*}{dt} = \frac{D_1}{D} = \frac{-4b_{22}b}{4b_{11}b_{22} - b^2} < 0$$

$$\frac{df^*}{dt} = \frac{D_2}{D} = \frac{b_{22}b^2 + 2b_{11}b_{22}^2}{4b_{11}b_{22} - b^2} > 0$$

$$\frac{dq^*_{isp}}{dt} = \frac{D_3}{D} = \frac{b(b_{11}b_{22} - b^2)}{4b_{11}b_{22} - b^2} > 0$$

$$\frac{dq^*_{cp}}{dt} = \frac{D_4}{D} = \frac{-2b_{22}(b_{11}b_{22} - b^2)}{4b_{11}b_{22} - b^2} < 0$$

Q.E.D.

As a consequence, we see that,

$$sgn\,\frac{dp^*}{dt} = -sgn\,\frac{df^*}{dt} = -1 \qquad (13)$$

$$sgn\,\frac{dq^*_{isp}}{dt} = -sgn\,\frac{dq^*_{cp}}{dt} = 1 \qquad (14)$$

From the perspective of the CP, an increase in t is only a unit cost increase (recall that marginal costs are constant). For this reason, it is expected that f^* increases with t regardless of equilibrium interactions. On the other hand, t has a more complex effect on an ISP's revenues as the revenue increase not only depends on t itself but also q_{cp}. As a consequence, in equilibrium, the relatively weak cross effects (as per the Slutsky matrix properties) are overcome by the ISP's own price effects in combination with the termination fee related revenues from the CP, leading to a decrease in p^*, which is the waterbed effect. Quantities and prices of the ISP and the CP move in the opposite direction with respect to each other. Furthermore, the quantities and prices of each firm also move in the opposite direction.

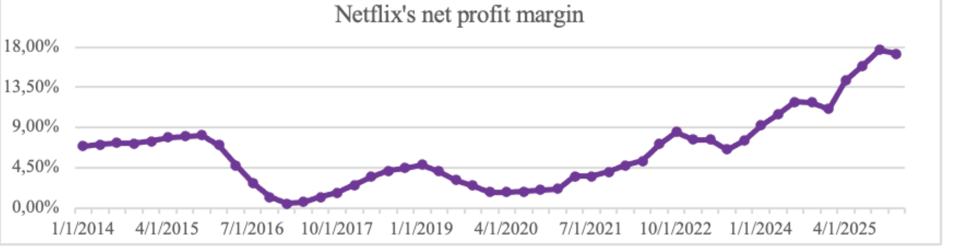
2.1.5. Dynamic considerations and elasticity

As the leading CP (in the United States), Netflix's pricing strategy is of constant interest. The business literature suggests that Netflix is operating at an inelastic point. There are also suggestions that Netflix is severely underpriced in consideration of dynamic concerns regarding their subscription base.

My demand structure gives market power to the content provider so it will never operate at the inelastic region of the demand curve. Note that, even if we change the market structure to an oligopolistic one at the CP level, this outcome will not change. For this reason, our equilibrium elasticities are higher than one in absolute value even when we calibrate the model with realistic values. In other words, inelastic demand that practitioners claim to observe in the market is not consistent with the static profit maximization in our static model.

However, in a dynamic model, a dynamic profit maximization along with the dynamics in the demand structure may dictate operation at the inelastic level. The intuition is that Netflix has a dynamic strategy that maximizes its subscriber base in the long run rather than maximize its current profits. As can be seen in Figure 2 below, Netflix's net profit margins were very low (below 5%) for the period 2012-2018, Macrotrends (2022), but it had a high valuation growth in the stock market from $5 billion to $116 billion, consistent with dynamic considerations (CompaniesMarketCap.com, 2022).

Figure 2. Netflix Profit Margins 2012-2018

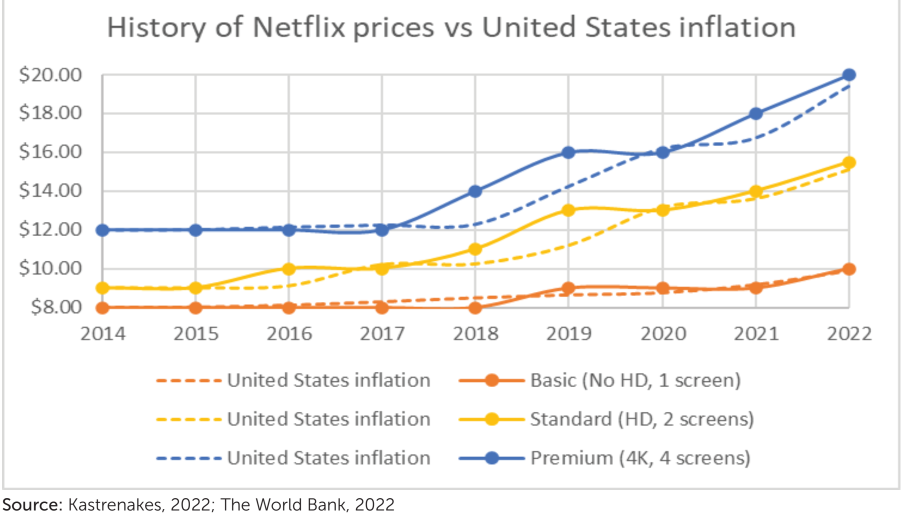


Source: Macrotrends.com

Particularly, 2012 Q4 and 2013 Q1, Netflix' net profit margin was below one percent level. Netflix made less than a 3% net profit margin in seven consecutive quarters starting from 2012 Q2. Another notable observation is that Netflix operated with a twenty-four quarter streak of less than a 5% net profit margin.

Figure 3 below displays the low correlation between the inflation in the U.S. and Netflix pricing in 2018 and 2019, suggesting a dynamic strategy. Note that there were entries to the market in the past seven years (Kastrenakes, 2022; The World Bank, 2022).

Figure 3. Netflix Prices vs United States Inflation



Source: Kastrenakes, 2022; The World Bank, 2022

Proposition 3: Own elasticities: $d\varepsilon_{11}/dt > 0$, $d\varepsilon_{22}/dt < 0$. Cross elasticities: $d\varepsilon_{12}/dt$ and $d\varepsilon_{21}/dt$ are indeterminate in general (see Proposition 2 and examples above).

$$\varepsilon_{11} = -b_{11}\left(\frac{p*}{q*isp}\right),$$

$$\varepsilon_{12} = -b\left(\frac{f*}{q*isp}\right),$$

$$\varepsilon_{21} = -b\left(\frac{p*}{q*cp}\right),$$

$$\varepsilon_{22} = -b_{22}\left(\frac{f*}{q*cp}\right)$$

Now that we have established the prices and quantities at the equilibrium, we will move on to surplus and welfare calculations. We have two other considerations than the typical consumer surplus and producer surplus calculations. The first one is total profits, which we will consider in our simulations so that we can compare the profit maximizing *t* with the total surplus maximizing *t*. Our purpose here is to see if *t* can be considered a facilitator of collusion. The second one is related to fixed costs. Netflix has very high fixed costs (Netflix, 2022). Fixed costs do not affect profit maximizing quantities. Also, producer surplus does not include fixed costs. However, as a low constant marginal cost product, the model solution tends to allocate high production to CPs. This allocation is not possible or acceptable if fixed costs are too high. While we assume away fixed costs at such high levels, we nevertheless point out their role to clarify the implications of some of our model's outcomes.

2.1.6. Welfare analysis of the equilibrium

There are two types of regulations when it comes to the timing of the regulation. The first one is the ex ante regulation and the second one is the ex post regulation. The ex post regulation is conducted by competition authorities and its central goal is to protect the consumer surplus in general (Kirkwood & Lande, 2008). In other words, the ex post competition, also known as competition policy in Europe and anti-trust policy in the United States, aims to protect competition, not competitors. The Ex ante regulation, or simply referred to as regulation, is typically conducted by industry specific regulatory bodies and its strategies can include protecting an emerging competitor against an incumbent dominant firm. For example, in the case of mobile network operators, mobile termination rates (MTR) between mobile networks are set at asymmetric levels to disadvantage the incumbent. A termination fee of the kind we consider in our article is the subject of ex ante regulation, hence we dwell on total surplus maximizing termination fees. However, we also examine the consumer surplus to understand the implications on consumers.

2.1.7. Consumer surplus

Consumer surplus is computed in the usual fashion where the demand function is integrated from zero to the equilibrium prices p^* and f^* in respective markets.

Proposition 4: Consumer Surplus in equilibrium is not linear in *t* and dCS_{isp}/dt and dCS_{cp}/dt are indeterminate.

Consumer surplus from each product is the area between the inverse demand curve and the equilibrium price and is given by

$$CS_{isp}(t) = \frac{(a_2 b_{11} b - 2a_1 b_{11} b_{22} + b_{11} b b_{22} c_{cp} - b_{11} b^2 c_{isp} + 2b_{11}^2 b_{22} c_{isp} + b^3 t - b_{11} b b_{22} t)^2}{2b_{11}(4b_{11}b_{22} - b^2)^2}$$

Consumer surplus from the CP is computed similarly is given by $CS_{cp}(t)$

$$CS_{cp}(t) = \frac{b_{22}(2a_2 b_{11} - a_1 b + b^2 c_{cp} - 2b_{11} b_{22} c_{cp} - b_{11} b c_{isp} + 2b^2 t - 2b_{11} b_{22} t)^2}{2(4b_{11}b_{22} - b^2)^2}$$

Then the (Total) consumer surplus is given by

$$CS = CS_{isp} + CS_{cp}$$

2.1.8. Producer surplus

Producer surplus is equivalent to variable profits, in other words, profits gross of fixed costs.

(Total) Producer surplus can be written in terms of total profits in equilibrium.

$$PS = \Pi^*_{isp} + F_{isp} + \Pi^*_{cp} + F_{cp}$$

2.1.9. Total surplus

As discussed above, maximizing total surplus is the central goal of the regulator by setting the level of *t*. Total surplus (TS) is the summation of consumer surplus and the producer surplus.

Proposition 5: Total Surplus in equilibrium: dTS/dt is indeterminate.

Total surplus under the imperfect complementarity model is as follows:

Figure 4. Consumer and Producer Surplus (ISP-based)

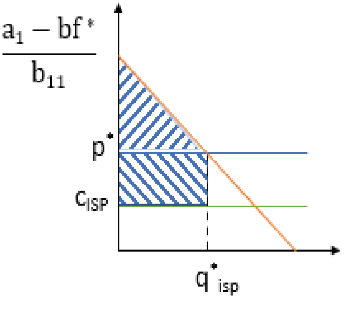
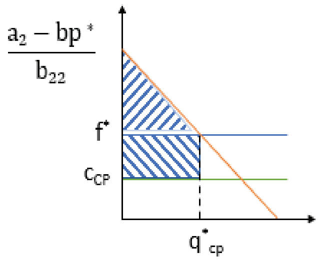


Figure 5. Consumer and Producer Surplus (CP-based)



Total surplus in equilibrium is the summation of consumer surplus and producer surplus in equilibrium:

$$TS = CS + PS$$

2.1.10. Empirical analysis of the model via simulations using plausible parameter values from the financial statements of the firms

Netflix and Comcast financials provide us with most of the basic data needed in our model to estimate the equilibrium prices and quantities. The termination fee can be set to zero or can be found from the total surplus or total profit maximization. While there are some suggestions on the elasticities of the firms in the business literature, we do not have the data to estimate them. For this reason, we use the available data and adjust the demand parameters to obtain reasonable prices and elasticities that are consistent with what we observe in the market.

First, we reintroduce the demand system for convenience:

$q_{isp} = a_1 - b_{11}.p - b.f$

$q_{cp} = a_2 - b.p - b_{22}.f$

I set a_1 and a_2 equal to the number of households in the United States, which is approximately 108,000,000 in 2017 and 120,530,000 in 2020 (Statista, 2022).[15]

[15] Statista definition of broadband is 200kbps (kilo bits per second) which is not sufficient for watching the lowest resolution, standard definition Netflix movie requires a minimum throughput of 1Mbps (mega bit per second). Therefore, we preferred the 2017 figures to be more realistic, although not critical for the outcome of our article.

The constant marginal cost for the CP is found from Netflix's financial statements, Netflix (2022) and set to be equal to $9 per subscriber per month and the constant marginal cost for the ISP is found from Comcast's financial statements, Comcast (2022) and is set to be equal to $86 per subscriber per month. The calculations are as follows:

$$MarginalCost = (1 - GrossMargin)xPrice$$

Table 1: Netflix and Comcast Marginal Cost Calculations

Firm	Gross Margin	Price	Cost
Netflix	41.64%	$15.49	$9.04
Comcast	36.36%	$134.99	$85.91

The scenarios that we run are as follows (To illustrate the possible outcomes, we tried to keep constant as many parameter values as possible without violating the model Slutsky matrix assumptions):

Table 2: Scenarios with Households, Own- and Cross-price Effects

Scenario	$a_1 = a_2$	b_{11}	b	b_{22}
1	108,000,000	300,000	5,000	500,000
2	108,000,000	300,000	200,000	500,000
3	108,000,000	300,000	5,000	210,000
4	108,000,000	300,000	200,000	210,000

The ISP price that we observe is about $130 from Comcast and Netflix price is about $15.

2.1.11. Scenario 1: Low cross price effect while CP's own price effect is higher than ISP's

Table 3: Scenario 1 Parameters for Determining Total Surplus Maximizing *t*

Scenario	$a_1 = a_2$	b_{11}	b	b_{22}	c_{isp}	c_{cp}
1	108,000,000	300,000	5,000	500,000	$86	$9

The equilibrium prices in Scenario 1 as a function of *t* in are as follows:[16]

Figure 6. Scenario 1 Prices and Quantities in Equilibrium[17]

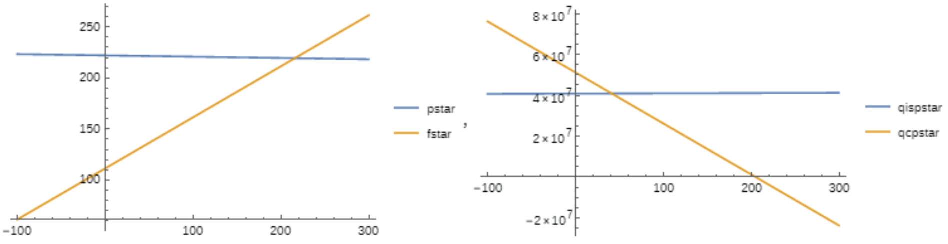


Figure 7. Scenario 1 Profits and CS based on ISP and CP[18]

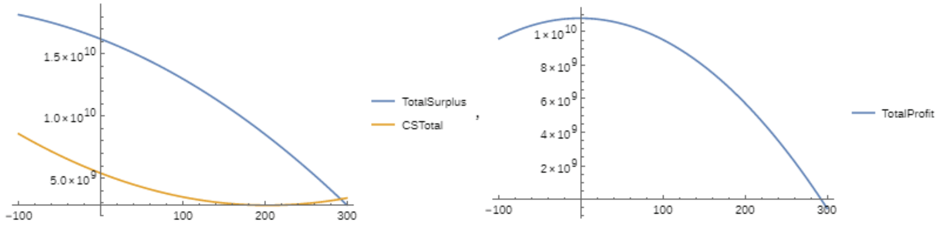
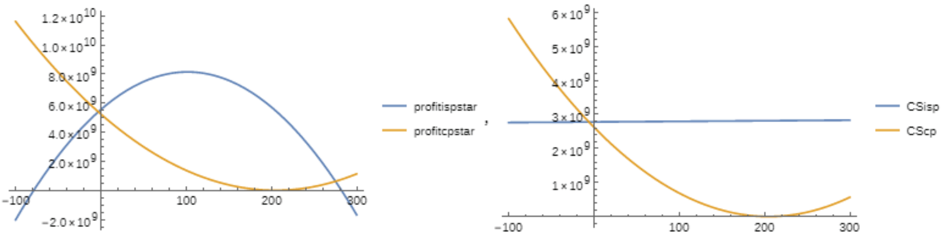


Figure 8. Scenario 1 TS, Total CS and Total PS[19]



[16] Solutions are by Wolfram Mathematica online student version. Code for the calculations are available upon request.

[17] Remark: although they may appear so to the eye, neither qispstar nor pstar are constant (see Proposition 1).

[18] Remark: although they may appear so to the eye, CSisp is not constant (see Proposition 4).

[19] Remark: Although it may appear so to the eye, the origin in the left panel is not zero.

Table 4: Scenario 1 at t = 0 and Total Surplus Maximizing *t* in Equilibrium

Name	t = 0	t = -205.97	Delta
pstar	222.07	224.65	2.58
fstar	111.39	8.39	-103
qispstar	40.8×10^6	40.5×10^6	-0.3×10^6
qcpstar	51.2×10^6	102.7×10^6	51.5×10^6
profitispstar	5.6×10^9	-15.5×10^9	-21.1×10^9
profitcpstar	5.2×10^9	21.1×10^9	15.9×10^9
CSisp	2.8×10^9	2.7×10^9	-0.1×10^9
CScp	2.6×10^9	10.5×10^9	7.9×10^9
CStotal	5.4×10^9	13.2×10^9	7.8×10^9
TotalSurplus	16.2×10^9	18.8×10^9	2.6×10^9
Elasticity11	-1.63	-1.66	-
Elasticity12	-0.01	-0.001	-
Elasticity21	-0.02	-0.01	-
Elasticity22	-1.09	-0.04	-
Total profit maximizing t = -1.33			

The model estimates monthly prices, quantities, and gross profits at *t* = 0 that are reasonably close in terms of orders of magnitude. In some cases, $q^*_{cp} > q^*_{isp}$ is consistent with multiple subscriptions. Estimated prices are generally higher than the actual prices. For Netflix, gross profits are approximately $12 billion in 2021. The model estimates higher gross profits thanks to the higher prices (f^*), about $60 billion. For Comcast, gross profits are $42 billion in 2021. The model estimates $66 billion in 2021.

Introducing the total surplus maximizing *t*, doubles the CP subscribers. This change increases the consumer surplus via an increase in CP-based CS that more than compensates for the slight decrease in ISP-based CS.

This Scenario illustrates a situation with quite weak cross effects, resulting in subsidizing the CP as the very low marginal cost producer. Of course, in the long run there are no fixed costs hence this result is just an indication that so long as CPs have low marginal costs and reasonably low fixed costs in relation to ISPs, they need to be continued to be subsidized via NN (or *t* = 0). In summary, if the cross-price effects are weak then the NN needs to be supported for total surplus maximization.

As we discussed in the section above, the model yields elastic demand in equilibrium by construction and commentators usually point out that Netflix's demand is inelastic. What needs to be carefully noted is that the commentators observe just one point, whereas, the demand for the content provider can in general be "elastic." Specifically, only dynamic considerations or competitive CP markets, which are not in our model, would yield an inelastic demand. Given that our parameter values are grounded in financial statements, this difference is very likely due to Netflix's dynamic strategy.

In addition to dynamic considerations, Netflix seems to be in the position of a firm with market power. Netflix made very low profits in some years suggesting that it is pricing below the static profit maximizing price (Macrotrends, 2022). See Figure 2 for recent profit margins. Moreover, recently, Netflix profits have been increasing as well as its subscriber base, albeit slower, while its prices remain the very similar in real terms (Figure 3). There may be two explanations that are consistent with these that are not necessarily mutually exclusive: 1) The demand for Netflix may have been increasing due to income increases or increases in willingness to pay due to preference changes, for example, during the pandemic. 2) Netflix's fixed costs may be decreasing. Indeed, there has been much speculation that due to Covid-19 during 2020-2021 and/or the fact that Netflix's original content quality has been deteriorating, less content investments were made (Denning, 2019). Both of these possibilities improve Netflix's profitability even in the context of pricing under the static profit maximizing price.

In summary, in this simulation, we essentially see that most social welfare originates from content providers as the negative total surplus maximizing t implies quite a big subsidy from the ISP to the CP. So much so that, at the optimal t, the ISP has negative profits, which implies that either the ISP should be owned by the government or the ISP should be regulated under the constraint of zero economic profits like a natural monopoly which would imply a slightly lower t (and a lower total surplus than optimum) in absolute value. Finally, we do not expect a merger in the market if cross (effects) price elasticities are this low.

As can be seen, the total industry profits are maximized at *t* which is almost zero (*t* = -1.33) whereas total welfare is maximized at *t* = -205. This largely alleviates the introduction of *t* and its regulation facilitating a cartel. This is also an argument against self regulation where *t* is determined between the ISP and the CP.

In general, the producer surplus does not include fixed cost. This is because the fixed cost does not change with quantity and surplus related analyses are done by changing quantities. However, in this simulation the importance of fixed costs in total surplus related regulation becomes apparent assuming that fixed costs are not sunk. In this simulation, even when we take the negative variable profits of the ISP by themselves, they are higher in absolute value than the total consumer surplus. So, an extremely high fixed cost that would neutralize the CP's profits would also cause the total surplus to be negative. Our intuition is that, the relative and absolute value of fixed costs are critical in understanding our model's implications. We assume that neither fixed cost is large enough to change our conclusions.

2.1.12. Scenario 2: High cross price effects while CP's own price effect is higher than ISP's

Table 5: Scenario 2 Parameters for Determining Total Surplus Maximizing *t*

Scenario	$a_1 = a_2$	b_{11}	b	b_{22}	c_{isp}	c_{cp}
2	108,000,000	300,000	200,000	500,000	$86	$9

The equilibrium prices in Scenario 2 as a function of t in are as follows:

Figure 9. Scenario 2 Prices and Quantities in Equilibrium

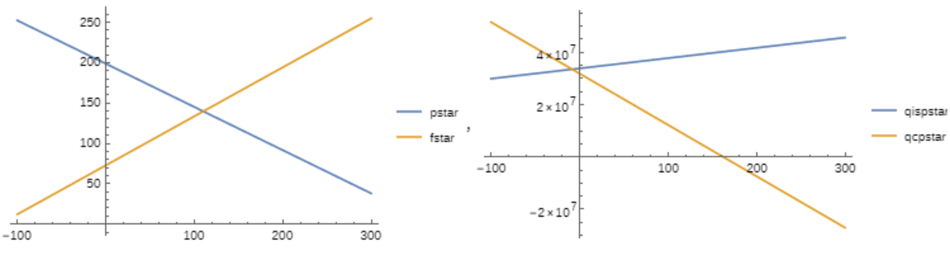


Figure 10. Scenario 2 Profits and CS based on ISP and CP

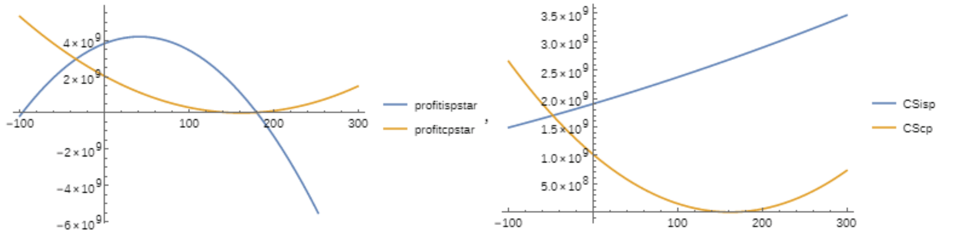


Figure 11. Scenario 2 TS, Total CS and Total PS

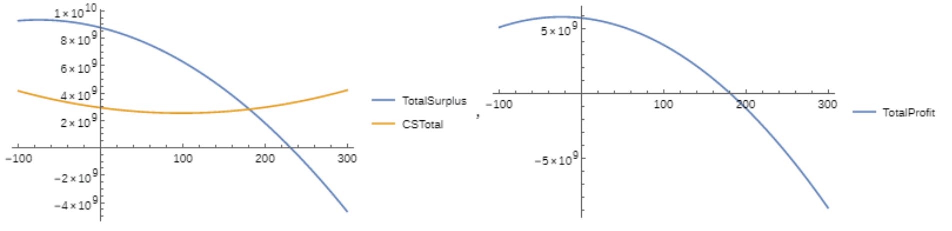


Table 6: Scenario 2 at t = 0 and Total Surplus Maximizing *t* in Equilibrium

name	t = 0	t = -75.41	delta
pstar	198.75	239.15	40.40
fstar	72.75	26.97	-45.78
qispstar	33.8×10^6	30.8×10^6	-3.0×10^6
qcpstar	31.8×10^6	46.7×10^6	14.9×10^6
profitispstar	3.8×10^9	1.2×10^9	-2.6×10^9
profitcpstar	2.0×10^9	4.3×10^9	2.3×10^9
CSisp	1.9×10^9	1.6×10^9	-0.3×10^9
CScp	1.0×10^9	2.2×10^9	1.2×10^9
CStotal	2.9×10^9	3.8×10^9	0.9×10^9
TotalSurplus	8.7×10^9	9.3×10^9	0.6×10^9
Elasticity11	-1.76	-2.32	-
Elasticity12	-0.43	-0.17	-
Elasticity21	-1.25	-1.02	-
Elasticity22	-1.14	-0.29	-
Total profit maximizing t = -24.45			

In this simulation, we kept the parameters the same as before except that the cross effects are higher without violating the model assumptions. When we increase the absolute value of the cross effects, we observe positive profits for both firms at the welfare maximizing *t* which implies that government ownership of the ISP is no longer an issue. However, $t < 0$ still implies that NN is required for TS maximization. In this case, as before, the profit maximizing prices of the CP are higher than the observed but reasonably close to the actual prices.

When it comes to the mergers we observe in the industry, although the *t* in our model is not endogenous, its negativity (-24.45) at the total profit maximizing output (not total surplus maximizing) is consistent with observed mergers. The suggestion is that the cross elasticities are high between the merging firms.

2.1.13. Scenario 3: Low cross price effects while ISP's own price effect is higher than CP's

Table 7: Scenario 3 Parameters for Determining Total Surplus Maximizing *t*

Scenario	$a_1 = a_2$	b_{11}	b	b_{22}	c_{isp}	c_{cp}
3	108,000,000	300,000	5,000	210,000	$86	$9

The equilibrium prices in Scenario 3 as a function of *t* are as follows:

Figure 12. Scenario 3 Prices and Quantities in Equilibrium

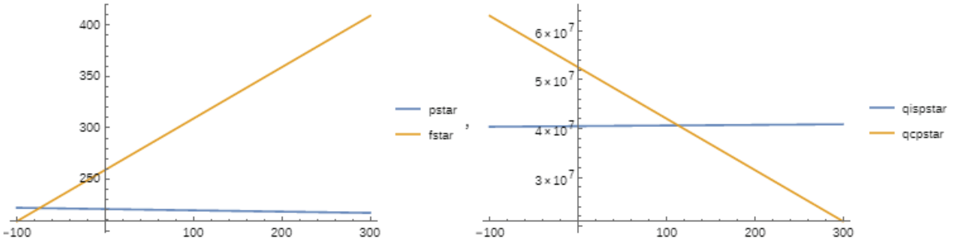


Figure 13. Scenario 3 Profits and CS based on ISP and CP

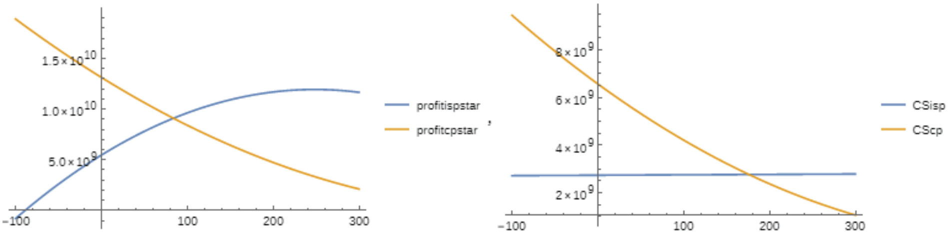


Figure 14. Scenario 3 TS, Total CS and Total PS

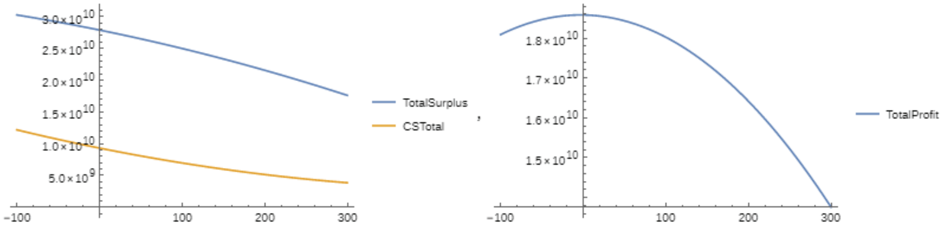


Table 8: Scenario 3 at t = 0 and Total Surplus Maximizing *t* in Equilibrium

Name	t = 0	t = -502.25	Delta
pstar	220.84	227.12	6.28
fstar	259.01	7.82	-251.19
qispstar	40.4×10^6	39.8×10^6	-0.6×10^6
qcpstar	52.5×10^6	105.2×10^6	52.7×10^6
profitispstar	5.4×10^9	-47.2×10^9	-52.6×10^9
profitcpstar	13.1×10^9	52.7×10^9	39.6×10^9
CSisp	2.7×10^9	2.6×10^9	-0.1×10^9
CScp	6.5×10^9	26.3×10^9	19.8×10^9
CStotal	9.3×10^9	29.0×10^9	19.7×10^9
TotalSurplus	27.8×10^9	34.5×10^9	6.7×10^9
Elasticity11	-1.64	-1.71	-
Elasticity12	-0.03	-0.001	-
Elasticity21	-0.02	-0.01	-
Elasticity22	-1.04	-0.02	-
Total profit maximizing t = -3.06			

This is an unlikely scenario considering that the ISP's profits turn out to be such a large negative value, but it reinforces the findings from Scenario 1 and 2.

2.1.14. Scenario 4: High cross effect while ISP's own price effect is higher than CP's

Table 9: Scenario 4 Parameters for Determining Total Surplus Maximizing *t*

Scenario	$a_1 = a_2$	b_{11}	b	b_{22}	c_{isp}	c_{cp}
4	108,000,000	300,000	200,000	210,000	\$86	\$9

The equilibrium prices in Scenario 4 as a function of *t* in are as follows:

Figure 15. Scenario 4 Prices and Quantities in Equilibrium

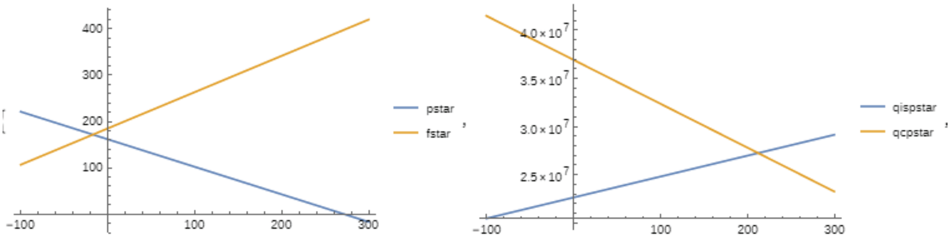


Figure 16. Scenario 4 Profits and CS based on ISP and CP

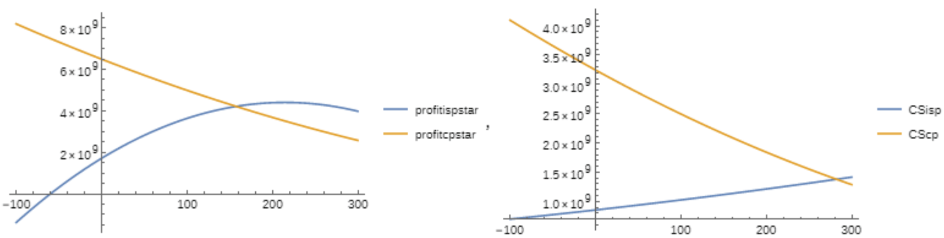


Figure 17. Scenario 4 TS, Total CS and Total PS

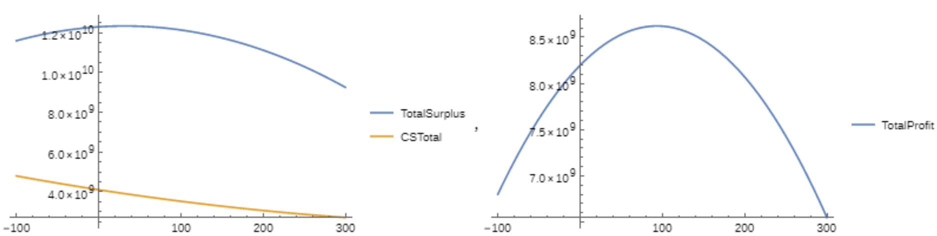


Table 10: Scenario 4 at t = 0 and Total Surplus Maximizing *t* in Equilibrium

Name	t = 0	t = 31.65	Delta
pstar	161.40	142.59	-18.81
fstar	184.78	209.57	24.79
qispstar	22.6×10^{6}	23.3×10^{6}	0.7×10^{6}
qcpstar	36.9×10^{6}	35.5×10^{6}	-1.4×10^{6}
profitispstar	1.7×10^{9}	2.4×10^{9}	0.7×10^{9}
profitcpstar	6.4×10^{9}	6.0×10^{9}	-0.4×10^{9}
CSisp	0.9×10^{9}	0.9×10^{9}	0.0×10^{9}
CScp	3.2×10^{9}	3.0×10^{9}	-0.2×10^{9}
CStotal	4.1×10^{9}	3.9×10^{9}	-0.2×10^{9}
TotalSurplus	12.2×10^{9}	12.3×10^{9}	0.1×10^{9}
Elasticity11	-2.14	-1.84	-
Elasticity12	-1.63	-1.80	-
Elasticity21	-0.87	-0.80	-
Elasticity22	-1.05	-1.24	-
Total profit maximizing t = 93.53			

In this scenario, while the equilibrium values are reasonable, the effects on welfare of the termination fee is relatively low. Particularly, the total surplus increases with the optimal *t* but by less than one percent (See Table 11). This increase is due to the increase in ISP profits. In contrast, there is a significant decrease in the consumer surplus due to the increase in CP prices. This scenario is the most consistent with what is currently happening, such as the SKB and Comcast asking for a payment in exchange for Netflix's content delivery to the end-users and Netflix resisting that.

In this simulation, we see that the total surplus is maximized by the CP's termination fee payment to the ISP different from the previous steps where *t* was negative for reasonable values. Social welfare increases as a result of the increase in consumer surplus and profits, which in turn is a result of the ISP's price decrease and consequent demand increase. This increase more than compensates the CP's consumer surplus and profit decrease. This problem is not equivalent to the elimination of double marginalization via side payments ($t.q_{cp}$) because 1) $f > 0$ which means end consumers both pay the "retailer (ISP)" via $p > 0$ and the wholesaler/upstream firm (CP) simultaneously 2) the concept of transformation is not exogenous because q_{cp} is not directly transformed into q_{isp} although it affects revenues 3) there are different costs of production (not crucial). Even though the total profit maximizing and the total surplus maximizing termination fees are both positive, they are not the same. This means, a regulator imposed *t* that CP has to pay the ISP which maximizes the total surplus does not mimic cartel behavior. Despite the ISP's margin cost being almost an order of magnitude larger than the CP's marginal cost, we observe that the production increase in favor of ISPs makes society better off compared to the case where no termination fees are payed by the CP to the ISP. In such a case, we need not reinforce NN to increase social welfare.

Table 11: Total Surplus Change in Four Scenarios

Scenario	Cross effect	High own effect	TS maximizing t	Change in TS relative to t = 0	Total profit maximizing t
1	Low	CP	-\$205.97	\$2.6×10^{9} (+16%)	-\$1.33
2	High	CP	-\$75.41	\$0.6×10^{9} (+7%)	-\$24.45
3	Low	ISP	-\$502.25	\$6.7×10^{9} (+24%)	-\$3.06
4	High	ISP	\$31.65	\$0.1×10^{9} (+0.8%)	\$93.53

2.2. Conclusion

Modeling the CP-ISP economic relationship under imperfect complementarity yields new significant results related to the introduction and determination of a total surplus maximizing termination fee, which is at the core of the net neutrality debate.

The strength of cross price effects between the CP and the ISP play a significant role in the outcome of the model. The ISP and the CP have a fairly good idea about their own and cross price effects and so can the regulator by collecting data from them. The scenarios we show in this study clearly indicate under which parameter values it is welfare-improving to reinforce NN or relax it to maximize the social welfare. If the cross-price effects are relatively weak then the total surplus maximizing termination fee is likely highly negative. This result suggests that net neutrality should be preserved, and, in some cases, ISPs may need to be subsidized. On the other hand, when the CP's own price effect is relatively high compared to that of the ISP's, along with high cross price effects, then we can expect mergers between ISPs and CPs, which should be allowed, or ISPs may launch their own CPs, which should also be accepted by regulators. Finally, if the ISP's own price effect is relatively high compared to that of the CP's, along with high cross price effects, then the total surplus maximizing *t* is positive. Only in this case, the government should relax the net neutrality principle.

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