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The Effect of Network Neutrality on the Incentive to Discriminate, Invest and Innovate: A Literature Review

Daeho Lee, Junseok Hwang

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151-742 서울시 관악구 관악로 599

Technology Management, Economics, and Policy Program
College of Engineering, Seoul National University
599 Gwanak-Ro, Gwanak-Gu, Seoul 151-742, South-Korea
Phone: ++82-2-880-9140, Fax: ++82-2-880-8389

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Jörn Altmann, Editor

Office: 37-305
Technology Management, Economics, and Policy Program
College of Engineering
Seoul National University
599 Gwanak-Ro, Gwanak-Gu
Seoul 151-742
South-Korea

Phone: +82-70-7678-6676
Fax: +1-501-641-5384
E-mail: jorn.altmann@acm.org

The Effect of Network Neutrality on the Incentive to Discriminate, Invest and Innovate: A Literature Review

Daeho Lee[1], Junseok Hwang[2]

[1] The School of Information Sciences
University of Pittshurgh
Pittsburgh, USA
dealfish@empal.com

[2] Department of Industrial Engineering
College of Engineering
Seoul National University
Seoul, South-Korea
junhwang@snu.ac.kr

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Abstract: With the development of the Internet and the significant impact it is having, network neutrality regulation has been receiving much attention. An analysis of the relevant literature suggests that the proponents and opponents of network neutrality disagree on the methods of developing the Internet. Therefore, it is important to review the literature on this issue for both future research and regulatory and practitioners' references. This paper categorizes network neutrality issues and organizes the relevant literature accordingly. In addition, it addresses why the network neutrality problem is so difficult to solve and what further study is required to solve it.

Keywords: Network neutrality, government regulation, innovation, investment, discrimination, vertical integration.

JEL Classification Numbers: D4, L1, L5.

1. Introduction

The early development of the Internet was based on the fundamental principles of openness and nondiscrimination. Motivated by these two principles, Internet service providers (ISPs) have provided neutral access to all application services and end users. The Internet's open and neutral structure has boosted the development of various Internet applications, and it would not be an exaggeration to say that this has spurred the proliferation of the Internet.

Through this dynamic, various applications have been developed in concert with the Internet. Most of these use more bandwidth and are more sensitive to latency than earlier application services [22]. Nevertheless, Internet Protocols (IPs) cannot distinguish between latency-sensitive and latency-insensitive applications owing to the basic principle of "best effort." Therefore, the role of ISPs responsible for what is known as the quality of service (QoS) has expanded in scope [82]: they now control and manage the network in order to maintain operativity. Moreover, a fast and stable network is the most important determinant of the quality of newly developed Internet applications that are bandwidth-intensive and latency-sensitive1. As applications (e.g., voice over Internet protocol (VoIP) and Internet protocol television (IPTV)) become more sensitive to latency, the need for network management increases.

These changes have modified the relationship between interested parties, especially ISPs and content providers (CPs). Many argue that network neutrality should be maintained in order to stimulate continuous Internet development through network innovation and investment. Network neutrality (also called "net neutrality" or "Internet neutrality") is a principle proposed for user access networks on the Internet; it advocates no restrictions on content. It proposes that data on the Internet is moved blindly and impartially, irrespective of its content, destination, or source. Many studies have explored the pros and cons of network neutrality, a topic that has both proponents and opponents.

An analysis of related literature suggests that both its proponents and opponents disagree on the best way to develop the Internet so as to maximize consumer gains. (1) To develop the Internet efficiently and improve the resulting consumer surplus and social welfare, it is necessary to invest in the network and innovate as regards content, application, and network layers. (2) In addition, the Internet can be developed fairly only when ISPs do not discriminate between application service providers (ASPs) and CPs. Following from these two principles, proponents assert that the market power of vertically integrated ISPs will spillover from the network layer into the application layer when the ISPs discriminate between non-integrated ASPs and CPs. They insist that network neutrality regulation by the government is essential because ISP discrimination will deter the development of the Internet and harm consumers and entire societies by limiting network investment incentives and stifling innovation at the application layer. On the other hand, opponents argue that vertical integration increases efficiency in the market and that network neutrality regulation is unnecessary because it reduces network investment incentives and deters

[1] Not every application that requires QoS is a high-bandwidth application. VoIP is an example. However, newly developed Internet application services tend to require high bandwidth [22].

innovation. Moreover, they claim that authorizing ISPs to manage the network will lead to the optimization of the Internet industry.

Therefore, it is important to review the literature on this issue for both future research and regulatory and practitioners' reference. Although Schuett [67] recently surveyed the economics literature on network neutrality, his review is limited to the key economics papers on the topic. This review broadens the scope of the literature reviewed, including papers from law and engineering as well, and at the same time expands on the economics literature surveyed by incorporating additional economics papers, including some more recent contributions.

This paper categorizes network neutrality issues and summarizes the economic background of each debate. In addition, this paper arranges the relevant literature according to that categorization and explores why the network neutrality problem is so difficult to solve and what further study is required to solve it.

The rest of this paper is organized as follows. The next section provides the economic background of the debate on vertical integration and fair competition and organizes the relevant papers on network neutrality related to that debate. Likewise, this paper places the network neutrality debate in the context of innovation in section 3, of ISP profit and network reinvestment in section 4, and of the effect of network neutrality in section 5. Section 6 explains the relationship between the different topics introduced in sections 2 through 5, and section 7 outlines the policy proposals offered by previous papers to solve the network neutrality problem. The final section summarizes and concludes the study.

2. Vertical Integration and Fair Competition

2.1. Vertical Integration

The network neutrality debate was started with the concern that oligopolistic ISPs would discriminate against relatively small CPs or end users using the ISPs' market power. Most ISPs are vertically integrated with cable TV or telecommunication companies; thus, their interests conflict with newly developed application services such as IPTV and VoIP. Farrell and Weiser [18], however, argued that ISPs could generate more profits through active competition between ASPs, as the Internet and its application services are complementary. Thus, the debate on the benefits of vertical integration is ongoing.

The United States regulated vertical integration along the lines of classical leverage theory until the 1950s. This theory asserted that when a monopoly of a tying product enforced its own tied product on consumers or prohibited consumers from buying competitors' tying products, the ensuing vertical integration hindered consumers' freedom of selection, unfairly excluded competitors, and helped expand the power of monopoly from the market of the tying product to that of the tied product.

In contrast, the Chicago School of antitrust points out that classical leverage theory lacks consistency. They insist that there is only "one monopoly profit," as consumers feel a willingness to pay not on each of the tying and tied products separately but on both products together. According to Posner [60], monopoly actually encourages more firms to

compete in the tied products market, because consumers will feel a stronger willingness to pay as the number of good and cheap tied products increases.

The assertion of the Chicago School of antitrust is not widely applicable. First, monopolies abuse their monopolistic strength while solving problems caused by the price regulation of tying products. Second, regardless of market efficiencies, monopolies can plot to make a monopolistic profit through price discrimination. Third, monopolies can use their power to preempt potential competitors. In addition, the Chicago School does not consider the result of high transaction costs to obstruct the cooperation of tying and tied product firms when existing firms are inefficient.

Similarly, Whinston [79] shows that the Chicago School's perspective holds only when the tying product of the monopoly is necessary for the competitor's tied product. If the market structure is monopolistic as a result of economies of scale in the tied market, monopolies can extend their market power to the tied product market, monopolize it, and generate higher profits by bundling their own tying and tied products together. Whinston also clarifies that this tying process can harm consumers and competitors. Carlton and Waldman [5] dynamically extend Whinston's findings and propose that the purpose of bundling tying and tied products is not to monopolize the tied product market but to protect the monopoly of the tying product market from the threat of the entrance of new competitors. Thus, the debate on the social benefits of vertical integration is ongoing. Meanwhile, each country is adjusting the level of regulation to suit its conditions.

The debate on vertical integration can also be applied to the Internet industry. Specifically, Rubinfeld and Singer [65] model the vertical integration between an ISP with significant downstream market power and an upstream broadband portal and explain that a vertically integrated firm can utilize two different types of market foreclosure: "content discrimination" against upstream competitors and "conduit discrimination" against downstream competitors. They show that the vertically integrated firm will often find it profitable to carry out content discrimination to sustain and expand its market power.

First, the vertically integrated firm protects its own network from competition by refusing to supply its affiliated content to rivals (conduit discrimination). In this case, end users may turn away from rivals because they cannot provide the content that the end users want, giving the vertically integrated firm a competitive advantage over its rival. Another means of market foreclosure is content discrimination whereby a firm will protect its affiliated content from competition by blocking or degrading rival content. In this case, it is very difficult for end users of the vertically integrated conduit firm to use the discriminated content, and the affiliated content can easily dominate the market.

Between these two types of discrimination, network neutrality is related to market foreclosure by content discrimination. The proponents of network neutrality argue that the Internet's open system has attained a remarkable economic achievement and efficiency and that this openness could not have been sustainable if ISPs were integrated vertically with ASPs. The opponents, however, argue that vertical integration is not always anticompetitive or harmful and that it usually improves economic efficiency.

Farrell and Weiser [18] agree that the open structure of the Internet has several advantages. For example, it accelerates component innovation, facilitates market entrance, keeps service fees low, and promotes development through the trial-and-error processes of many market participants. However, the efficiencies of price-setting, innovation, and marketing decrease with the separation of two firms producing complementary products, because neither firm considers the effect of its business strategy on the other. Moreover, Farrell and Weiser insist that vertical integration in the Internet market is more likely to improve market efficiency because it eliminates the hold-up risk of a contract between service providers and facilitates innovation through vertical cooperation.

Thierer [76] argues that support for the prohibition of vertical integration is based on a misconception and that vertical integration expedites the development of the broadband market and provides consumers with broader options. Thierer also stresses that the network neutrality regulation that turns the network into a “dumb pipe” has a negative effect on competition and can never be a wise policy. Another researcher, Yoo [86], insists that vertical integration is efficient when every link is competitive and that broadband policy should focus on promoting competition, not in content or application but in the last mile. Thus, Yoo opposes any network neutrality regulation, as this would depress last-mile competition. According to Crowcroft [12], last-mile operators who own and want to profit from long-haul networks have sufficient incentive to provide a walled garden through bundling with higher level services or by providing faster lanes to their own services. However, the author disagrees with the notion that additional network neutrality regulation is necessary, because present regulations are sufficient to regulate the monopolistic process of the last mile.

On the other hand, initial openists like Lessig [41] protest that regulating vertical integration between broadband network providers and ISPs through law is the best way to protect network neutrality. Wu [83] insists that platform providers will attempt further monopolization using their monopolistic market power and emphasizes that two conditions are needed to sustain the unregulated vertically integrated monopoly: the incentive to discriminate against ASPs and the incentive to compete with potential platform competitors. For this reason, he believes that network neutrality regulation is necessary.

Another researcher, van Schewick [78], details the limitations of the theory of the Chicago School of antitrust and warns that the limitations mentioned above could be fatal to the Internet service market. Moreover, van Schewick analyzes the Internet service market using an economic benefit–cost analysis and finds that network operators can extend their profits even by discriminating among Internet application services. She insists that this motivation for discrimination can be a threat to Internet service innovation and that vertical integration should occur on network neutrality principles because innovation at the application layer is more effective than that at the network layer.

In general, the proponents insist that the vertical integration of ISPs will impede the development of the entire Internet industry because it will lead to ISP discrimination against ASPs. They praise the considerable evolution brought about by the open structure of the Internet, while opponents emphasize the redundancy of regulation by arguing that vertical integration improves efficiency and that vertically integrated ISPs have no reason

to discriminate against ASPs. This view is obtained by applying the efficiency problem of vertical integration, which is still an issue in the field of economics, to the Internet industry. However, according to Guo et al. [26], who analyzed the issue using a game-theoretic model, social welfare may decrease or increase with vertical integration according to the range of parameter values. The network neutrality debate can thus be understood as a process of questioning which of either vertical integration or an open structure is more efficient for the Internet industry and whether vertically integrated ISPs will discriminate against ASPs.

2.2. Fair Competition (Incentives for Discrimination)

The proponents maintain that the network is neutral; therefore, no packet that travels on the Internet infrastructure can be treated unequally. In other words, the network is supposed to be neutral. However, they argue that ISPs have sufficient incentive to discriminate among Internet packets and that packet discrimination can occur on the basis of the origin, destination, and content of the packet. According to the proponents, the main underlying phenomenon that the ISPs can exploit is network congestion, not over the entire Internet backbone but over the last mile, something that was first pointed out by Cheng et al. [6].

However, the principle of Internalizing Complementary Efficiencies (ICE) and the two-sided market model imply that an ISP vertically integrated with a CP has a weak incentive to discriminate against other CPs. First, according to the principle of ICE, a monopoly in market A has no incentive to place constraints on competition in market B, because when products A and B are complementary, its monopoly in market A can benefit from the vitalization of competition in market B. We apply this theory to the Internet market and find that when there is more innovation and competition in the content and application markets, or when competition in the content and application markets can elevate the value of its services, a monopolistic ISP can increase profits through the internalization of the complementary values by sustaining the open structure instead of using the spillover of its market control power and discriminating against other CPs.

The result of applying the two-sided market model to the Internet shows that an increase in the number of CPs increases the value of Internet access for end users, thereby causing higher demand for Internet access. An increase in the number of end users leads to an increase in the value of Internet access for CPs. This means that the ISP has sufficient incentive to keep the content and application market open, as doing so will lead to positive feedback, thereby increasing the number of CPs, the investment in content and application, and the profit of the ISP.

For this reason, most opponents of network neutrality maintain that ISPs have no incentive to discriminate against CPs or ASPs2. Conversely, most proponents dismiss this view and predict discrimination. Economic theories forecast that an operator's long-term interest equals that of the public and should be enough to provide the best applications on the operator's neutral platform. However, Wu [82] investigated the interests of network

[2] For instance, see Speta [73] [74].

operators and found that they tend to favor short-term results and restrict some applications structurally and contractually. Cheng et al. [6] regard network congestion as the basic underlying source of discrimination that the ISPs wish to exploit, and they model network congestion to address the network neutrality problem.

In addition, van Schewick [78] assumes that ISPs also offer content/application/portal services that are complementary to the ISP service, showing that ISPs have an incentive to discriminate against competitors in the complementary market. To be precise, this concept holds that packet discrimination can occur on the basis of the origin or destination of the packet. Moreover, van Schewick emphasizes that the threat of discrimination is more severe than expected because the Internet industry has more exceptions than described by Farrell and Weiser [18]. In addition, contradicting the common assumptions, van Schewick maintains that discrimination can be a better strategy for an ISP even if it does not manage an ASP. Kocsis and de Bijl [37] also claim that ISPs have incentives to differentiate their network horizontally. ISPs can distinguish themselves from one another on the basis of the origin or destination of the packet by entering into exclusive deals with application providers.

Crowcroft [12] disagrees that network neutrality regulation is necessary. However, the author agrees that some ISPs may block a specific application or degrade the performance of the application to which overlay services are crucial. According to him, ISPs can discriminate packets not on the basis of the origin or destination, but of the content of the packet.

Issues regarding fair competition and vertical integration are ongoing and complex. However, they still represent the key factors of the network neutrality debate given that they influence the entry barrier level, the promotion of competitiveness, the innovation of the entire Internet industry, and network investment incentives. These conditions also deeply affect social welfare.

3. Innovation

Joseph Schumpeter established the theoretical basis for determining technical innovation. His first innovation theory, Schumpeter Mark I, was proposed in his work published in 1934. In this research, he emphasizes the entrepreneurial spirit and characterizes the pattern of innovation activity as “creative destruction,” in which the ease of the technological entrance and innovation of startup companies plays an important role. Schumpeter Mark II, proposed in his paper published in 1942, emphasizes “creative accumulation” and the role of R&D and large firms in innovation. According to Malerba and Orsenigo [46], Mark I and Mark II respectively contain patterns of “widening” and “deepening.” For Mark I, the base of innovation widens with the continuous entrance of innovators [46]; in Mark II, the companies that accumulate technical and innovative abilities dominate the market [45].

According to Schumpeter Mark II, as a firm grows, it becomes more innovative relative to its size and its market power becomes an incentive for technical innovation.

Later economists dubbed this view “Schumpeter’s hypothesis” and tried to verify it. Scherer and Huh [66] use the intensity of R&D expenditure as an index for innovation and empirically demonstrate a reverse-U relationship between firm size and the intensity of R&D expenditure, finding that firm size mostly affects innovation positively, but does so negatively when it becomes inappropriately large. Kamien and Schwartz [36] also analyzed the relationship between firm size and innovation using the intensity of R&D expenditure, finding no significant connection. According to Acs and Audretsch [1], market concentration levels have a negative effect on innovation. In addition, Soete [72], Freeman [23], Rothwell and Zegveld [63], Pavitt [55], Pavitt et al. [56], and Cohen et al. [10] empirically reveal that there is no significant relationship between a firm’s size and its level of innovation.

With regard to innovation, deregulationists say that large firms play a key role in destructive construction, a view put forth by Schumpeter Mark II, whereas openists focus on start-up firms, as does Schumpeter Mark I [83].

Zhu [90] argues that the Internet has never been, and is not designed to be, neutral. According to the author, traffic prioritization promotes and coexists with Internet innovation. However, the author endorses partial regulation to prohibit the overuse of market power and discrimination. Hahn and Wallsten [27] also oppose network neutrality. Proponents say that network neutrality accelerates innovation by facilitating the expansion of the network infrastructure and guaranteeing the transmission of time- and quality-sensitive services, but Hahn and Wallsten [27] dismiss their opponents’ concerns while warning that regulation could hurt consumers by depressing investment incentives and distorting innovation. Sidak [71] maintains that deregulation becomes a catalyst for network innovation in that it induces network investment while also leading to innovation at the edges of the network.

Yoo [86] claims that there is no evidence that “innovations operating at the network’s edge” should be preferred over “innovations in the network’s core,” though proponents insist that innovation in CPs and ASPs are more important and that network neutrality is necessary for the promotion and preservation of Internet innovation. In addition, Yoo [87] emphasizes that no one can ensure CP and ASP innovation without the guarantee of Internet access. According to the author, network neutrality is unnecessary and innovation occurs more efficiently in open architectures because, within them, ISPs maintain their own neutrality. On the other hand, when innovation is activated in closed architectures, regulation is unnecessary because network neutrality actually deters innovation.

Roycroft [64] points out, however, that Yoo’s [87] assertion is not appropriate because it does not consider the innovation and economic development brought by network neutrality. Besides Roycroft, many others stress that innovation in terms of application at the edges is more important than centralized network innovation (see, for instance, [37]).

Moreover, van Schewick [78] maintains that the threat of discrimination decreases the number of innovators at the application level considerably by reducing innovation incentives for isolated developers. Although discrimination gives network providers the incentive to participate in innovation at the application level, the reduction in the number

of isolated developers would be much larger than that of network providers because the number of network providers is lower than that of complementary isolated Internet developers. Hogendorn [30] shares this view and stresses the dynamic, public values of the Internet. The author describes the Internet as "general purpose technology," seeing the Internet as a platform for various innovations; thus, applications above the platform become, in turn, a source of further innovation. Accordingly, the author emphasizes that the social value of maintaining network neutrality and opening the Internet is greater than the value gained from price discrimination by ISPs and government policies that degrade content quality.

Additionally, Lessig [40] states that the current Internet structure should be sustained because the Internet's "end-to-end" framework provides the best condition for Internet innovation. According to Economides [14], when ISPs charge a termination fee to CPs and ASPs, those that are already paying charges at marginal cost levels should, in a properly operating market, be paying much more; this fact suppresses content and application production as well as edge-of-network innovation. Moreover, when ISPs impose a paid prioritization, the winner of the service market will be the entrepreneur who has paid for prioritization, and the firm that attains market penetration is likely to sustain its market power for a long time due to the network effect of the Internet market. Economides is concerned that paid prioritization will ultimately deter innovation, and he therefore endorses network neutrality.

In sum, the proponents and opponents of network neutrality assert innovation in ways consistent with the terms of Schumpeter Mark I and Mark II, respectively. One can formulate this difference by way of Wu and Yoo [84]:

> "A lot of the difference between Christopher's view and my (Wu) own stems from how we think the process of innovation occurs. Christopher, rather like Joseph Schumpeter in his later years, believes that large firms … drive telecommunications innovation … Christopher thinks incumbents like AT&T will rarely or perhaps never threaten innovation. Instead he views them as the driving force of the technologies of tomorrow … I (Wu) think … that in general, incumbents, particularly in a monopoly position, have a strong incentive to block market entry and innovative technologies that threaten their existing business model. My faith is that economic growth is driven by market entry…"

The economic relationship between a firm's characteristics, such as firm size and innovation, is a difficult one to understand. For this reason, new concepts that emphasize the systemic characteristic of innovation have recently receiving much attention, and many studies have been conducted from this perspective (see, for example, [24] [44]). Research on innovation systems regards innovation as interaction for knowledge creation, propagation, and utilization among various innovators [43] [50]. In other words, innovation is achieved through interaction among relevant innovators rather than by a single firm [16] [47] because innovation is characterized by high uncertainty and complicated interactions, which are necessary for accumulating knowledge for innovation [43] [54].

Close cooperation and adjustments among government, network providers, device providers, and content service providers are required in the Internet industry. For instance, the Internet cannot provide any utility to end users if there is no content to provide through the network, and Internet devices serve no purpose if there is no demand for network providers. Every actor should cooperate so as to enhance innovation in the Internet industry. Especially with regard to the Internet market, innovation in the ASP market spills over into the ISP market in various ways. Conversely, innovation in the ISP market spills over into the ASP market. It is difficult to explain whether network neutrality should be regulated in the sense that both types of innovation affect each other and are important for the development of the Internet industry.

4. ISP Profit and Reinvestment in the Networks

Investment in the Internet industry, which requires a high initial outlay, is more important than that in any other industry. Hahn and Wallsten [27] underline the importance of this by discussing the two-sided market. According to them, the government should impose pricing rules so that broadband service providers have enough incentive to invest in and create innovation with their own network by earning at least as much as their costs. In a two-sided market, the price is not equal to the marginal cost, and one side often subsidizes the other side [62]. Moreover, when demand is uncertain and the players are interdependent, it is more difficult for prices to cover the marginal costs [17]. Another characteristic of the two-sided broadband market is the existence of direct and indirect network externalities; these externalities are positive unless end users or applications induce network traffic congestion [27]. Furthermore, society cannot internalize the benefit of these externalities without sufficient investment in the broadband platform. Consequently, a regulation policy that induces continuous investment in the broadband platform is necessary for the continuous and effective development of the Internet.

Because regulation affects a firm's financial decisions profoundly over the long term, it is considered the key determinant of investment incentive [4]. One of the main purposes of regulation is to maximize social welfare by promoting competition. However, regulation that promotes competition sometimes regulates the conduct of incumbent monopolies while reducing a firm's incentive to invest [4]. Thus, it may conflict with individual gains. Laffont and Tirole [38] also point out that there is usually a trade-off between promoting competition to improve social welfare after the stabilization of infrastructure and encouraging incumbents to invest in and maintain that infrastructure.

In practice, there is considerable debate regarding whether network neutrality regulation influences network investment positively or negatively, with proponents and opponents holding fast to their respective positions. According to Wallsten and Hausladen [81], the European Union is trying to solve the network neutrality problem through local loop unbundling (LLU). However, even LLU, which is simpler than network neutrality, causes concern; some warn that LLU lowers the incentive to invest in the network [11] [31] [35] [89], while others assert a nonnegative effect to the contrary [8] [58] [59] [80].

This paper now turns to the different views of the effect of network neutrality on an ISP's investment incentive. Yoo [85] argues that, when network service providers escape from the end-to-end principle and customize their access service to each end user, investment in last-mile facilities will accelerate and that this will prevent the broadband access market from monopolizing the market. Yoo [87] also mentions that network neutrality discourages an ISP from constructing new networks and impairs its ability to manage them.

Hahn and Wallsten [27] claim that the profits of broadband providers should be invested in the network. They warn that investment in the platform will be lower than the socially optimal level if broadband providers are not allowed to charge platform users freely, as they will lack sufficient incentive to construct the network so as to internalize the network externality.

Ford et al. [20] and Musacchio et al. [48] analyze the network neutrality issue through an economic model. First, Ford et al. [20] analyze network neutrality under monopoly and duopoly assumptions and warn that network neutrality commoditizes the product because it narrows the difference between ISPs. Accordingly, it can harm network reinvestment and development. Musacchio et al. investigate how the operator's network investment incentive, network quality, and consumer price are all affected by whether network neutrality is followed. They find that, when network neutrality is not maintained, network operators realize greater profits and end users receive a larger surplus.

On the other hand, Cheng et al. [6] propose an economic model to solve the network neutrality problem and determine the winner and loser when network neutrality is not maintained. According to them, except in some specific cases, broadband service providers have greater incentive to invest in network infrastructure when they follow the network neutrality principle. This paper shows that broadband service providers always invest in network infrastructure at the socially optimum level under network neutrality, whereas they underinvest or overinvest in the absence of network neutrality.

According to Odlyzko [51], price discrimination is not a negative approach from an economic point of view; the United States and the United Kingdom permit it in the transportation industry (e.g., trains, highways, and canals). Profits from price discrimination are much greater in the Internet industry, however. He asserts that the cost of expanding the network in response to heightened Internet traffic has been overestimated and that ISPs need not obtain extra capital through price discrimination in order to construct a broadband infrastructure.

Peha [57], Choi and Kim [7], Lee and Wu [39], and Economides [14] maintain that, unless the network neutrality rule is maintained, ISPs may try to discriminate against ASPs by resorting to prioritization and that prioritization will deplete the investment incentives of ISPs. According to Economides, paid prioritization prevents ISPs from upgrading the network and downgrades service quality. When consumers choose their content service, the relative speed of the service is more important to them than its absolute speed. Thus, content service providers are willing to pay for faster service in an effort to dominate the market, and the value of the fast lane increases with congestion in the network. Moreover,

although network providers' profits increase through paid prioritization, this does not imply increased investment in the network [14]. Network providers have fewer investment incentives because they normally have market power. Hence, their additional benefit is more likely to be embodied by shareholders' additional benefits. Moreover, empirical research by Turner [77] shows an increase in investment when the government relaxes the level of regulation.

In addition, according to van Schewick [78] and Dhamdhere and Dovrolis [13], ISPs can increase their profits through appropriate strategies without violating the network neutrality rule; they reject their opponents' view that ISPs' profits can be protected and invested in the network only in the absence of network neutrality.

To sum up, opponents hold that ISPs have sufficient incentive only when they have the authority to manage their own network and consequently generate adequate levels of profit. In contrast, proponents state that ISPs can earn more when they follow network neutrality and that additional profits do not require increased investment in the network. How network neutrality will affect the benefits and investment incentives of an ISP remains a contentious issue and requires further empirical study.

5. Effect of Network Neutrality

As mentioned above, the ultimate objective of this debate is the development of the Internet for the benefit of its consumers. In other words, this paper discusses the effect of network neutrality on network investment and innovation to maximize consumer surplus and social welfare by increasing the efficiency of the Internet. Chapter 5 addresses the pros and cons of network neutrality in terms of its effect on efficiency, consumer surplus, and social welfare.

5.1. Neutrality and the Efficiency of the Internet

How will network neutrality affect the Internet's efficiency? Proponents such as Wu [83] assert that public information and communication networks are most effective under the network neutrality principle.

Economides [14] analyzes the network neutrality problem under the assumption that ISPs charge ASPs a termination fee, showing that this termination fee does not reflect all of the relevant social effects, as network operators cannot internalize the value of the network's externality and spillover effect. Accordingly, this fee will be higher than the socially optimal level and will reduce the return value to consumers and the virtuous circle defined by the network externality and spillover effect. Kocsis and de Bijl [37] agree that access tiering will deplete social welfare owing to its negative effects on both static and dynamic efficiency. However, they oppose regulation because the characteristics of the ICT industry leave them concerned about the government's ability to enforce network neutrality meaningfully.

Levinson [42] also criticizes this policy due to the inefficiency that network neutrality will bring. According to him, network neutrality compels ISPs to not charge a fee for QoS

service, which will obviously create inefficiency. Furthermore, it is not in fact neutral to treat each application with different levels of sensitivity to delay or jitter. Ford et al. [20] argue that network neutrality limits ISPs from differentiating their network from other networks, thus effectively commoditizing broadband access to the Internet. They emphasize that network neutrality, which promotes the commoditization of broadband access service, will be inefficient and harmful if it deters efficient entry. Finally, Ganley and Allgrove [25] oppose network neutrality on the principle that network neutrality regulation is not only inefficient but also undesirable.

5.2. Consumer Surplus and Social Welfare

Yoo [87] stresses that network neutrality can shift Internet charges from heavy users of broad bandwidth to light users and criticizes network neutrality on that basis. Ford et al. [20] find that network neutrality has a negative effect on social welfare: it disturbs entrance by creating competition between commoditized products and lowering profits. The model proposed by Ford et al. shows that the new entrance always increases consumer surplus and network neutrality decreases consumer surplus by deterring the entrance. In terms of price regulation, network neutrality is necessary for the maximization of short-term social surplus but unnecessary in the long term because it does not interrupt innovative activities [70]. Hermalin and Katz [28] investigate the effect of product-line restriction with a two-sided market model. The result implies that monopoly and duopoly platforms can be either beneficial or harmful to social welfare, with the latter being more likely.

Economides and Tåg [15] also use a two-sided market model under both monopoly and duopoly market assumptions, but their result shows that network neutrality will increase the overall surplus, thus contradicting Hermalin and Katz [28]. According to Economides [14], when a network operator delays the standard lane, all of the ASPs will want to use the priority lane, even with additional charges. This will place all ASPs in a dilemma, as every one of them would receive the same service they received without additional charges while paying additional charges. This would harm not only ASPs and CPs but end users as well.

Some papers approach network neutrality in terms of its social cost. As Lee and Wu [39] and Bauer [2] contend, there is a considerable difference between no fees and small fees. If ISPs charge even a small termination fee, each CP has to contract with every last-mile broadband provider that the CPs consumers subscribe to and thus incur a new transaction cost [2] [14] [39].

Clarke [9] says that we need a more stable and wider bandwidth with a continuous increment in network usage as the traffic usage pattern changes from e-mail and web browsing to peer-to-peer applications and real-time services. This study estimates the cost of expanding network bandwidth and suggests that the use of multicast rather than unicast significantly reduces the cost. However, Odlyzko [51] argues that Clarke overestimates the adoption ratio of IPTV and ignores future cost reductions.

6. The Connection between Vertical Integration, Discrimination, Innovation, Reinvestment, Efficiency, and Social Welfare

This paper categorized network neutrality literature into six groups, reviewing them separately in sections 2 through 5. However, network neutrality, vertical integration, discrimination, innovation, reinvestment, efficiency, and social welfare are closely connected to each other.

According to Rey and Tirole [61], the vertical integration of ISPs increases the incentive for discrimination, because if a firm that owns a bottleneck product (an essential facility) integrates a firm in the complementary segment, the former may foreclose or discriminate against the complementary market. If an ISP can discriminate against complementary competitors, then it can reduce the amount of innovation at the application level [78]. According to van Schewick, discrimination increases the incentive for ISPs to participate in application-level innovation, but this increment cannot offset the decrement in innovation by the isolated producers.

From another perspective, price discrimination leads to inefficiency in the market and decreases the incentive to invest in the network [14]. According to van Schewick [78], network neutrality is beneficial in that it increases the amount of application-level innovation, but it decreases the incentive for ISPs to invest in the network. van Schewick shows that network neutrality regulation increases social welfare because the increment in application-level innovation is more important than the decrement in investment.

In contrast, opponents stress that network neutrality decreases the levels of investment and innovation in networks and harms consumers and society as a result. Hahn and Wallsten [27] worry that network neutrality can decrease the investment incentive, distort innovation, and eventually harm consumers. Zhu [90] also insists that network neutrality is irrelevant because traffic prioritization promotes innovation. According to Sidak [71], a nonregulatory environment encourages investment in the network, and this investment induces innovation at the edges of the network. Shrimali [70] shows that, over the long term, price discrimination does not deter innovation and decrease social welfare.

In sum, proponents argue that ISPs have sufficient incentive to discriminate against ASPs when there is no network neutrality regulation, and vertical integration further increases the incentive to discriminate. When ISPs discriminate against ASPs, application innovation will clearly decrease, finally decreasing the efficiency of the Internet industry and the welfare of the entire society. In contrast, opponents insist that network neutrality reduces the incentive to invest in the network and leads to a decrement in innovation at the network infrastructure level. Thus, the six categories mentioned in sections 2 through 5 are correlated. Therefore, each of them can have a cause-and-effect relationship as regards the others at the same time, while structurally all of the related issues can be resolved if only some of them are resolved. Section 7 reviews the policy proposals aimed at solving the network neutrality problem discussed in earlier studies.

7. Policy Proposals to Solve the Network Neutrality Problem

7.1. Open Access

Early proponents believed that open access could solve the non-neutral network problem and that the concepts of open access and network neutrality are not very different. Open access demands that operators who have the facilities to provide broadcasting and telecommunication services share the facilities with those who do not.

As the network neutrality debate progressed, though, the view emerged that open access could not quell the network neutrality debate and that the concept of network neutrality itself had changed. According to Wu [82], open access is potentially counterproductive because broadband operators will try to block the provision of QoS with the cooperation of ISPs when open access is enforced. Moreover, operators will keep trying to control Internet usage even after open access is enforced. Consequently, the author warns that a "structural remedy" such as open access can harm the neutrality of the network.

In addition, open access opens conduits (such as cable and DSL) for intermediaries such as America Online, while network neutrality opens up the network to content [29]. According to the model proposed by Hogendorn, open access cannot encourage access to content and, therefore, cannot be a substitute for network neutrality. For this reason, if the main aim of regulation is the opening of the network for content, it is a better option to consider a form of network neutrality that also regulates intermediaries.

Bauer [2] tests the innovation incentive using an economic model under three different scenarios: no network neutrality, nondiscrimination (including open access), and full regulation. He concludes that no scenario can resolve the fundamental issue of network neutrality.

7.2. Vitalizing Competition

Most opponents deprecate the idea that the network neutrality issue can be resolved by government regulation. Instead, they believe that vitalization of the competition at the network level can eliminate the incentive for discrimination and solve the network neutrality problem naturally. This paper will now address the vitalization of competition as a possible solution to the network neutrality issue.

According to the OECD [53], an ISP can spillover its market power only when it has enough market power in the Internet access market. Accordingly, if the competition between ISPs were sufficiently intense, there would be no debate. The OECD's report emphasizes that the vitalization of the competition between operators in the broadband Internet market most effectively guarantees fair competition. Sidak [71] also suggests that the network neutrality debate is meaningless if the ISP market is adequately competitive and that intensifying competition in the ISP market would solve the network neutrality problem. Kocsis and de Bijl [37] stress the importance of network competition and forecast that such competition would eliminate the negative effects of discrimination. However, they add that it is unclear how much competition would be enough. In Wu and Yoo [84],

Yoo insists that network neutrality focuses on maintaining competition at the application and content layers, which is the wrong focus, as these layers are competitive enough. The debate should instead focus on the effect of network neutrality on last-mile competition.

In contrast, van Schewick [78] claims that competition cannot solve the debate, as ISPs will still have the incentive to prefer their own service and exclude competitors even after competition is introduced; he shows various cases in which ISPs engage in discrimination against isolated ASPs or CPs over competition in the Internet service market. Musacchio et al. [49] use an analytic model to compare the economic benefits of one-sided and two-sided pricing. The result suggests that the negative effect of network externalities increases as the number of ISPs increases under a two-sided pricing regime, because an ISP will ignore the fact that charging CPs harms the end users of every ISP by decreasing CP investment. This implies that increasing the number of ISPs would not solve the network neutrality problem but would merely harm social welfare.

Conversely, some studies investigate the effect of network neutrality on the vitalization of competition. For example, Economides [14] maintains that termination fees and paid prioritization distort the competitive environment and raise the entrance barrier. On the other hand, Yoo [87] argues that network neutrality fixes the current monopoly of the network market by interrupting the entrance of new entrepreneurs.

7.3. Other Proposals

In addition to open access and the vitalization of competition, both the proponents and opponents of these views have proposed various solutions.

The network neutrality principle proposed by Wu [82] allows operators to manage their own network provided broadband users are not adversely affected by this. Hence, broadband operators should not constrain end users from accessing the Internet, except when necessary to protect the hardware, quality, and security of the network. On the other hand, Yoo [88] proposes a type of network diversity that will give end users the benefits of a variety of products and easily accommodate technical dynamics.

According to Crowcroft [12], given that the Internet continues to evolve, no definition of network neutrality can explain the meaning of neutrality. Thus, Crowcroft proposes a multipart meta-definition that defines network neutrality in terms of connectivity, performance, service, and cross-layering. In addition, Jordan [32] divides the Internet into two layers and proposes different regulations for each. Jordan insists that this will maximize social welfare and trigger continuous Internet development by applying the free market model based on Title I forbearance to the application layer and applying an open interface based on Title II to the infrastructure layer according to the layered principle.

Additionally, Hahn and Wallsten [27] assert that the government should focus on liberalizing the allocation of the frequency in wireless communication and the vitalization of competition by lowering the entrance barrier. They argue that if broadband operators continue to attempt to overuse their market power, they should be regulated through antitrust laws.

Speta [75] stresses that to solve the network neutrality problem, it is most important to investigate whether ISPs have market power. In the short term, the government or the regulator should regulate ISPs so that the ISPs open every action-changing packet priority and not block any packet. Over the long term, on the other hand, Speta emphasizes the necessity of an in-depth study of the market power of ISPs.

Ganley and Allgrove [25] hold that regulation that gives consumers more choice is the most desirable kind, and Jordan [33] proposes a policy that guarantees open access by controlling the United States Universal Service Fund with a layered model. In addition, de Bijl and Peitz [3] insist that the government should consider network neutrality and ex-post regulation, and Shrimali [70] emphasizes the importance of a balanced approach because the network neutrality debate is very complicated.

8. Conclusion

For the past few years, the network neutrality debate has been a burning international issue.3 In the United States, the Federal Communications Committee (FCC) has tried to extend the range of its network neutrality regulation from wired to wireless communication. As the range of regulated players broadens, more perspectives and opinions collide. As the debate progresses, it appears that virtually all of the players agree on the basic principle that any regulation should induce fair competition by maintaining the openness of the Internet. However, they cannot agree on what the range and method of that network neutrality regulation should be.

The proponents and opponents of network neutrality could not reach a consensus, even after the FCC announced the notice of proposed rulemaking (NPRM) [19]. The debate is still running on parallel lines; the only difference is that the focus of the debate has shifted from the issues of fair competition, innovation, and network investment to those of "reasonable network management," nondiscrimination, and transparency. However, even if the players cannot agree on the nature of network neutrality, they do agree that the Internet has a large effect on national economies, that it keeps developing, and that it is time to establish government policies that will lead to greater Internet openness.

The network neutrality issue has received much attention recently, as it is the key factor in the future expansion of the Internet. Moreover, much research on the issue has been carried out over a short time frame. As discussed in this paper, much debate has raged about whether the vertical integration of ISPs harms fair competition, whether ISPs have an incentive to discriminate against ASPs, and whether network neutrality regulations increase the incentive to invest in the network. The discussion is heated because economic theory provides no proof of any one assertion. Thus, both the proponents and opponents continue to hold contrasting views on the issues of vertical integration, innovation, and

[3] This paper does not discuss the trend of the network neutrality debate of each country because that is beyond the scope of this paper. See Wallsten and Hausladen (2009) for the EU case and OECD (2006) for the OECD case. One can also find the US policy and the responses of various players on the homepage of the FCC (http://www.fcc.gov/).

investment incentives, as well as the effect on efficiency and consumers. Moreover, no paper has hitherto used data that substantiate the assertions of either party. Wallsten and Hausladen [81] prove that incumbents are less invested in the optical network, as the region relies more on local loop unbundling using EU data. However, they only conclude that the EU's approach, which emphasizes the unbundled network as a solution to the network neutrality problem, is uncertain, irrespective of whether or not it is effective. As there is no definite economic theory governing the network neutrality debate, verification through actual data is the only means of proving an assertion. Finally, more investigation into reasonable network management is needed. As noted from the response to the FCC's network neutrality NPRM, most agree that the Internet should be managed; however, there have been few discussions on when and how this should be done. Peha [57] and Frieden [21] provide permissible and impermissible traffic management practices. More precisely, Jordan and Ghosh [34] propose a framework that divides traffic management into reasonable and unreasonable management types. However, research on reasonable network management remains limited. This also needs to be addressed.

Pertinently, below is an excerpt from Wu and Yoo [84]:

> "Christopher believes that, at least when it comes to information networks, technology is changing the conditions for market entry in physical networking… At the risk of sounding like a dinosaur, I [Wu] am skeptical. Despite the mists and magic of the Internet, I don't think the basic economics of transportation infrastructure, and particularly telecom's last mile, have changed all that much."

Accordingly, a tiny difference of opinion on how future technology will evolve can change the perspective on whether network neutrality regulation is proper. Proponents are correct in saying that the innovation of ASPs is more important. However, there can be no progress by ASPs without progress by ISPs, and vice versa. Just as Liebig's Law contends that the minimum inorganic component limits the growth of the entire plant, the growth of the Internet will be limited if either the ISP or the ASP is underdeveloped. In conclusion, it is important to establish a policy that can make both ISPs and ASPs expand symmetrically while minimizing any side effects through research that uses real data.

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