# Net Neutrality and the Pricing of Internet Service and Content

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Eric Rasmusen

*Abstract*

This paper explores two effects of net neutrality that might be expected to hurt consumers. First, it disallows contracts between service provider and content companies that would address the problem of monopoly of complementary goods. Second, it reduces the profits of service providers, which results in small markets being entirely unserved because the price to consumers is insufficient to reach zero profits and in larger markets being served by only one service provider because entry of a second provider would reduces profits below zero.

Rasmusen: Dan R. and Catherine M. Dalton Professor, Department of Business Economics and Public Policy, Kelley School of Business, Indiana University. 1309 E. 10th Street, Bloomington, Indiana, 47405-1701. (812) 855-9219. erasmuse@indiana.edu, http://www.rasmusen.org.

This paper: http://www.rasmusen.org/papers/net-neutrality.pdf.

## 1. Introduction

Companies like Comcast and ATT, whom I will call "service providers", sell internet service to consumers. This is a prerequisite to the consumer buying (or receiving in exchange for having to read advertising) internet content such as is provided by Netflix and Google, whom I will call "content companies".[1] Can the downstream service providers can take advantage of their blocking position to enrich themselves at the expense of the content companies and consumers? This is the motivation behind the various regulatory prohibitions called "net neutrality". One net neutality policy bans internet service providers from providing faster service for some kinds of content than others. A service provider could not, for example, prioritize long-distance surgery signals over the same number of packets of You-Tube video. This form of regulation would, I expect, have few defenders among economists, since consumers desire different qualities of service for different types of content and banning higher prices for higher quality reduces social surplus. A second kind of net neutrality is to prohibit service providers from providing faster speed— or indeed, providing any access at all— to individual content companies unless they pay for it. This prohibition is more interesting, and is the subject of this paper.[2]

The Federal Communications Commission's 2015 regulations imposed a "no-blocking rule" which

> "prohibits broadband providers from charging edge providers a fee to avoid having the edge providers content, service, or application blocked from reaching the broadband providers end-user customer." (FCC 2015, section 113; section 120 does the same for reduced speed)

[1]The FCC has used the terms "edge provider" for content companies, "BIAS provider" for service providers, and "end user" for consumers. I find those terms opaque.

[2]Gans (2015) and Gans and Katz (2016) note that for a rule to make much difference, it must be based on whether pricing is based on content, not on whether it is the consumer or the content company that is charged. If the rule merely says service providers cannot charge the content company for access to the consumer, the providers could instead charge the consumer for access to the content company.

In addition, it imposed a "no paid prioritization rule":

> A person engaged in the provision of broadband Internet access service, insofar as such person is so engaged, shall not engage in paid prioritization. (section 18)

Paid prioritization is defined as

> "the management of a broadband providers network to directly or indirectly favor some traffic over other traffic, including through use of techniques such as traffic shaping, prioritization, resource reservation, or other forms of preferential traffic management, either (a) in exchange for consideration (monetary or otherwise) from a third party, or (b) to benefit an affiliated entity. (FCC 2015, section 18)

Content provision is differentiated, with large amounts of market power arising from innovation and from network externalities. Service provision is a commodity, with switching costs, but with negligible loyalty to a particular provider's service. If every market had numerous service providers, net neutrality would make no difference, a point often made. Each service provider would compete with the others, and any attempt to impose a content fee would be rejected by the content provider, who could destroy that service provider if he wished simply by refusing to transmit through him adn reducing his service's quality to be slightly below that of the other service providers. At the same time, the content providers would have no incentive to charge fees to the service providers, because they could charge the fees to the ultimate consumer instead.

Thus, the situation that requires analysis is where both the service provider and the content company have market power. Such situations are realistic, because the market for internet service is still new, with some geographical areas unserved even by one service provider, much less two or whatever number is needed for effective competition. In other words, some markets for service provision are natural monopolies.

Since content companies have differentiated products and many have significant market power (e.g., Google, Amazon, Facebook), service provider natural monopolies are like successive monopolies. Google picks a content price and Comcast picks a service price that the consumer pays. If we allow the two companies to charge each other for the advantage of serving the customer with two products instead of one, we create a bargaining game between the two, a game which might end up with Google paying Comcast for access to the consumer or Comcast paying Google for access to the content. In theory, this could go either way. Industry belief seems to be that it would end up with Google paying Comcast. Whether this ends up improving social surplus and whether it ends up helping consumers, hurting them, or leaving them unaffected is unclear, so formal modelling may be useful.

It seems to be a question of who should get more profits, and for economists that is the heart of the debate. If we deregulate, Comcast charges Google a fee, Comcast is richer, and service provision expands to new regions. If we require net neutrality, Comcast can't charge Google and Comcast is poorer, but Google is richer and will innovate further in content. The question is which marginal elasticity of supply of innovation is greater, in markets or in content.

Robin Lee and Tim Wu make the argument for net neutrality that content companies need incentivizing in their 2009 *Journal of Economic Perspectives* article, verbally, though carefully and at length). Economides & Tag (2012) and Greenstein, Peitz & Valletti (2016) have models illustrating the tradeoff between incentivizing content and incentivizing service. There exist many articles on subtle aspects of the situation concerned with details of price discrimination and the operations of two-sided markets, in the tradition of the classic Rochet & Tirole (20xx) article on two-sided platforms (see, too, Weyl (2010))—for example, Choi & Kim (2010), Economides & Hermalin (2012), and Choi, Jeon & Kim (2015). The present paper will try to very simply address two points that seem to have been overlooked. First, under net neutrality the complementary content and service monopolies lead to prices too high even to maximize industry profits, so the more complicated vertical contracting arrangements prohibited by net neutrality can reduce prices as well as enrich sellers. Second, since payments by the content company to the service provider increase service profits, it not only encourages entry into markets otherwise unserved because they are too small (part of the basic tradeoff), but also allows two service providers to fit profitably into a market where only one could otherwise survive. As a result, deregulation could reduce prices in already-served markets as well as cause new markets to be served. A complication, however, is that some customers buy just service, and some buy both service and content. Removal of net neutrality might reduce one price, but raise the other, as we will explore in the analysis.

## 2. The Model

Let there be two types of consumers, nonvaluers and valuers in a market of size $m$. The fraction $\gamma$ who are nonvaluers buy only service, at price $p$, while the fraction $(1-\gamma)$ who are valuers buy only the combination of service at price $p$ (from a service provider) and content at price $r$ (from a content provider), but value the content at amount $v$. Let demand be linear, so the demand equation per unit mass of consumers for nonvaluers is is

$$q^s = (\alpha_0 - \alpha_1 p) \tag{1}$$

and for valuers (who buy both service and content) it is

$$q^b = (\alpha_0 + \alpha_1 v - \alpha_1(p+r)) \tag{2}$$

We will also divide the consumers into two other groups based on their preference between the two service providers when we come to analyze duopoly.

A service provider incurs a cost $K$ to enter, but the content company has no entry cost. The marginal costs of service and content are

$c_s$ and $c_c$, where these are low enough that at least some consumers are willing to buy if the price equals marginal cost, i.e. if

$$c_s < \frac{\alpha_0}{\alpha_1} \ c_c < v \tag{3}$$

By net neutrality we will mean a regulatory regime in which service providers choose $p_1$ and $p_2$ (or just $p$ if a monopoly) and the content provider chooses $r$. We will also consider a net neutrality scenario in which service providers can price discriminate among consumers, giving a discount to a consumer who also buys content– but cannot impose charges on the content company, or require a consumer to pay a higher service price if he also buys content. By deregulation we will mean regime in which service providers make contracts with the content provider that require concessions for access to the service customers—bilateral contracts only, however, rather than three-way contracts that would allow horizontal collusion. We will consider both a contract in which the service provider requires a lump sum payment $T$ for access to its customers and contracts in which the service provider agrees to charge price $p$ for service and the content company agrees to charge price $r$ for content to the service provider's customers, and in which the content firm also pays a lump sum transfer $T$ to the provider. The service provider will prefer a contract that sets prices, but this might be suspect under antitrust law even if it resulted in reduced prices. Moreover, it might be unwise to commit to prices given the benefit of flexibility in prices in a changing environment.

Under net neutrality, we will assume that the service providers and content firm choose their prices simultaneously. Under deregulation, we will assume that the service provider or providers simultaneously make take-it-or-leave it offers to the content firm, that one provider's offer cannot be made contingent on whether the other provider's offer is accepted or rejected, and that the provider's threat to block access to its customers if its offer is rejected is binding. As discussed in the introduction, these assumptions are made to give the service providers maximal bargaining power, the situation feared by advocates of net neutrality.

The market model thus has the features that (a) some consumers buy nothing, some buy just service and some buy both content and service, and (b) if the price of either service or content falls, the quantities demanded of both service and content will increase. The model uses prices as strategies rather than the quantities used in the best-known article on the pricing of complements, Economides & Salop (1992). That is because the objective here is to look at contracting between the parties, which is more naturally expressed in terms of price-setting, lump sum transfers, and per-unit access fees, rather than as the effect of complements on Cournot competition. Note, too, that this model has the limitation that neither of the two types of consumers switch from buying both service and content to buying just service as the price of content rises. Each group of consumer has a continuum of values, but while it would be feasible to have just one group with a two-dimensional continuum of values for service and content for the monopoly case (though we would lose linearity of the demand curve), it would be infeasibly complex once we add duopoly preference for one or the other service provider.

## 3. Monopoly

The monopoly service provider sells to the nonvaluer fraction $\gamma$ and the valuer fraction $(1-\gamma)$ of consumers in a market of size $m$, so its profit is, assuming non-negative sales to both valuers and nonvaluers,

$$m[\gamma q^s+(1-\gamma)q^b][p-c_s]-K = m[\gamma(\alpha_0-\alpha_1 p)+(1-\gamma)(\alpha_0+v/\alpha_1-\alpha_1 p-\alpha_1 r)][p-c_s]-K \tag{4}$$

Differentiating with respect to the service price $p$, equating to zero, and solving for $p$ yields the service provider's reaction function:

$$p = \frac{\alpha_0+(1-\gamma)\alpha_1 v+\alpha_1 c_s}{2\alpha_1} - \frac{(1-\gamma)\alpha_1 r}{2\alpha_1} \tag{5}$$

The content company sells just to the valuer fraction $(1-\gamma)$ of consumers, for profit of

$$m(1-\gamma)q^b[r-c_c] = m(1-\gamma)(\alpha_0+\alpha_1 v-\alpha_1 p-\alpha_1 r)][r-c_c] \quad (6)$$

Differentiating with respect to the content price $r$, equating to zero, and solving for $r$ yields the content company's reaction equation:

$$r = \frac{\alpha_0+\alpha_1 v}{2\alpha_1}+\frac{c_c}{2}-\frac{p}{2} \quad (7)$$

Note that the price of service falls in the price of content. Similarly, the price of content falls in the price of service. The price choices are strategic substitutes, even though the goods are complements. Ordinarily, a Bertrand game has strategic complements, in contrast to a Cournot game's strategic substitutes. That, however, is because ordinarily the products are substitutes, not complements, even though they may be imperfect substitutes. Here, the products are complements, which reverses the strategies to be strategic complements to each other. That will account for some surprising features of the present model, which behaves more like a Cournot game than a differentiated Bertrand game. It has a first-mover advantage, for example: if the service provider could move first, it would charge a higher price and the content company would react with a lower price than in the simultaneous-move game we have here. This is like the higher output of a Stackelberg leader compared to the Stackelberg follower.

Solving the two reaction equations for $p$ and $r$ to find them in terms of the exogenous parameters yields [3]

$$p = \frac{(1+\gamma)\alpha_0+(1-\gamma)\alpha_1 v+2\alpha_1 c_s-(1-\gamma)\alpha_1 c_c}{(3+\gamma)\alpha_1} \quad (8)$$

and

$$r = \frac{\alpha_0+(1+\gamma)\alpha_1 v+2\alpha_1 c_c-\alpha_1 c_s}{(3+\gamma)\alpha_1} \quad (9)$$

so the combined price for service and content is

$$p+r = \frac{(2+\gamma)\alpha_0+2\alpha_1 v+\alpha_1 c_s+(1+\gamma)\alpha_1 c_c}{(3+\gamma)\alpha_1} \quad (10)$$

[3] using python

As one would expect, a firm's price rises in its own marginal cost. Its price will fall in the marginal cost of the other firm, since that higher marginal cost increases the other firm's price, which reduces demand for a complement. The demand parameters matter to the price of content through their effect on the price of service. If the demand curve's slope, $\alpha_1$, increases, then both prices fall; if the intercepts $\alpha_0$ and $v$ increase, both $p$ and $r$ rise.

### 2.2b. Monopoly Price Discrimination under Net Neutrality.

Net neutrality is about whether the service providers can impose charges on the content company in return for access. An equivalent pricing policy would be for the service providers to charge consumers for access to the content company. We will assume that net neutrality rules this out, though in policy discussions this equivalence is often ignored. Net neutrality does not prohibit service providers from charging consumers using complex price discrimination schemes, but we will assume that service providers do not observe a customer's type directly. We will, however, consider a scenario in which service providers observe whether a customer buys content as well as service, and we will assume that net neutrality allows the service provider to charge a lower price to content-buying customers. That would be giving a discount for accessing content, not a charge.

Using price discrimination, the monopoly service provider will sell to nonvaluer consumers at price $p^s$ and valuer consumers at price $p^{both}$. Net revenue (ignoring the fixed cost) from nonvaluers is

$$m\gamma(\alpha_0 - \alpha_1 p^s)[p^s - c_s] \tag{11}$$

so the profit-maximizing price is

$$p^s = \frac{\alpha_0}{2\alpha_1} + \frac{c_s}{2}. \tag{12}$$

Net revenue from valuers is, ignoring the fixed cost $K$,

$$m(1-\gamma)(\alpha_0 + \alpha_1 v - \alpha_1 p^b - \alpha_1 r)[p^b - c_s] \tag{13}$$

so the service provider's reaction function is

$$p^b = \frac{\alpha_0 + \alpha_1 v}{2\alpha_1} + \frac{c_s}{2} - \frac{r}{2} \tag{14}$$

The content company sells just to the valuer fraction $(1-\gamma)$ of consumers, for profit of

$$m(1-\gamma)q^b[r - c_c] = m(1-\gamma)(\alpha_0 + \alpha_1 v - \alpha_1 p^b - \alpha_1 r)][r - c_c] \tag{15}$$

which gives us the same reaction function for the content company as when the service provider does not price-discriminate:

$$r = \frac{\alpha_0 + \alpha_1 v}{2\alpha_1} + \frac{c_c}{2} - \frac{p^b}{2} \tag{16}$$

Solving the two reaction functions for $r$ and $p^b$ yields

$$p^b = \frac{\alpha_0 + \alpha_1 v}{3\alpha_1} + \frac{2c_s}{3} - \frac{c_c}{3} \tag{17}$$

and

$$r = \frac{\alpha_0 + \alpha_1 v}{3\alpha_1} + \frac{2c_c}{3} - \frac{c_s}{3}, \tag{18}$$

for a combined price for content plus service of

$$p^b + r = \frac{2\alpha_0 + 2\alpha_1 v}{3\alpha_1} + \frac{c_s}{3} + \frac{c_c}{3}. \tag{19}$$

The service provider wishes to charge a higher price for service alone than for service to customers who also buy content if $p^s > p^b$, which is the case if

$$\frac{\alpha_0}{\alpha_1} - c_s > 2(v - c_c) \tag{20}$$

Ordinarily which of two groups of customers is charged more by a price discriminator depends on the elasticities of demand of each group. Here, this is complicated by the fact that reason for the stronger demand of valuers is that they are paying a second seller, the content company. Thus, there are two forces at work. The first is that a price discriminator wishes to charge a higher price when demand is less elastic, which would by itself lead to $p^b > p^s$, since service plus content has stronger demand than service alone. The second is that the content company is also charging a price $r$ for the bundle, so the net demand facing the service provider is more elastic than if the content company's price were zero, which would tend to make $p^b < p^s$. If $v - c_c$ is small, the first effect dominates; content's extra value $v$ does not increase willingness to pay by much relative to the content company's price, which rises with $c_c$, so the net demand facing the service company is more elastic for the bundle than for service alone.

Thus, our second net neutrality scenario is one in which the service provider is allowed to price discriminate in favor of customers who buy content but forbidden to price discriminate against them. If $\frac{\alpha_0}{\alpha_1} - c_s > 2(v - c_c)$ the service provider will favor content customers in this way; otherwise the price for both kinds of customers will be uniform. We will compare both kinds of net neutrality with deregulation in which the service provider is free to price discriminate in any way and to contract over prices and transfer payments with the content company.

## 2.2. Monopoly Deregulation

### 2.2a. Monopoly: Lump-Sum Transfers Alone; No Contracting over Price

In this regime, prices are still chosen independently, but the content firm pays lump sum transfer $T$ to the provider. In equilibrium, the service and content prices are chosen to be exactly the same as under net neutrality since a lump sum does not affect marginal incentives. The service provider will make a take-it-or-leave-it offer of access to its customers in exchange for $T = m \cdot \pi^c(\textit{net neutrality})$, where we define $\pi^c(\textit{net neutrality})$ to be the content company's profit per unit of consumer under net neutrality, whether it be the single-price or the price-discrimination scenario. The service provider will accept. Similarly, let us define$\pi^s(\textit{net neutrality}) - K$ as the service provider's profit under net neutrality. In the lump-sum transfer regime, the service provider's profit will rise from $m \cdot \pi^s(\textit{net neutrality}) - K$ to $m \cdot \pi^s(\textit{net neutrality}) - K + T$; that is, to

$$m \cdot \pi^s(\textit{net neutrality}) + m \cdot \pi^c(\textit{net neutrality}) - K. \tag{21}$$

The threshold size of market that induces entry under net neutrality is

$$m_1(net\ neutrality) = \frac{K}{\pi^s(net\ neutrality)}. \tag{22}$$

The threshold under the transfer-only Regime is

$$m_1(regime\ 1) = \frac{K}{\pi^s(net\ neutrality) + \pi^c(net\ neutrality)}, \tag{23}$$

which is smaller. Thus, under the transfer-only regime small markets which would be unserved under net neutrality are now served, though the monopoly price is unchanged.

2.2b. Monopoly: The Efficient Pricing Regime. In this regulatory regime, the service provider offers a contract to the content company in which it agrees to charge $p$, the content firm agrees to charge $r$, and the content firm pays lump sum transfer $T$ to the service provider. The service provider's aim in offering a contract is to maximize the sum of service and content profit, and then to set $T$ so that the sum goes to himself. He has two price instruments, $p$ and $r$, which in effect are a price $p$ to the nonvaluers and a price $(p + r)$ to the valuers. Thus, he will choose $p$ to maximize profit from the nonvaluers and then choose $r$ to obtain the $(p+r)$ that maximizes profit from the valuers. This results in the price for service being the same as it was under net neutrality: discrimination,

$$p = \frac{\alpha_0}{2\alpha_1} + \frac{c_s}{2}. \tag{24}$$

Industry revenue from the valuers is, if we denote by $w = p + r$ the combined price,

$$m(1-\gamma)q^b[p+r-c_s-c_c] = m(1-\gamma)(\alpha_0+\alpha_1 v-\alpha_1(p+r))[p+r-c_s-c_c] \tag{25}$$

This is maximized by

$$p + r = \frac{\alpha_0 + \alpha_1 v}{2\alpha_1} + \frac{c_c + c_s}{2} \tag{26}$$

so

$$r = \frac{v + c_c}{2} \tag{27}$$

The transfer would be chosen to drive content company profits down to zero, so

$$T = m(1-\gamma)q^b[r - c_c] = m(1-\gamma)(\alpha_0 + \alpha_1 v - \alpha_1(\frac{v + c_c}{2}))\frac{v - c_c}{2}. \tag{28}$$

As in the case of the transfer-alone regime, the efficient pricing regime raises service provider profits relative to net neutrality, whether with price discrimination or without. Service provider profits will be even higher than just with the transfer, since the efficient pricing regime maximizes the sum of service and content profits, taking into account their complementarity, and in both types of deregulation the service provider ends up with the entire profit. Thus, the efficient pricing regime results in previously unserved markets now being served a fortiori.

**Proposition 1:** *Moving from net neutrality to deregulation results in some previously unserved markets being served. Allowing contracting over prices will also help consumers. In markets with a single service provider, the move reduces the combined price of service and content. If content customers previously paid less for service than customers buying service alone, the price of service alone remains unchanged. Otherwise, the service-alone price rises if the gains from trade from service are high enough relative to those from content (i.e.g if* $\frac{\alpha_0}{\alpha_1} - c_s > 2(v - c_c)$ *and falls otherwise.*

*Proof.* We have already shown that some previously unserved markets will now be served because the higher profits of the service provider will for marginal values of market size $m$ move profits from negative to positive after paying the fixed cost $F$.

Let us now consider prices. With price discrimination, net neutrality had

$$p^b + r = \frac{2\alpha_0 + 2\alpha_1 v}{3\alpha_1} + \frac{c_s}{3} + \frac{c_c}{3}. \tag{29}$$

Under the efficient pricing regime,

$$p + r = \frac{\alpha_0 + \alpha_1 v}{2\alpha_1} + \frac{c_c + c_s}{2} \tag{30}$$

The net neutrality combined price minus the efficient pricing regime combined price equals $\frac{\alpha_0+\alpha_1 v}{6\alpha_1} - \frac{c_s+c_c}{6}$. We assumed $c_c < v$ and $c_s < \frac{\alpha_0}{\alpha_1}$ so that some consumers would be willing to buy if the price equalled marginal cost. Thus, the combined price is higher under net neutrality. The price for just service was the same under net neutrality, so valuers gain from deregulation while nonvaluers are indifferent.

Under the efficient pricing regime,

$$p + r = \frac{\alpha_0 + \alpha_1 v}{2\alpha_1} + \frac{c_c + c_s}{2} \tag{31}$$

Under net neutrality without price discrimination we found

$$p + r = \frac{(2+\gamma)\alpha_0 + 2\alpha_1 v + \alpha_1 c_s + (1+\gamma)\alpha_1 c_c}{(3+\gamma)\alpha_1} \tag{32}$$

Straightforward if tedious algebraic manipulation shows that the difference between the net neutrality and efficient pricing regime combined prices is positive if

$$(1+\gamma)\alpha_0 + (1-\gamma)\alpha_1 v > [1-\gamma]\alpha_1 c_c + [1+\gamma]\alpha_1 c_s \tag{33}$$

This too is positive given the model's assumptions that $c_c < v$ and $c_s < \frac{\alpha_0}{\alpha_1}$. Thus, the combined price of service and content is lower under deregulation. ■

We earlier established that the price of service alone under the efficient pricing regime is equal to the $p^s$ that the service provider would charge under net neutrality if it had no regulatory constraints on price discrimination. We also established that the profit-maximizing $p^s$ was higher than $p^b$ if $\frac{\alpha_0}{\alpha_1} - c_s > 2(v - c_c)$ and lower otherwise. If the inequality is true, then if price discrimination unfavorable to nonvaluers were allowed before, the price would be unchanged after deregulation. If If the inequality is true and even price discrimination unfavorable to nonvaluers was prohibited under net neutrality, then deregulation, by allowing price discrimination, raises the price of service alone. If the inequality is false, then the service provider wished to charge service-alone customers a lower price under net neutrality, which is forbidden. Thus, if it is false, deregulation will permit the service provider to reduce the price for service alone.

The analysis of the efficient pricing regime also shows the inefficiency of pricing under net neutrality, and how it could be changed to obtain a pareto-superior outcome. Suppose we start with price discrimination and net neutrality. What we have found is that to maximize industry profits, the price of service alone should be kept the same or reduced, while the combined price of service and content, $(p^{both} + r)$, should be reduced. In the efficient pricing regime, this is done by reducing $p^{both}$ and increasing $r$, with the increase in content company net revenues taken away by the transfer $T$. Both service provider and content company could be better off than under net neutrality, however, even without transfers; they could agree to jointly reduce their prices.

Provider profits would be higher under the efficient pricing regime than under the transfer-only regime, so smaller markets would be served than under that regime or under net neutrality: $m_1$ is smaller. For consumers in those markets, efficient pricing is clearly better than net neutrality, whether price discrimination was allowed or not. As for consumers in markets that would be served under either regime, if price discrimination had been taking place under Net Neutrality, both valuers and nonvaluers benefit from lower prices under efficient pricing. If price discrimination had not been taking place, then valuers benefit from lower prices under efficient pricing, but nonvaluers would see higher prices if they are a large enough fraction of all consumers and the value of content is sufficiently low.

## 3. Duopoly

Let us now consider a market big enough for a second service provider to operate profitably. For this, we need to model duopoly competition. We will use a symmetric differentiated Bertrand model.

Consumers are equally and randomly split into two groups, each preferring a different service provider. The demand curve facing service provider 1 in terms of the service price $p_1$ and content price $r_1$ charged its customers and the equivalent prices $p_2$ and $r_2$ for service provider 2's customers depends on whether service provider 2's price is so high that its sales fall to zero— or, more relevant to the present context, if the content company rejects the service provider's offer and the service provider blocks access to its valuer customers. For the nonvaluer consumers, we will assume the demand curves are, if $q_1 \geq 0$ and $q_2 \geq 0$,

$$\begin{aligned} q_1^s &= .5(\alpha_0 - \alpha_1 p_1 + \alpha_2 p_2) \\ q_2^s &= .5(\alpha_0 - \alpha_1 p_2 + \alpha_2 p_1) \end{aligned} \tag{34}$$

and for the valuers,

$$\begin{aligned} q_1^b &= .5(\alpha_0 + \alpha_1 v - \alpha_1(p_1 + r) + \alpha_2(p_2 + r)) \\ q_2^b &= .5(\alpha_0 + \alpha_1 v - \alpha_1(p_2 + r) + \alpha_2(p_1 + r)) \end{aligned} \tag{35}$$

If $p_2 > \frac{\alpha_0 + \alpha_2 p_1}{\alpha_1}$, service provider 2 has zero sales to nonvaluers. Substituting that price for $p_2$, we have the monopoly demand curve for nonvaluers,

$$q^s = .5(\alpha_0 \frac{\alpha_1 + \alpha_2}{\alpha_1} - \frac{\alpha_1^2 - \alpha_2^2}{\alpha_1} p) \tag{36}$$

and similarly for valuers,

$$q^b = .5((\alpha_0 + \alpha_1 v)\frac{\alpha_1 + \alpha_2}{\alpha_1} - \frac{\alpha_1^2 - \alpha_2^2}{\alpha_1}(p + r)) \tag{37}$$

The use of the parameters $\alpha_0$ and $\alpha_1$ in this duopoly section is inconsistent with the notation in the previous section for monopoly. The models are consistent, because the market demand curves are linear, but the values of the parameters are different. They could be replaced with $\delta$ and $\theta$ (for example) but it is hoped that the inconsistent but more similar notation will be easier for the reader to follow. To compare prices between the two sections of the paper, one would convert the parameters in the monopoly section thus:

$$\alpha_0(monopoly) = \alpha_0 \frac{\alpha_1 + \alpha_2}{2\alpha_1}, \quad \alpha_1(monopoly) \qquad = \frac{\alpha_1^2 - \alpha_2^2}{2\alpha_1} \tag{38}$$

We assumed that $c_s < \frac{\alpha_0(monopoly)}{\alpha_1(monopoly)}$, so $c_s < \alpha_0 \frac{\alpha_1+\alpha_2}{\alpha_1^2-\alpha_2^2} = \alpha_0 \frac{\alpha_1+\alpha_2}{(\alpha_1+\alpha_2)(\alpha_1-\alpha_2)} = \frac{\alpha_0}{(\alpha_1-\alpha_2)}$, so it continues to be true that $c_s < \frac{\alpha_0}{\alpha_1}$ in the duopoly section. We assumed that $c_c < \alpha_1(monopoly)v$, so $c_c < \frac{\alpha_1^2-\alpha_2^2}{2\alpha_1}v = \alpha_1 v(\frac{1}{2} - \frac{\alpha_2^2}{2\alpha 1})$, which ensures that $c_c < \alpha_1 v$ using the duopoly notation since $(\frac{1}{2} - \frac{\alpha_2^2}{2\alpha 1}) < 1$.

## Duopoly Net Neutrality without Price Discrimination

Service provider 1's profit is $[.5m\gamma q_1^s + .5m(1-\gamma)q_1^b](p_1 - c_s) - K$, which equals

$$[.5m\gamma(\alpha_0 - \alpha_1 p_1 + \alpha_2 p_2) + .5m(1-\gamma)(\alpha_0 + \alpha_1 v - \alpha_1(p_1 + r) + \alpha_2(p_2 + r)](p_1 - c_s) - K, \tag{39}$$

yielding the reaction function

$$p_1 = \frac{\alpha_0 + (1-\gamma)\alpha_1 v}{2\alpha_1} + \frac{c_s}{2} + \frac{\alpha_2}{2\alpha_1}p_2 - \frac{\gamma\alpha_1 + (1-\gamma)\alpha_2}{2\alpha_1}r \tag{40}$$

As in monopoly, the service and content prices, $p_1$ and $r$, are strategic substitutes. The two service providers' prices, $p_1$ and $p_2$ are strategic complements, the typical result in Bertrand models.

The content company's profit is $m(1-\gamma)(q_1^b + q_2^b)(r - c_c)$, which equals

$$\begin{aligned} &[.5m(1-\gamma)(\alpha_0 + \alpha_1 v - \alpha_1(p_1 + r) + \alpha_2(p_2 + r)) \\ &+ .5m(1-\gamma)(\alpha_0 + \alpha_1 v - \alpha_1(p_2 + r) + \alpha_2(p_1 + r)](r - c_c) \end{aligned} \tag{41}$$

The content company's reaction function is

$$r = \frac{\alpha_0 + \alpha_1 v}{\alpha_1 - \alpha_2} + \frac{c_c}{2} - \frac{1}{4}p_1 - \frac{1}{4}p_2 \tag{42}$$

The equilibrium prices are then, if we let $\theta = \alpha_1 - \alpha_2$,

$$p_1 = p_2 = \frac{[2(1-\gamma)\theta - 2\alpha_2]\alpha_0 + [2(1-\gamma)\theta - 2\alpha_2]\alpha_1 v + 2\theta\alpha_1 c_s - [\theta\gamma + \alpha_2]\theta c_c}{\theta[4\alpha_1 - 3\alpha_2 - \theta\gamma]}, \tag{43}$$

$$r = \frac{[3\alpha_1 - \alpha_2]\alpha_0 + [4\alpha_1 - 2\alpha_2 - \theta(1-\gamma)]\alpha_1 v - \theta\alpha_1 c_s + [2\alpha_1 - \alpha_2]\theta c_c}{\theta[4\alpha_1 - 3\alpha_2 - \theta\gamma]}, \tag{44}$$

$$p + r = \frac{(5-2\gamma)\alpha_0 + (5-\gamma)\alpha_1 v + \alpha_1 c_s + (2\alpha_1 - \theta\gamma)c_c}{4\alpha_1 - 3\alpha_2 - \theta\gamma} \tag{45}$$

## Duopoly Net Neutrality with Price Discrimination

The net revenue of service provider 1 from nonvaluers (excluding K) is

$$mq_1^s(p_1^s - c_s) = .5m(\alpha_0 - \alpha_1 p_1^s + \alpha_2 p_2^s)(p_1^s - c_s), \tag{46}$$

which yields the reaction equation

$$p_1^s = \frac{\alpha_0 + \alpha_2 p_2^s + \alpha_1 c_s}{2\alpha_1}, \tag{47}$$

and, since the equilibrium is symmetric,

$$p_1^s = p_2^s = \frac{\alpha_0 + \alpha_1 c_s}{2\alpha_1 - \alpha_2}, \tag{48}$$

The net revenue of service provider 1 from valuers (excluding K) is

$$mq_1^b(p_1^b - c_s) = .5m(\alpha_0 + \alpha_1 v - \alpha_1(p_1^b + r) + \alpha_2(p_2^b + r))(p_1^b - c^s), \tag{49}$$

which yields the reaction equation,

$$p_1^b = \frac{\alpha_0 + \alpha_1 v + \alpha_1 c_s}{2\alpha_1} + \frac{\alpha_2 p_2^b}{2\alpha_1} - \frac{(\alpha_1 - \alpha_2)r}{2\alpha_1} \tag{50}$$

The content company will choose $r_1 = r_2 = r$ to maximize its profit:

$$.5mq_1^b(r - c_c) + .5mq_2^b(r - c_c) = .5m(\alpha_0 + \alpha_1 v - \alpha_1(p_1^b + r) + \alpha_2(p_2^b + r))(r - c_c) + .5m(\alpha_0 + \alpha_1 \tag{51}$$

and will have the reaction function,

$$r = \frac{2(\alpha_0 + \alpha_1 v) + 2(\alpha_1 - \alpha_2)c_c}{4(\alpha_1 - \alpha_2)} - \frac{p_1^b}{4} - \frac{p_2^b}{4} \tag{52}$$

Solving out the reaction equations for the two service providers and the content company yields

$$p_1^b = p_2^b = \frac{\alpha_0 + \alpha_1 v - (\alpha_1 - \alpha_2)c_c + 2\alpha_1 c_s}{3\alpha_1 - \alpha_2} \tag{53}$$

$$r = \frac{(\frac{\alpha_1}{\alpha_1 - \alpha_2})(\alpha_0 + \alpha_1 v) + (2\alpha_1 - \alpha_2)c_c - \alpha_1 c_s}{3\alpha_1 - \alpha_2} \tag{54}$$

$$p_1^b + r = \frac{\frac{2\alpha_1 - \alpha_2}{\alpha_1 - \alpha_2}(\alpha_0 + \alpha_1 v) + \alpha_1 c_s + \alpha_1 c_c}{3\alpha_1 - \alpha_2} \tag{55}$$

## Duopoly Deregulation: The Lump-Sum Access Charge Regime

Now that there are two service providers, their ability to make take-it-or-leave-it offers to the content provider is offset by the competition between them to make the most attractive offer. Suppose both service providers offer $T$. The content company has a choice between paying $T$ to both, or paying $T$ to just one and serving only its customers. Thus, the transfer will no longer be able to take away the entire profits of the content company. Instead, we should expect

$$m \cdot [\gamma\pi^s(net\ neutrality) - 2T = m \cdot \pi^s(serving\ just\ one) - T \tag{56}$$

and

$$T = m \cdot \pi^s(net\ neutrality) - m \cdot \pi^s(serving\ just\ one). \tag{57}$$

With a monopoly service provider, we saw that prices would be unchanged going from net neutrality to the lump-sum access charge regime. The same will be true with duopoly, but the if one service provider's offer is rejected would be different, and we must find these off-equilibrium prices in order to find the size of the transfer. In this regime, the service providers offer have not specified prices, and so they are chosen in the knowledge of whether both offers have been accepted, or just one. Suppose service provider 1's offer which is rejected. Service provider 2 would then end up as a monopoly service provider for valuers.

If price discrimination is allowed, service provider 2 will charge the duopoly price to nonvaluers and the monopoly price to valuers. We have already found these prices. [say where].

If price discrimination is not allowed, service provider 2 must charge the same price to both types of consumers. It will maximize

$$[.5m\gamma(\alpha_0 - \alpha_1 p_1 + \alpha_2 p_2) + .5m(1-\gamma)(.5((\alpha_0 + \alpha_1 v)\frac{\alpha_1 + \alpha_2}{\alpha_1} - \frac{\alpha_1^2 - \alpha_2^2}{\alpha_1}(p_2 + r_2))(p_2 - c_s) - K. \tag{58}$$

We will not calculate the value of $p_2$ when service provider 1's offer is rejected and price discrimination is allowed, since it will not affect the qualitative result. What matters is that whether price discrimination is allowed or not, the rejection of service provider 1's offer results in the content provider earning positive profits. The size of these profits will depend on whether price discrimination is allowed or not. If it is allowed, then service provider 2 will charge a higher price to valuers than if price discrimination is disallowed. This is worse for the content provider, but is balanced by onlyh having to pay $T$ rather than $2T$.

### Duopoly Deregulation: The Efficient Pricing Regime

As in the lump-sum access charge regime, the equilibrium transfer will give the content provider positive profits, unlike with monopoly. In the efficient pricing regime, however, each service provider offers a contract which specifies prices. Thus, the out-of-equilibrium prices will be the prices specified in the equilibrium offer by the service provider whose offer is accepted. These out-of-equilibrium prices will be different than in the lump-sum access charge regime, and will have lower prices for valuers, which will benefit the content provider since that increases the quantity demanded.

What will the equilibrium prices offered be? For nonvaluers, who buy only service, the efficient pricing regime service prices will be the same as under net neutrality with price discrimination. For valuers, service provider 1 now chooses the sum $(p_1 + r_1)$ to maximize the sum of its profit and the content company's profit from its customers:

$$.5mq^b(r - c_c) = .5m((\alpha_0 + \alpha_1 v) - \alpha_1(p_1 + r_1) + \alpha_2(p_2 + r_2))(p_1 + r_1 - c_s - c_c), \tag{59}$$

This yields the reaction equation

$$p_1 + r_1 = \frac{((\alpha_0 + \alpha_1 v) + \alpha_1(c_s + c_c)}{2\alpha_1} + \frac{\alpha_2(p_2 + r_2)}{2\alpha_1} \tag{60}$$

and the symmetric equilibrium

$$p_1 + r_1 = p_2 + r_2 = \frac{\alpha_0 + \alpha_1 v + \alpha_1(c_s + c_c)}{2\alpha_1 - \alpha_2} \tag{61}$$

so since the price of service alone is the same as under net neutrality with price discrimination,

$$p_1 = p_2 = \frac{\alpha_0 + \alpha_1 c_s}{2\alpha_1 - \alpha_2}, \tag{62}$$

and the price of content under the efficient pricing regime is

$$r_1 = r_2 = fixthis \frac{((\alpha_0 + \alpha_1 v) - \alpha_1(c_s + c_c)}{2\alpha_1 - \alpha_2} - \frac{(\alpha_0 + \alpha_1 v) + \alpha_1 c_s}{2\alpha_1 - \alpha_2} \tag{63}$$

Under price discrimination the combined price was:

$$p_1^b + r = \frac{\frac{2\alpha_1 - \alpha_2}{\alpha_1 - \alpha_2}(\alpha_0 + \alpha_1 v) + \alpha_1 c_s + \alpha_1 c_c}{3\alpha_1 - \alpha_2} \tag{64}$$

In the efficient pricing regime it is:

$$\frac{((\alpha_0 + \alpha_1 v) + \alpha_1(c_s + c_c)}{2\alpha_1 - \alpha_2} \tag{65}$$

Thus, the price is lower in the efficient pricing regime than under net neutrality with price discrimination.

Straightforward but lengthy algebra also shows that the combined price is lower under the efficient pricing regime if we move there from net neutrality without price discrimination.

What about the transfers $T_1$ and $T_2$ from the content company to the two service providers? As in the lump-sum transfer regime, the content company will be left with positive profits even after the transfer because it has the option of accepting just one of the two service providers' offers. In fact, the content company's position is even better MAYBE NOT–LOWER PRICE FOR THE CONTENT COMPANY in the efficient pricing regime, because the service providers' offers specify not only the transfer but the prices to consumers, and those prices are lower than the monopoly price relevant to setting the transfer in the lump-sum transfer regime.

Let me think. If one company's offer is rejected, then compared to the lump sum regime, the content company gets a lower price, I'm pretty sure, and I am very sure the service company's pric is lower.

**Proposition 2.** *Under duopoly, xxxx*

**Concluding Remarks**

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