Telecommunications Policy 35 (2011) 764–772

Contents lists available at ScienceDirect

Telecommunications Policy

URL: www.elsevier.com/locate/telpol

Network neutrality and difference in efficiency among Internet application service providers: A meta-frontier analysis

Daeho Lee*,[1], Junseok Hwang[2]

Technology Management, Economics, and Policy Program, Seoul National University, San 56-1, Sillim-dong, Kwanak-gu, Seoul 151-742, South Korea

ARTICLE INFO

Available online 21 August 2011

Keywords:
Network neutrality
Efficiency
Meta-frontier function
Internet application
Internet service provider

ABSTRACT

As Internet applications evolve and require wider and more stable bandwidth, Internet service providers (ISPs) try to maximize their profit by controlling application service providers (ASPs); this has caused a network neutrality debate. This article categorizes ASPs into four groups by bandwidth-usage attributes and latency sensitivity. By estimating the efficiency of these groups, their efficiency differences are estimated, indicating evidence of discrimination of ISPs when network neutrality is not maintained. Meta-frontier analysis is used to compare efficiencies across companies using different production function technologies. Finally, a Tobit regression model is used to determine which variables explain the difference of efficiencies. The estimation result indicates that the discrimination of ISPs against ASPs is not significant enough to decrease the efficiency of any application group.

1. Introduction

With the development of broadband Internet, many applications have been actively developing in the market. Among these applications, newly developed Internet application services tend to require high bandwidth (Frischmann & van Schewick, 2007), and a wide and stable network becomes a very important determinant of the quality of those services. This is because applications use more bandwidth and are more sensitive to latency. According to Wu (2003), for instance, a delay of a couple of seconds does not matter in the case of latency-insensitive services such as e-mail, but it does matter in the case of real-time streaming of movies. When an application requires wide bandwidth and is sensitive to latency, Internet service providers (ISPs) can increase their bargaining power. Thus, ISPs can harass application service providers (ASPs) by degrading their Internet access service or increasing the price of this service. For this reason, network neutrality (NN) proponents assert that ISPs have greater incentives to discriminate against application services, as such services use more bandwidth and are more sensitive to latency (see e.g. Wu, 2003). Moreover, greater incentives to discriminate against Internet application services that use wider bandwidth and are more sensitive to latency can cause a decrease in the average efficiency of such firms.

According to the foreclosure theory, a firm with the market power in a tying product market (by vertical takeover, for instance) can squeeze the profit margins of firms manufacturing the tied product by restricting the access to or increasing the price of the tying product (see Hart & Tirole, 1990; Ordover, Saloner, & Salop, 1990; Salinger, 1988). The profit of the

* Corresponding author. Tel.: +82 880 8680; fax: +82 880 8389.
E-mail addresses: deafish@snu.ac.kr (D. Lee), junhwang@snu.ac.kr (J. Hwang).
[1] Corresponding author is a Doctorate in economics from TEchnology Management, Economics and Policy program (TEMEP) in Seoul National University. He is specialized in Telecommunications Policy and Network Neutrality.
[2] The author is a Professor in TEMEP. He is specialized in Telecommunications and IT Policy.

0308-5961/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.telpol.2011.07.005

tied product firms will decrease because of a reduced demand for their services or higher input prices charged to them, which will lead to a fall in their efficiency level. Syverson (2010) also points out that spillovers can be a possible channel through which the external environment affects efficiency levels, and producer practices can have spillover effects on the efficiency levels of other firms.

Applying the foreclosure theory to the debate on NN, the average efficiency level of the application service group that uses wider bandwidth and is more sensitive to latency will be lower than the average efficiency levels of other groups. If the assertion of the NN proponents is right, ISPs are more likely to discriminate against ASPs that use wider bandwidth and are more sensitive to latency by degrading their Internet access service or increasing the price of their service. Considering that a wide and stable network is the most important determinant of the quality of Internet application services that use wide bandwidth and are latency sensitive; the profit of ASPs that use more bandwidth and are more sensitive to latency will be reduced due to the higher price of input from ISPs or the lower quality of output. This implies a fall in the efficiency level of such ASPs.

Accordingly, the proponents of NN suggest that NN can prevent ISPs from abusing their monopolistic market power and thereby increase consumer welfare by encouraging innovations among ASPs.

However, the opponents of NN assert that there is no reason for the ISPs to discriminate against ASPs. From the viewpoint of economic theory, the principle of internalizing complementary efficiencies (ICE) and the two-sided market model generally imply that ISPs, when vertically integrated with content providers (CPs), have a weak incentive to discriminate against other CPs. First, according to the principle of ICE, a monopoly in market *A* has few incentives to impede competition in market *B* when products *A* and *B* are complementary. This is because the monopoly in market *A* can benefit from the intensification of competition in market *B*. Upon logically applying this theory to the Internet market, when there are a large number of innovative competitors in the content and application market or when the competition leads to an increase in the value of all services, a monopolistic ISP can increase its profit through the internalization of the complementary values. Thus, profit can be increased by sustaining the open structure and not through the spillover of market control power by discriminating against other CPs.

If the two-sided market model can be applied to the Internet market, it will be observed that with an increase in the number of CPs, Internet access will become more attractive to end users, and this in turn will lead to increased demand for Internet access. Similarly, it will also be observed that with an increase in the number of end users, Internet access will also become more attractive to CPs. This means that ISPs have sufficient incentives to foray into the content and application market because of the increased demand for Internet access. This increased demand will in turn raise the number of CPs, the investment on the content and application market, and finally, the profit of ISPs.

Because of the abovementioned reasons, most of the NN opponents maintain that ISPs do not have any incentive to discriminate against CPs or ASPs (see e.g. Speta, 2000a, 2000b).

If the ISPs discriminate against different groups of ASPs in a different manner as the NN proponents assert, the quality of the Internet Protocol TV (IPTV) service will degrade further as compared to the e-mail service. The e-mail service is not sensitive to latency, and therefore, its quality will not degrade much even when the ISPs discriminate against e-mail service providers. The degradation of quality leads to a decrease in sales while the input levels are maintained, and this in turn leads to a decline in the ASP's efficiency.[3] On the other hand, if the assertion of the NN opponents is correct, there will be no significant difference in the efficiency between the ASP groups.

Accordingly, this study investigates the issue of NN and tests the arguments of the proponents and opponents of NN on whether the efficiency of ASPs will decrease as their requirements of a wider and more stable bandwidth increase. The study categorizes application services into four distinct groups according to the attributes of bandwidth usage and latency sensitivity, and compares the efficiency of those four groups. The efficiency is estimated using a parametric frontier function model,[4] and the difference in efficiency among the groups is tested by estimating the technology gap ratio (TGR), so that the discrimination by ISPs when NN is not maintained can be recognized. This approach accommodates the group heterogeneity in application service production and obtains comparable technical efficiencies using the meta-frontier analysis proposed by Battese, Rao, and O'Donnell (2004).[5] The meta-frontier function has an advantage over traditional stochastic frontier functions in that it allows for technology differences reflected in group-specific frontiers as a base for efficiency comparisons. To the best of the authors' knowledge, the frontier methodology has not been previously applied to ISPs and NN. The methodology is extended by identifying the determinants of inefficiency and by estimating and analyzing their impacts.

The rest of this paper is organized as follows. Section 2 describes the econometric methodology, and Section 3 explains the data. Section 4 describes the estimation results of the meta-frontier analysis. Section 5 presents the ISP efficiency estimation results, and finally, Section 6 summarizes the findings and concludes the paper.

[3] See Section 2 for details.

[4] Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977) developed the original parametric stochastic frontier model, which has been extended by Battese and Coelli (1992), Kumbhakar (2002), and others. For a literature review, see Heshmati (2003).

[5] Although meta-frontier concepts were introduced by Battese et al. (2004), they have not been applied in practice, and few applications are found in the context of production efficiency. Recently, Chen and Song (2008) estimated efficiency and technology gaps in China's agriculture using a regional meta-frontier analysis, and Boshrabadi, Villano, and Fleming (2007) calculated technical efficiency and varietal differences in pistachio production in Iran using the same methodology.