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**“Net Neutrality,” Non-Discrimination
and Digital Distribution of Content Through the Internet**

Nicholas Economides
Stern School of Business, NYU

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Abstract

The vast majority of US residential consumers face a monopoly or duopoly in broadband Internet access. Up to now, the Internet was characterized by a regime of “net neutrality” where there was no discrimination in the price of a transmitted information packet based on the identities of either the transmitter or the receiver or based on the application or type of content that it contained. The providers of DSL or cable modem access in the United States, taking advantage of a recent regulatory change that effectively abolished net neutrality and non-discrimination protections, and possessing significant market power, have recently discussed implementing a variety of discriminatory pricing schemes. This paper discusses and evaluates the implication of a number of these schemes on prices, profits of the network access providers and those of the complementary applications and content providers, as well as the impact on consumers. We also discuss an assortment of anti-competitive effects of such price discrimination, and evaluate the possibility of imposition of net neutrality by law.

Key words: net neutrality, Internet, price discrimination, vertical restrictions, two-sided pricing, horizontal cooperation, raising rivals’ costs

JEL Classification: L1, D4, L12, L13, C63, D42, D43

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** Professor of Economics, Stern School of Business, N.Y.U., 44 West 4th Street, New York, NY 10012, (212) 998-0864, economides@stern.nyu.edu, <http://www.stern.nyu.edu/networks/>, and Executive Director, NET Institute, <http://www.NETinst.org> .

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1. Introduction

The Internet is a global network of interconnected networks that connect computers. The Internet allows data transfers as well as the provision of a variety of interactive real-time and time-delayed telecommunications services. Internet communications are based on common and public protocols. Hundreds of millions of computers are presently connected to the Internet. The vast majority of computers owned by individuals or businesses connect to the Internet through commercial Internet Service Providers (“ISPs”).¹ Users connect to the Internet either by dialing their ISP, connecting through cable modems, residential DSL, or through corporate networks. For 99% of US residential customers, access to the high speed broadband Internet is through DSL or cable modem. Typically, routers and switches owned by the ISP send the caller’s packets to a local Point of Presence “POP” of the Internet. Dial-up, cable modem, and DSL access POPs as well as corporate networks dedicated access circuits connect to high speed hubs. High speed circuits, leased from or owned by telephone companies, connect the high speed hubs forming an Internet Backbone Network (“IBN”).

The Internet has been established as the primary global network for digital communications. A number of different services are provided on the Internet, including e-mail, browsing (using Internet Explorer, Firefox, Opera, or others), Peer-to-Peer services, Internet telephony (Voice over Internet Protocol “VOIP”), and many others. A number of different functions/applications run on top of the Internet browser, including information services (Google, Yahoo, MSN), display of images, transmission of video and others. Since the advent of Mosaic, the first browser, in 1993, the text-based Internet was enhanced to allow for images and video to be transmitted on it in digital form. Presently, even full length movies are regularly downloaded, rented or sold, through commercial services over the Internet and shown on PCs and TVs.

As video services and digital distribution of content over the Internet are growing, Internet broadband access providers AT&T, Verizon and a number of cable TV companies, have recently demanded additional compensation for carrying valuable digital services. Ed Whitacre, AT&T’s CEO has been recently quoted in BusinessWeek referring to AT&T’s Internet infrastructure: “Now what they would like to do is use my pipes free, but I ain’t going to let them do that because we have spent this capital and we have to have a return on it.”²

¹ Educational institutions and government departments are also connected to the Internet but do not offer commercial ISP services.

² Interview of Ed Whitacre, BusinessWeek November 7, 2005.

Q. How concerned are you about Internet upstarts like Google (GOOG), MSN, Vonage, and others?

A. How do you think they’re going to get to customers? Through a broadband pipe. Cable companies have them. We have them. Now what they would like to do is use my pipes free, but I ain’t going to let them do that because we have spent this capital and we have to have a return on it. So there’s going to

The claim that consumers, content, or applications providers use the Internet for free is certainly incorrect. On the Internet, users pay ISPs for access to the whole Internet. Similarly, ISPs pay Internet backbones for access to the whole Internet.³ ISPs pay per month for a pipe of a certain bandwidth, according to their expected use.⁴ When digital content (or information packets of any service) is downloaded by consumer *A* from provider *B*, both sides, that is, both *A* and *B* pay. *A* pays to his ISP through his monthly subscription, and *B* pays similarly. In turn, ISPs pay to their respective backbones through their monthly subscription.

So, what was AT&T's CEO asking for? He was asking for the abolition of "net neutrality," a regime that does not distinguish in terms of price between bits or packets depending on the services that these bits and packets are used for, and also does not distinguish in price based on the identities of the uploader and downloader. This pricing regime has prevailed on the Internet since its inception. Presently, an information packet used for VOIP, for email, for an image, or for a video is priced equally as a part of the large number of packets that correspond to the subscription services of the originating and terminating ISP, and additionally there is no discrimination based on the identities of uploader and downloader. AT&T and Verizon and some cable companies would like to abolish the regime of net neutrality and substitute for it a pricing schedule where, besides the basic service for transmission of bits, there will be additional charges by the Internet operator for services applied to the originating party (such as Google, Yahoo, or MSN). The access network operators also have reserved the right to charge differently based on the identity of the provider even for the same type of packets, for example charge more Google than Yahoo for the same transmission. The proposed Internet model without net neutrality would be closer to the traditional pre-Internet telecommunications model where customers pay per service.⁵ It would also be a very sharp departure from the way the Internet has been designed and run since its inception.

After the acquisition of AT&T by SBC⁶ and of MCI by Verizon, taking advantage of a change in regulatory rules by the Federal Communications Commission, AT&T and Verizon now advocate price discrimination based on which application and

have to be some mechanism for these people who use these pipes to pay for the portion they're using. Why should they be allowed to use my pipes?

The Internet can't be free in that sense, because we and the cable companies have made an investment and for a Google or Yahoo! (YHOO) or Vonage or anybody to expect to use these pipes [for] free is nuts!

³ This service is called "transit." See Economides (2005a). Additional to transit service, Internet backbones of comparable size "peer" with each other, which means that they agree not to exchange money for exchanged traffic.

⁴ See Economides (2005a), Figure 2.

⁵ See Economides (2005a) for a discussion of the differences between the Internet and earlier digital data networks, and (2005b) for an exposition of traditional telecommunications regulation.

⁶ SBC changed its name to AT&T after it acquired AT&T.

on which provider the bits they transport came from.⁷ AT&T and Verizon would like to abolish the regime of net neutrality and substitute for it a complex pricing schedule where, besides the basic service for transmission of bits, there will be additional charges by the Internet access operator applied to the originating party (such as Google, Yahoo, or MSN) even when the application provider is not directly connected to AT&T or Verizon, that is, even when Google's ISP is not AT&T or Verizon.⁸

The broadband Internet access providers most likely new pricing scheme will impose price discrimination on the provider side of the market and not on the subscriber, that is, it will be a version of *two-sided* pricing. This is uniquely possible to firms operating within a network structure. Besides traditional networks, such two-sided pricing is also possible by intermediaries in exchange networks (such as the exchanges themselves).⁹ There is presently considerable debate on the legality as well as the efficiency properties of the implementation of such complex rules by broadband Internet access firms mainly because of the very considerable market power of such firms.

2. Abolition of Non-discrimination Requirements

Electronic networks are based on a number of levels of operation that are complementary with each other and necessary to operation. The Internet has been based on low level protocol sets of protocols, primarily TCP/IP. These protocols define three basic separate levels of functions of the network: (i) the hardware/electronics level of the physical network; (ii) the (logical) network level where basic communication and interoperability is established; and (iii) the applications/ services level. The Internet separates the network interoperability level from the applications/ services level.¹⁰ This means that, unlike earlier centralized digital electronic communications networks, such as CompuServe, AT&T Mail, Prodigy, and early AOL, the Internet allows a large variety of applications and services to be run “at the edge” of the network and *not* centrally. This means that users have a tremendous amount of choice: if a user wants to download video he can without asking permission from a central authority in the network; if a user wants to run a spyware stopper of his choice, that is his choice – it is not chosen by the network.

The tremendous degree of choice of applications and content on the Internet is a direct consequence of its design, where intelligence, applications, services, and content live “at the edge” of the network and are only dependent on the network for connectivity. A key consequence of net neutrality in pricing has been very successful innovation, resulting for example in Google, Yahoo, MSN and a large number of applications that

⁷ Recently, Deutsche Telecom and Telecom Italia have made similar proposals.

⁸ The proposed Internet model without net neutrality would be closer to the traditional pre-Internet telecommunications model where customers pay per service. See Economides (2005b).

⁹ See Economides (2005c) for a discussion of two-sided pricing in a network.

¹⁰ See Whitt (2004), Cerf (2006a), among others.

were developed by companies that do not own any network infrastructure. Large numbers of companies have been able to innovate at the edge of the network. This has included new ways of distribution of content (both news and entertainment),¹¹ distribution and modification of applications as well as many the creation of many new applications, for example, interactive advertising.

Since its beginnings as a commercial network, the Internet, like traditional telecommunications services and networks, was governed by non-discrimination requirements. Networks could not discriminate with respect to the identity of those receiving information packets, those sending them, the nature of the information packets and the function they performed, the content of the packets, the frequency of interactions, etc. The only discrimination that networks were allowed was their ability to price according to bandwidth used. Transmitters and receivers of Internet information packets are charged according to the amount of bandwidth they subscribe to. For example, a residential DSL customer may buy from his ISP a 384Kb per second bandwidth pipe, while a business customer may buy a large multiple of this. Similarly, ISPs are charged by Internet backbones subscription fees according to bandwidth.

In the summer of 2005, the Federal Communications Commission changed the classification of Internet transmissions from the category of “telecommunications services” to the category of “information services.”¹² This implied that now there were no non-discrimination restrictions on the Internet. The remarks of the president of SBC (now AT&T after SBC acquired AT&T in 2005-6) and similar moves by Verizon and cable TV companies underscore that the network infrastructure operators are keen to extract more value from the surplus generated by the information packets they transmit. This surplus accrues to both final consumers as consumers’ surplus (difference between what consumers are willing to pay and what they actually pay) and as profits to applications or content providers. It is widely believed that a key reason for the proposed change is the increasing introduction of video services by AT&T and Verizon. It is expected that such services may congest the “last mile” broadband Internet access as it is presently sold, and AT&T and Verizon would like to set up pricing so that consumers will buy their content rather than that of competitors. However, the broadband access providers have not committed to any restriction on their ability to extract additional surplus from consumers, content or application providers. Additionally, the broadband access providers have also not committed to not using some extreme price discrimination instruments, and their lobbyists have proposed congressional bills that formalize into law the ability of the access providers to impose any price discrimination scheme. Presently residential consumers pay at most \$24 billion a year for broadband Internet access. The consumers’ surplus and the profits of complementary applications and content providers

¹¹ There are significant changes in many industries because of the Internet. For example, dissemination of news through the Internet has cut radically in the circulation of newspapers and resulted in a round of consolidations.

¹² In mid 2005 the FCC reclassified Internet service so that it was no longer subject to non-discrimination rules. Also see *National Cable & Telecommunications Association v. Brand X Internet Services*, 125 S. Ct. 2688 (2005).

that distribute through the Internet are a very large multiple of this. Thus, the access providers have the potential to seriously disrupt the distribution of wealth between content, applications, and transmission.

To put the proposed change in perspective, it is useful to understand what general discriminatory pricing would mean on the traditional telecommunications network. If a telephone company were not bound by law not to discriminate according to the identity of parties to a phone call, it could routinely charge more for phone calls between investment bankers since these phone calls are more likely to generate more value than the average phone call. If phone companies were unregulated with respect to discrimination, they could charge more for fax telephone calls than for other calls, since fax transmissions are more likely to be more valuable on the average than phone calls. Similarly, a telephone company with no non-discrimination requirements could charge a high price for 911 emergency calls since the willingness to pay for these calls is obviously high.

As discussed earlier, the Internet under net neutrality separated the network layer from the applications/services layer. This allowed firms to innovate “at the edge of the network” without seeking approval from network operator(s).¹³ The decentralization of the Internet based on net neutrality facilitated innovation resulting in big successes such as the creation of the World Wide Web, Google, MSN, Skype, Yahoo, etc. Net neutrality also increased competition among the applications and services “at the edge of the network” which did not need to own a network to compete. Additionally, the existence of network effects on the Internet implies that efficient prices to users on both sides (consumers and applications) should be lower than in a market without network effects. Instead we see an attempt to increase prices that will reduce network effects and innovation.

3. Detailed Examination of Anti-competitive Concerns Arising from the Abolition of Net Neutrality

a. Horizontal Concerns

Abolition of net neutrality raises both horizontal and vertical antitrust and public interest issues. Besides pricing issues among the vertical concerns are also concerns that the network operators will discriminate against certain content and political opinions.

We start with a discussion of the horizontal concerns. Carriers in the “last mile” to the home have significant market power. Residential retail customers may well have difficulty changing ISPs in response to price or quality changes. For the vast majority of residential consumers in the US, there are only one or two choices for broadband Internet access; these choices are either DSL or access through Cable TV and their resellers. Cable TV has coverage of approximately 85% of US households but significantly lower

¹³ Vint Cerf, one of the “fathers of the Internet,” has called this environment “innovation without permission” of the network. See Cerf (2006a).

market penetration. Most cable TV companies offer broadband Internet access service only in conjunction with a digital cable TV package.¹⁴ Because of technical limitations, DSL is offered only to households that are not too far from a local telephone company switch, and its capabilities diminish as the distance from the switch increases. The vast majority of US households cannot buy DSL service (so called “naked DSL”) without at the same time subscribing to voice telephone service on the same line.¹⁵ Even where naked DSL is available, its price often significantly exceeds the price of DSL service with voice provision on the same line. Because of coverage and bundling issues and the very limited number of available providers of residential Internet broadband access, typically one or two, the broadband Internet access provider, typically AT&T, Verizon, or a cable TV company, have significant market power. Additionally, the complications of changing equipment, configuration, email addresses, etc., imply significant switching costs for customers which add to the market power of local access providers. Finally residential customers are much more affected by bundled broadband Internet access with other services such as telecommunications and cable television. However, despite the significant market power in the Internet broadband access market, carriers are unable to effectively discriminate in price between monopoly and duopoly customers. Marketing through mass channels constrains carriers to set up prices for large regions, typically covering a number of states. Some carriers have nationwide pricing. Thus, carriers have difficulty extracting consumers’ surplus to the extent that is proportional with their market power.

Carriers upstream on the Internet backbone transmission market have much less market power because, despite some concentration, there is a much more egalitarian distribution of market shares on the backbone. Market shares of national backbones are listed in Table 1 based on 1999 data and projections. In papers filed in support of the merger of SBC and AT&T as well as of the merger of Verizon with MCI, there was mention of two recent traffic studies by RHK. These studies showing traffic for 2004, summarized in Table 2, show a dramatic change in the ranking of the networks, with AT&T now being first and MCI being fourth. They also show that now a much bigger share of traffic (over 40%) is carried by smaller networks. These latest traffic studies show that the earlier concerns of the EU and the USDOJ that the Internet backbone market would tilt to monopoly were proved to be overstated.¹⁶

¹⁴ Even when broadband Internet access is offered by itself, it is typically offered at the full price of the bundle of Internet access and digital cable TV combined.

¹⁵ There is no technical requirement for this, and the EU has mandated unbundling of the fixed local telecommunications network that allows DSL to be provided separately from voice service, as well as in its absence.

¹⁶ See Economides (2006a) for a more detailed discussion of the EU and DOJ concerns at the WorldCom-MCI and MCI-Sprint mergers.

Table 1: Market Shares of National Internet Backbones¹⁷

| Company | 1997 | 1999 | 2001 (projected in 1999) | 2003 (projected in 1999) |
|-----------------------------|-------------|-------------|---|---|
| MCI WorldCom | 43% | 38% | 35% | 32% |
| GTE-BBN | 13% | 15% | 16% | 17% |
| AT&T | 12% | 11% | 14% | 19% |
| Sprint | 12% | 9% | 8% | 7% |
| Cable & Wireless | 9% | 6% | 6% | 6% |
| All Other | 11% | 21% | 22% | 19% |
| Total | 100% | 100% | 100% | 100% |

Table 2: Carrier Traffic in Petabytes per Month in 2004¹⁸

| Company | Traffic | | | | Market share among all networks |
|---|----------------|---------------|---------------|---------------|--|
| | 1Q2004 | 2Q2004 | 3Q2004 | 4Q2004 | 4Q2004 |
| A (AT&T) | 37.19 | 38.66 | 44.54 | 52.33 | 12.58% |
| B | 36.48 | 36.50 | 41.41 | 51.31 | 12.33% |
| C | 34.11 | 35.60 | 36.75 | 45.89 | 11.03% |
| D (MCI) | 24.71 | 25.81 | 26.86 | 30.87 | 7.42% |
| E | 18.04 | 18.89 | 21.08 | 25.46 | 6.12% |
| F | 16.33 | 17.78 | 17.47 | 19.33 | 4.65% |
| G | 16.67 | 15.04 | 14.93 | 15.19 | 3.65% |
| Total traffic Top 7 networks | 183.53 | 188.28 | 203.04 | 240.38 | 57.78% |
| Total traffic all networks | 313 | 313 | 353 | 416 | 100% |

Thus, concentration in the Internet backbone market is lower than in the broadband access market and has decreased in the last five years. Additionally, both firms and ISPs can connect with multiple suppliers. This practice, named “multi-homing,” is done by many ISPs, as well as their business customers, for two reasons. First, ISPs multi-home on various backbones to avoid outages, and for the same reason

¹⁷ Source: *Hearing on the MCI WorldCom-Sprint Merger Before the Senate Committee on the Judiciary*, Exhibit 3 (Nov 4, 1999) (Testimony of Tod A. Jacobs, Senior Telecommunications Analyst, Sanford C. Bernstein & Co., Inc.), Bernstein Research, *MCI WorldCom* (March 1999) at p. 51.

¹⁸ Data from *RHK Traffic Analysis – Methodology and Results*, May 2005. The identities of all networks are not provided, but it is likely that B, C, E and F are Level 3, Quest, Sprint, and SBC in unknown order.

large business customers multi-home on ISPs. Second, both ISPs and customers multi-home to put additional competitive pressure toward their service suppliers. Compared to the residential customer who has almost always either one or two broadband Internet access choices, business customers have many choices, especially large business customers. The fact that Internet access is more competitive for large business customers is also reflected in the significantly lower prices per unit of bandwidth that large business customers pay, both in comparison to residential customers and small business customers.

We first consider two-sided pricing by a monopolist who charges both final consumers and applications or content providers. We then discuss price discrimination by a monopolist. We follow up with price discrimination in oligopoly.

i. A Two-sided Pricing Model

We first consider the strategic interactions between a network monopolist A_0 , an applications or content company B_1 (selling a complementary good to the network company) and final consumers when the network can charge a fee to both consumers and applications.¹⁹ In the mathematical part of the text, for brevity we will be using the word “application” to mean both applications and content. The network firm sells Internet connection to end-users at price p_0 . The application provider sells the application to end-users at price p_1 . The application provider also pays a per unit access fee s to the network, set by the network.

Assuming a linear demand structure, let the demand function of network services be $q_0 = a_0 - b_0 p_0 - d p_1$, and the demand of the application B_1 be $q_1 = a_1 - b_1 p_1 - d p_0$.²⁰ The quantity intercept a_0 of the network demand (representing actual sales when all prices are zero) depends on the inherent quality and functions of the network and the variety of applications that are transported by the network.²¹ The parameter d measures the strength of the complementarity between the network and the application. We assume $b_0, b_1 > d$, *i.e.*, that the own-price effect of each product dominates the cross-price effect. Finally, to create a benchmark, we assume zero costs. The profit function of the network is $\pi_0 = \pi_{0u} + \pi_{0a}$, where $\pi_{0u} = p_0 q_0$ is the network profit from users, and $\pi_{0a} = s q_1$ is the network profit from the application access fees. The profit function of the application provider is $\pi_1 = (p_1 - s) q_1$.

Firms set prices in a two-stage game. In stage one, the network sets the access fee s paid by the application provider. In stage two, the network and the application provider set

¹⁹ The mathematical structure of this model is similar to Economides and Katsamakas (2006).

²⁰ This demand system can be generated by a population of users of differing willingness to pay. For example, it can be generated by a population of users of uniformly distributed types, each with a unit demand. This demand system can also be generated by a representative consumer with quadratic utility function.

²¹ The maximum sales of the network, a_0 , can be larger than the maximum sales of the application, a_1 , *i.e.*, $a_1 \leq a_0$.

end-user prices p_0, p_1 simultaneously. We assume that firms set prices non-cooperatively, and we characterize the subgame-perfect Nash equilibria.

We start by analyzing the last stage of the game. Imposing maximization conditions with respect to the choices of prices p_0 and p_1 by the network and the application, we find the network and application prices as respectively increasing and decreasing functions of the network access fee s .²² In the first stage of the game, the network chooses fee s anticipating the second stage equilibrium prices. Its necessary condition for profit maximization is $\frac{d\pi_0}{ds} = \left(p_0 \frac{dq_0}{ds} + q_0 \frac{dp_0}{ds}\right) + \left(s \frac{dq_1}{ds} + q_1\right) = 0$. A marginal increase of s affects both profit streams of the network firm. The profit from users increases by $p_0 \frac{dq_0}{ds}$ and decreases by $q_0 \left| \frac{dp_0}{ds} \right|$. The profit from the application firm increases by q_1 and decreases by $s \left| \frac{dq_1}{ds} \right|$. Both profit streams of the network are concave in s and therefore the total network profit is concave in s . The network's choice of s maximizes the sum of the two profit streams. The effect of s on the network profit from users is $\frac{d\pi_{0u}(s)}{ds} = d \frac{d(a_1(2b_0b_1+d^2)-6b_1(b_0b_1-d^2)s)-2a_0b_1(2b_0b_1+d^2)}{(4b_0b_1-d^2)^2}$. The profit from users is decreasing at $s = 0$, since $\frac{d\pi_{0u}(0)}{ds} = d \frac{a_1d(2b_0b_1+d^2)-2a_0b_1(2b_0b_1+d^2)}{(4b_0b_1-d^2)^2} < 0$. Therefore, the fee s_u^* that would maximize only the network profit from users is negative.

The effect of fee s on the network profit from the application is $\frac{d\pi_{0a}(s)}{ds} = b_1 \frac{2a_1b_0-a_0d-4(b_0b_1-d^2)s}{4b_0b_1-d^2}$. This profit is increasing at $s = 0$, if $2a_1b_0 - a_0d > 0$. Then s_a^* is positive, and therefore s^* may be positive or negative ($s_u^* < s^* < s_a^*$). The access fee s^* is positive when, at $s = 0$, the access profit from the application is increasing at a faster rate than the profit from users is decreasing. Figure 1 shows an example of that case. Figure 2, shows the relationship between the network's access fee to the application, the network profit, the application's profit and the total industry surplus, which is the sum of the profits of the network, the profits of the application, and consumers' surplus.

The two-stage game has a unique sub-game perfect Nash equilibrium given by the following prices:

$$s^* = \frac{a_1(8b_0^2b_1^2 + d^4) - a_0b_1d(8b_0b_1 + d^2)}{2b_1(b_0b_1 - d^2)(8b_0b_1 + d^2)}, \quad p_0^* = \frac{a_0b_1(8b_0b_1 + d^2) - a_1d(10b_0b_1 - d^2)}{2(b_0b_1 - d^2)(8b_0b_1 + d^2)},$$

$$p_1^* = \frac{a_1(12b_0^2b_1^2 - 2b_0b_1d^2 - d^4) - a_0b_1d(8b_0b_1 + d^2)}{2b_1(b_0b_1 - d^2)(8b_0b_1 + d^2)}.$$

²² Specifically, as $p_0 = \frac{2a_1b_1-d a_1-3db_1s}{4b_0b_1-d^2}$ and $p_1 = \frac{2a_1b_0-d a_0+(2b_0b_1+d^2)s}{4b_0b_1-d^2}$. Notice that $\frac{dp_1}{ds} > 0$ and $\frac{dp_0}{ds} < 0$, that is, as

expected, the application price increases with the access fee s because the application firm faces a higher marginal cost, while the network price decreases as the application has a higher price. These two effects imply that sales of the network (respectively application) increase (decrease) in the access fee s :

$\frac{dq_0}{ds} = -b_0 \frac{dp_0}{ds} - d \frac{dp_1}{ds} > 0$ and $\frac{dq_1}{ds} = -b_1 \frac{dp_1}{ds} - d \frac{dp_0}{ds} < 0$.

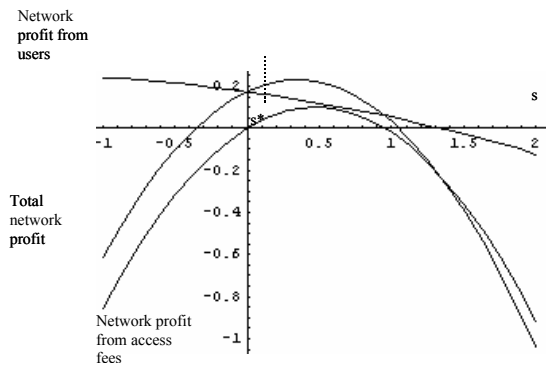


Figure 1: Network Profit Streams And Access Fee s^*

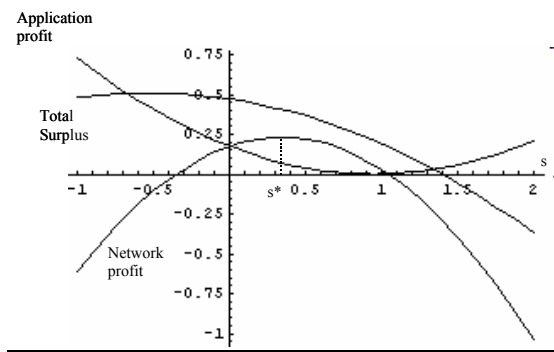


Figure 2: Network Profits, Application Profits and Total Industry Surplus

Thus, total surplus is lower when the network charges a positive fee to applications, even though a positive fee will typically be part of the equilibrium. Intuitively, this can be explained as follows. The fee acts as a marginal tax on the application and increases its marginal cost and the price that it charges to final consumers. Because of the complementarity between the application and the network, increasing the price of the application also hurts network sales. Thus, imposing a fee on the application has a larger negative impact on total industry surplus than imposing the same fee on the consumers and no fee on the application. The same argument can be put in terms of network effects. Because there are network effects between the application and the network, the network imposing a fee on the application has some negative effect on itself and therefore imposing a fee on applications reduces total industry surplus.²³

ii. Price Discriminating Monopolist

One of the features of the Internet is that it supports large numbers of applications and services. There is wide range in the willingnesses to pay for each type of service,

²³ Although the duopoly competition model for access with monopoly or duopoly applications had not yet been developed, there is no reason to believe that the main result on reduction of surplus by the imposition of fees on applications is going to be different.

and there is wide dispersion in its distribution. Additionally, there is no simple index or measure of capacity or bandwidth use that correlates well with willingness to pay. For example, bandwidth use is high for some highly valued services, such as video on demand, but bandwidth use is very low for information services such as search or bidding in auctions in real time which are also highly valuable.

In the absence of a legal mandate of non-discrimination, Internet broadband access providers may attempt to capture the consumer surplus that remains after uniform pricing. There are two reasons for that. First, even for a monopolist, price discrimination according to elasticities of demand increases profits. Second, uniform regional pricing discussed earlier constrains carriers profits to duopoly levels that can be significantly improved through price discrimination.

In selling to residential customers, a last mile monopolist carrier will typically have the incentive to reduce capacity of “plain” broadband Internet access service and/or degrade it so that it can establish a “premium” service for which it will charge additionally content or applications provider.

Suppose that information packets may differ according to willingness to pay. Let packet of type/function i be offered at price p_i and its demand be $D_i(p_i)$, $i = 1, \dots, n$, under price discrimination. Alternatively all packets are sold at the same price p . Assuming that the cost of transmission is the same for all packets, a price discriminating network monopolist faces cost $C(\sum D_i(p_i))$, and its profits under discrimination (Π_d) are

$$\Pi_d = \sum p_i D_i(p_i) - C(\sum D_i(p_i)).$$

It is easy to show that maximization of the monopolist’s profits implies

$$[p_i - C'(\sum D_i(p_i))]/p_i = 1/\varepsilon_i,$$

where ε_i is the elasticity of demand for packets of type i . Alternatively when all packets are sold at the same price, the monopolist maximizes Π_u (“u” for uniform pricing)

$$\Pi_u = p[\sum D_i(p)] - C(\sum D_i(p)).$$

Maximization of profits implies

$$[p - C'(\sum D_i(p))]/p = [\sum D_i(p)]/[\sum D_i(p)\varepsilon_i],$$

That is, the percentage of price to cost margin is a weighted average of the elasticities of demand for the various types of packages.

In general, the coordinated introduction of price discrimination schemes may reduce output. There is a general theorem that price discrimination that reduces total

output also reduces total surplus.²⁴ Thus, the first anti-competitive concern is that price discrimination will reduce output, and therefore be anti-competitive.

iii. Additional Oligopolistic Concerns

There are three additional considerations that reinforce this anti-competitive concern. First, most applications on the Internet exhibit network effects. This means that the last transaction/sale/download is worth more to the consumer when the market share of compatible applications is higher. For example, using search through Google is more valuable if Google has a larger market share. Using YouTube is more valuable when there are more subscribers to this web place. Additionally, more decide to subscribe and post when this web space has more subscribers. The existence of network effects implies that the efficient prices are below the perfectly competitive prices, that is, below marginal cost.²⁵ Broadband access providers are charging, at best, duopoly prices which are typically considerably higher than perfectly competitive prices. Thus, increasing present market prices as an effect of price discrimination will increase price divergence from efficient prices.

Second, the fact that application and content providers will be charged rather than directly the subscribers is likely to mask the true cost of Internet service to residential subscribers and create an additional distortion and surplus loss.²⁶

Third, since in many geographic areas competition in broadband access is duopolistic, the creation of a “premium” service and the necessary reduction in bandwidth capacity of plain service to create it is likely to be coordinated. The coordinated reduction of capacity in “plain” service is reminiscent of cartel behavior. Therefore introduction of coordinated price discrimination may have anti-competitive consequences. In particular, if there is sufficient evidence that the markets for “plain” and “premium” services are sufficiently different, the cartelization of “plain” service is likely to be a Sherman Section 1 violation.

b. Vertical Concerns

There is also a variety of potentially anti-competitive vertical effects which may result in Sherman Section 2 violations.

I. First, a carrier may favor its own content or application over that of independent providers. VOIP provided over broadband Internet competes with traditional circuit-

²⁴ This is contingent on all markets are served under uniform pricing, which holds here since we are starting with all markets served under net neutrality. See Schwartz (1990).

²⁵ See Economides (1996, 2005c).

²⁶ The generally more competitive market for large business customers will not shield them from the levies imposed by the access carriers.

switched service provided by AT&T, Verizon and with VOIP provided by cable TV operators. Independent VOIP could be subject to discrimination. Additionally, both AT&T and Verizon are gearing to distribute video, and could favor their video service over that of others. In the absence of non-discrimination rules, the last mile carriers can leverage their market power in the broadband access market to their voice telecommunications market. This applies to both telecommunications companies who can degrade opponents VOIP service to protect their fixed line voice service, as well as cable companies who may degrade opponents VOIP service to protect their own VOIP service. There are similar concerns for the carriers' video service. It should be clear that, although active sabotage of a competitors service is an obvious form of discrimination, the network access providers do not need to use these tactics. To effectively discriminate against a competitor, it will be sufficient for the access provider to set a high discriminatory fee that will effectively block profitable operation by the competitor.²⁷

II. Second, the anti-competitive concerns are hardly limited to products and services currently provided by the firms with market power in the access market. The carriers can also leverage market power in broadband access to the content or applications markets through contractual relationships. There can be a number of these:

(i) A carrier can contract with an Internet search engine (or other application, or video content provider) to put it in "premium" service, while searches using other search engines have considerable delays using "plain" service. In this setup, the "plain" service can be tweaked to be sufficiently slow that consumers will choose to do almost all their searches with the search engine in "premium" service. By making "take it or leave it offers" to the various search engines, the access carrier can extract a large part of the profits of the complementary good, here search engines. In effect, this type of strategy can determine who will be the successful search (or application, or content) company. It gives tremendous power to the network company without it being obtrusive and actively sabotaging any company.

(ii) In the same setup, a carrier can actively sabotage a search engine (or application or content) company with similar results as above.

4. Calibration of Potential Welfare Losses

There are no published estimates of the elasticities of demand for various Internet applications. Thus, it is very hard to estimate the exact effect of the proposed price discrimination scheme. However, Goolsbee (2006), using early data, estimates the elasticity of demand for broadband Internet access to be approximately $\epsilon = 3$ at \$40 with marginal cost at \$25, *i.e.*, at a 60% markup over cost.²⁸ We may assume that a new price discrimination scheme would precipitate a moderate increase in average price of at least 20%. This would imply a deadweight loss ("DWL") of at least 6% of the annual total

²⁷ See Economides (1998).

²⁸ Here marginal cost does not mean the cost of a single transmission. It rather means deployment of service to a customer.

Internet broadband access bill, using the standard approximate calculation $DWL = (\Delta P)(\Delta Q)/2 = \varepsilon(QP)(\Delta P/P)^2/2$, where $\Delta P/P$ is the proposed percentage price increase, here 20%, and ε is the elasticity of demand, here 3. OECD (2006) puts the number of broadband subscriptions in the US at 50 million. This brings the annual revenue to networks from broadband access to \$24 billion and the estimated direct welfare loss to residential consumers to roughly \$144 million annually. Currently, there is no good estimate of the additional welfare loss to business customers.

The above estimate is a moderate lower bound on the surplus losses that may be generated by price discrimination by the access networks. Besides the direct losses of the consumers, the proposed price discrimination scheme will additionally decrease surplus in a variety of ways:

- (i) It will decrease consumers', applications, and content providers surplus because it will imply a further divergence from efficient pricing in the presence of network effects;
- (ii) will foreclose on the margin potential entrants in complementary applications and content markets;
- (iii) will decrease innovative activity of applications and content providers at the edge of the network; and
- (iv) will give the access providers the ability to choose which content and/or application will be successful removing the significant benefits of mix and match

It is difficult to quantify the extent of these surplus losses. We note however that the present residential access bill is below \$24 billion, while the profits of the complementary goods and services and applications plus consumers surplus are a large multiple of this amount.

5. Policy Implications

The question posed in 2007 in front of US Congress is whether it should intervene now by imposing non-discrimination restrictions or if it should wait for antitrust suits to be filed and resolved. In my opinion, it is better to impose the non-discrimination restrictions by law because

- (i) Suits take time and much damage can be done before they are resolved. The legal system is slow and lawsuits will not be resolved in "Internet time."
- (ii) There is a variety of antitrust concerns while each suit will typically deal with one issue. Thus, delays may be compounded while each type of suit is adjudicated.
- (iii) The Internet is a key essential network for growth of the US economy. The US is already lagging behind 14 OECD countries (typically less developed and with lower per capita income) in Internet penetration, as seen in Figures 3 and 4. Figure 5 shows that a number of countries with higher broadband Internet penetration than the US have lower population densities, so US population density does not explain low US penetration.²⁹ Since the Internet is a key factor for

²⁹ Iceland, Finland, Norway, Canada and Sweden have lower population densities than the US but significantly higher broadband Internet penetration.

future growth, high penetration is desirable and adding price discrimination is unlikely to help.

- (iv) Increasing prices through two-sided pricing will not increase network traffic or grow the network!
- (v) Even if in the end there are no antitrust violations connected with the abolition of net neutrality, the abolition of net neutrality is likely to have significant negative consequences on innovation on the Internet and therefore it is in the public interest to prevent it by law.

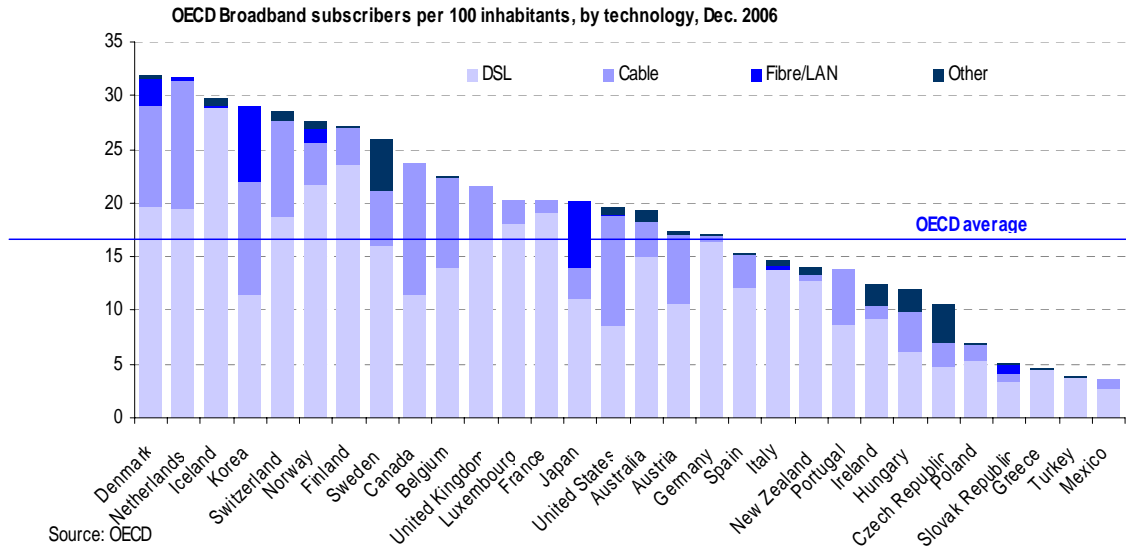


Figure 3: Market Penetration of Internet Broadband Among OECD Countries By Type of Technology Used

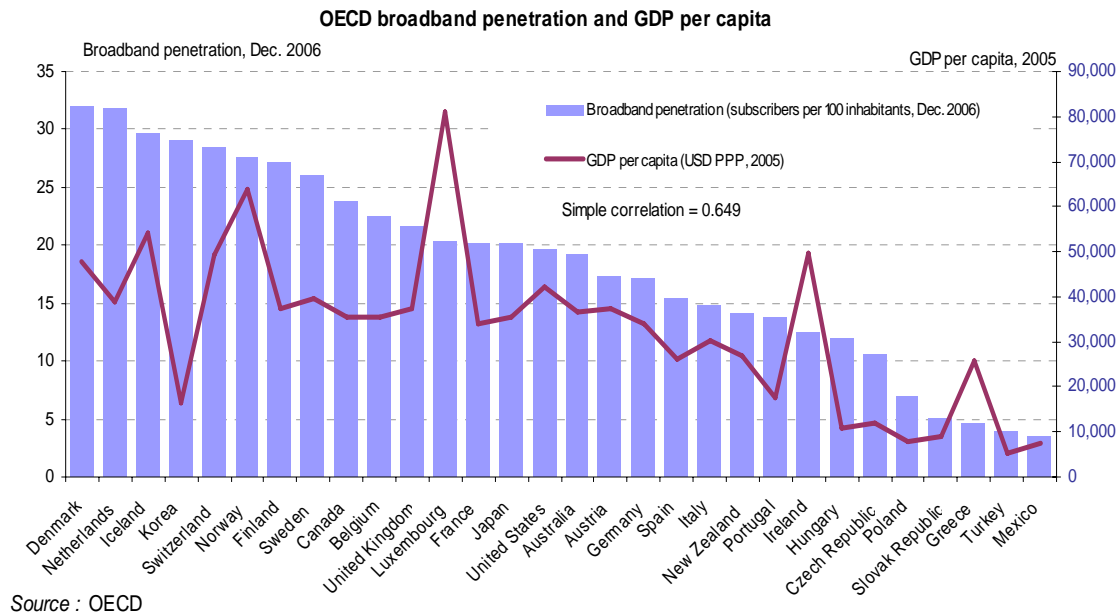


Figure 4: Broadband Internet Penetration and per Capita Income

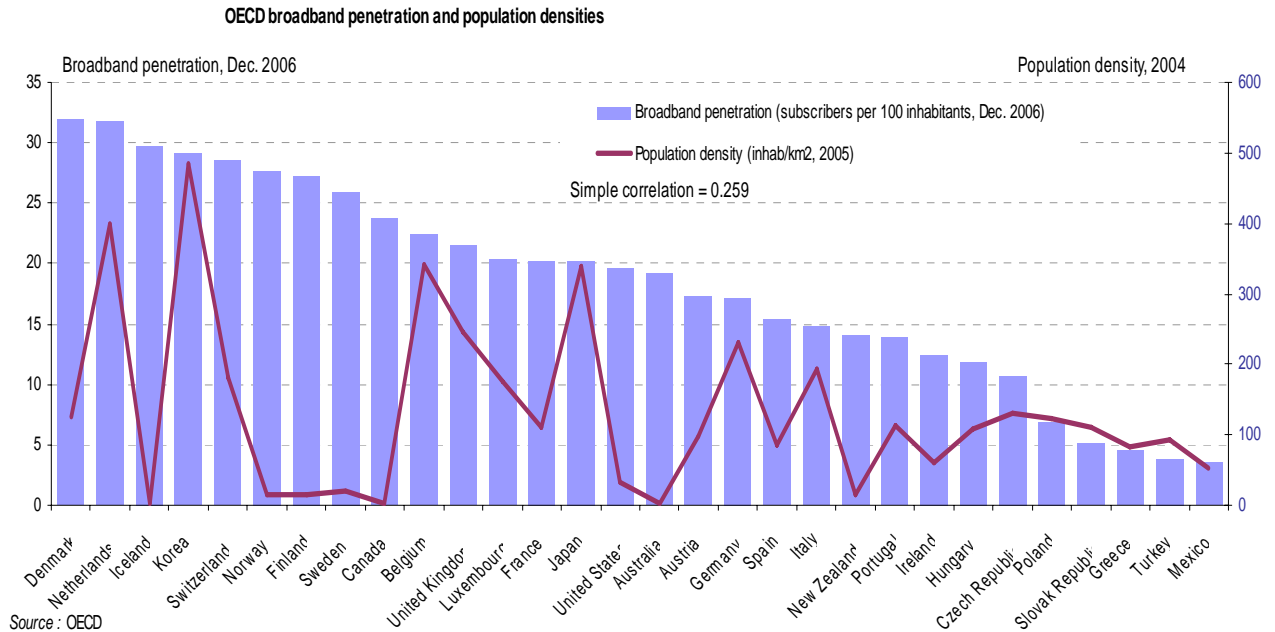


Figure 5: Broadband Internet Penetration and Population Density

6. Concluding Remarks

The Internet is the most important telecommunications network of the last fifty years. Utilizing public protocols and standards and taking advantage of very significant advances in electronics, computers, fiberoptics, and laser technology, the Internet has been an engine of growth for the US and world economy by facilitating innovation “at the edge” of the network. Relying on public protocols, applications were developed to run across the Internet and content was disseminated on the Internet without approval or consent by Internet operators. Tremendous successes resulted such as the World Wide Web and all the applications that run on it, including big financial successes such as Yahoo and Google as well as big benefits of social interaction network and great leaps in civil society through new discussion forums and formats.

The Internet is a relatively new network, with only a dozen or so years in its commercial form. Its tremendous acceptance and success has made it as essential part of both business and personal life. All previous electronic networks including early successes such as AOL have abandoned proprietary formats and folded in the Internet. The success of the Internet this far has been based on openness and non-discrimination which until recently were guaranteed by US telecommunications regulation. Recently this regulation has been abolished leading to proposals by broadband Internet access providers to radically change pricing on the Internet. This paper shows that these changes are likely to hurt consumers and diminish innovative activities in complementary sectors such as computer applications and content dissemination. These pricing

proposals, if implemented, are likely to raise a variety of significant anti-competitive concerns, outlined in detail in the paper.

Among these concerns is the possibility that access providers will degrade and/or restrict capacity in traditional Internet access to force applications and content providers to use their new “premium” service. The possibility exists that this degradation and restriction of capacity will happen in a coordinated way, in a cartel-like fashion. We show that, even in the absence of such discrimination, because of the existence of network effects, charging a fee to applications is likely to hurt both consumers and whole benefit that the Internet brings to society.

There is large number of vertical anti-competitive concerns. The access networks, if left unrestrained by non-discrimination rules, have incentives to favor their own services, applications, and content and kill competing services, such as VOIP, an alternative telephone service running over the Internet. Additionally, the access networks have incentives to leverage their access monopoly or duopoly market power in many other complementary markets by offering take-it or leave-it contracts. Thus, the access providers will be able to determine who will be the winner in search, content, and many other applications and services. This would be highly detrimental to consumers and many industries that rely on the Internet.

So the present question before Congress is whether to allow the Internet to be run without non-discrimination rules or whether to impose specific non-discrimination rules. A number of considerations favor imposing a specific rule supporting net neutrality. First, litigation is very slow, and much damage can be done before the resolution of litigation. Second, there are a number of different antitrust concerns, and litigation will have to deal with one at a time. Third, the Internet is a crucial network for US growth, and its penetration is low compared to many other countries of much lower per capita income, and the imposition of discrimination is likely to make things worse. Fourth, because of network effects, the correct public policy is to subsidize the Internet, rather than increase its price. The price discrimination schemes discussed are likely to effectively increase the price consumers pay for Internet access. Finally, innovation “at the edge” of the network has flourished under the regime of net neutrality and would be significantly threatened by discriminatory actions.

7. **Bibliography**

- Bauer, Johannes M. (2006), "Dynamic Effects of Network Neutrality," mimeo.
- Cerf, Vinton G. (2006a), *Prepared Statement of Vinton G. Cerf*, U.S. Senate Committee on Commerce, Science, and Transportation. Hearing on "Network Neutrality," February 7, 2006.
- Cerf, Vinton G. (2006b), *Prepared Statement of Vinton G. Cerf*, U.S. Senate Committee on the Judiciary. Hearing on Reconsidering our Communications Laws, June 14, 2006
- Economides, Nicholas (1996), "The Economics of Networks," *International Journal of Industrial Organization* (1996), vol. 14, no. 2, pp. 675-699, lead article. Pre-publication electronic copy available at http://www.stern.nyu.edu/networks/Economides_Economics_of_Networks.pdf.
- Economides, Nicholas (1998), "The Incentive for Non-Price Discrimination by an Input Monopolist," *International Journal of Industrial Organization*, vol. 16 (March 1998), pp. 271-284. Pre-publication electronic copy available at http://www.stern.nyu.edu/networks/The_Incentive_for_Non-Price_Discrimination.pdf.
- Economides, Nicholas (2005a), "The Economics of the Internet Backbone," in Ingo Vogelsang (ed.) *Handbook of Telecommunications*. Amsterdam: Elsevier Publishers, 2005, pre-publication copy at http://www.stern.nyu.edu/networks/Economides_ECONOMICS_OF_THE_INTERNET_BACKBONE.pdf.
- Economides, Nicholas (2005b), "Telecommunications Regulation: An Introduction," in Richard R. Nelson (ed.) *The Limits and Complexity of Organizations*, Russell Sage Foundation Press, New York, 2005, pre-publication copy at http://www.stern.nyu.edu/networks/Economides_Telecommunications_Regulation.pdf.
- Economides, Nicholas (2005c), "Competition Policy in Network Industries: An Introduction," in Dennis Jansen (ed.), *The New Economy and Beyond: Past, Present and Future*, Edward Elgar (2006), pre-publication copy at http://www.stern.nyu.edu/networks/Economides_Competition_Policy.pdf.
- Economides, Nicholas (2006), "Public Policy in Network Industries" in Paolo Buccirossi (ed.), *Handbook of Antitrust Economics*, Cambridge, The MIT Press (2006), pre-publication copy at http://www.stern.nyu.edu/networks/Economides_Public_Policy_In_Network_Industries.pdf.
- Economides, Nicholas, and Evangelos Katsamakos (2006), "Two-sided Competition of Proprietary vs. Open Source Technology Platforms and the Implications for the Software Industry," *Management Science* vol. 52, no. 7, pp. 1057-1071 (July

- 2006). Pre-publication electronic copy available at http://www.stern.nyu.edu/networks/Economides_Katsamakas_Two-sided.pdf.
- Ford, George S., Thomas M. Koutsky, and Lawrence J. Spiwak (2006), "Network Neutrality and Industry Structure," Phoenix Center Policy Paper Number 24.
- Frieden, Rob (2006), "Network Neutrality or Bias? Handicapping the Odds for a Tiered and Branded Internet," mimeo.
- Frischmann, Brett and Barbara van Schewick (2006), "Yoo's Frame and What it Ignores: Network Neutrality and The Economics of an Information Superhighway," mimeo.
- Lehr, William H., Marvin A. Sirbu, Sharon E. Gillett and Jon M. Peha (2006), "Net Neutrality Arms Race Scenarios for the Network Neutrality Arms Race," mimeo.
- Goolsbee, Austan (2006), "The Value of Broadband and the Deadweight Loss of Taxing New Technology," *Contributions to Economic Analysis and Policy*, vol. 5, no. 1.
- H. R. 5273, "Network Neutrality Act of 2006," 109th Congress, 2d Session, proposed bill by Rep. Markey.
- May, Randolph J. (2006), "Why Stovepipe Regulation No Longer Works: An Essay on the Need for a New Market-Oriented Communications Policy," *Federal Communications Law Journal*, vol. 58, pp. 103.
- Mctaggart, Craig (2006), "Was the Internet Ever Neutral?," mimeo.
- Meinrath, Sascha D. and Victor W. Pickard (2006), "The New Network Neutrality: Criteria for Internet Freedom," mimeo.
- National Cable & Telecommunications Association v. Brand X Internet Services*, 125 S. Ct. 2688 (2005).
- OECD (2006), "Broadband Penetration Report," June 2006, mimeo.
- Odyzko, Andrew (1999), "Data Networks are Mostly Empty and For Good Reason," *IT Professional*, vol. 1, no. 2, (March/April 1999), pp. 67-69.
- Peha, Jon M. (2006), "The Benefits and Risks of Mandating Network Neutrality, and the Quest for a Balanced Policy," mimeo.
- Rochet, J.C. and Jean Tirole (2004), "Two-sided Markets: An Overview," working paper, IDEI, University of Toulouse.
- Schmalensee, Richard (1981), "Output and Welfare Implications of Monopolistic Third-degree Price Discrimination," *American Economic Review*, vol. 71, pp. 242-7.

Schwartz, Marius (1990), "Third-Degree Price Discrimination and Output: Generalizing a Welfare Result," *American Economic Review*.

Tirole, Jean (1988), *The Theory of Industrial Organization*, MIT Press.

van Schewick, Barbara (2006), "Towards an Economic Framework for Network Neutrality Regulation," Working Paper.

Whinston, Michael D. (1990), "Tying Foreclosure, and Exclusion," *American Economic Review*, vol. LXXX, pp. 837--859.

Whitt, Richard S. (2004), "A Horizontal Leap Forward: Formulating A New Communications Public Policy Framework Based on the Network Layers Model," *Federal Communications Law Journal*, vol. 56, pp. 587 (May, 2004).

Wu, Tim (2005), "Network Neutrality, Broadband Discrimination," *Journal of Telecommunications and High Technology Law*, vol. 2, pp. 141.

Wu, Tim (2006), "Testimony of Tim Wu," House Committee on the Judiciary Telecom & Antitrust Task Force, Hearing on "Network Neutrality: Competition, Innovation, and Nondiscriminatory Access."

Yoo, Christopher S. (2006), "Beyond Network Neutrality," Law & Economics Working Paper Number 05-16, Vanderbilt University Law School.