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Complementary innovation and network neutrality

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A B S T R A C T

One of the central goals of network neutrality policies is to safeguard Internet-based innovation. Historically, entrepreneurial activities in applications and services were a main driver of innovation and stimulated complementary advances in networking. With the increasing heterogeneity of services, this virtuous cycle of complementary innovation is changing. Building on evolutionary theories of innovation and the notion of general-purpose technologies, we examine how these changes affect Internet-based innovation. In this framework, we analyze the effects of network neutrality policies on innovation dynamics. Our analysis reveals that network neutrality regulations as currently implemented may impede and delay innovation experiments that require a differentiated quality of service arrangements. To overcome such undesirable effects on innovation, we propose an approach that allows safeguarding important goals of network neutrality while permitting a differentiation of network services in support of next-generation innovation.

1. Introduction

Safeguarding the innovation dynamics of the digital economy is an overarching concern in the network neutrality debate.[1] Despite this centrality, the effects of different policy designs on Internet-based innovation are not well understood. Arguments that originated in computer science and engineering, especially modularity theory (van Schewick, 2010), influenced the early policy discussion. Given the importance of these policy decisions for the Internet, social science and legal researchers started to examine network neutrality in the late 1990s (Marsden, 2017). Economists focused attention on the effects of network neutrality policies on static and dynamic efficiency. These contributions have generated nuanced insights about the conditions under which network neutrality regulations may facilitate or impede innovation. However, with the increasing heterogeneity of applications and services and the rapid migration to all-IP networks, the nature of the complementarities between networks and services is changing. Consequently, current analysis and policy prescriptions do not fully capture the breadth and dynamics of Internet-based innovation. This paper offers a more general approach to examine the multifaceted relations between network neutrality and innovation.

The key elements of current network neutrality policies are a response to specific cases of abuse (e.g., the case involving BitTorrent and Comcast in the United States) and were shaped by a controversial debate among experts and stakeholders (Marsden, 2010). Although many rationales for and against network neutrality are based on broader societal concerns, the protection of entrepreneurship and innovation is a recurring objective. Proponents of "strict" network neutrality espouse the generic premise that treating every datagram equally at no cost to content providers would best enable a virtuous cycle in which application and services innovation stimulate network infrastructure investment and innovation (see the discussion in Krämer, Wiewiorra, & Weinhardt, 2013; Peitz &

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[1] Other goals, such as protecting the freedom of speech and human rights, also motivate network neutrality policy (Belli & De Filippi, 2016; Nunziato, 2009). Reconciling economic and political goals is challenging but can be achieved with a proper combination of safeguards (Bauer & Obar, 2014). This paper focuses on the economic aspects of the discussion.

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Schuett, 2016). Opponents of network neutrality interventions embrace unfettered market forces as the institutional setting most conducive to Internet-based innovation (Thierer, 2006). Between these opposite groups are experts who advance that differentiation of network services, network management, and charges to content providers seeking higher quality of service (QoS) should be permitted except when abused in anti-competitive fashion. In this approach, sometimes referred to as "weak" network neutrality, limited policy intervention is needed as a stopgap in situations when competition and market forces fail to achieve desirable outcomes (Atkinson & Weiser, 2006; Brito et al., 2010).

Proponents of strict network neutrality strongly influence prevailing policies in the United States (FCC, 2015), the European Union (EU) (BEREC, 2016; EU, 2015), and in several other countries. These policy measures target traffic management practices of access networks, vertical pricing and agreements, and interconnection with and among Internet Service Providers (ISPs). With some national and regional variation, regulations limit or fully prohibit network management practices that prioritize, throttle, or block applications, content, and devices. They generally also prohibit network operators from charging content providers for a higher QoS and special arrangements, such as zero-rating agreements between network operators and individual content providers. U.S. and EU regulations allow exceptions to these rules if they serve the purpose of efficient network operation, are for specialized services, and if they are deemed nondiscriminatory (Marcus, 2016). Under new leadership, the U.S. Federal Communications Commission (FCC) initiated a review of the network neutrality policies in 2017, with the intention to repeal key provisions (FCC, 2017).

Although these regulations are inspired by strict neutrality principles, specific regulations may be rebutted if there is sufficient evidence supporting such a modification. In the U.S. legal setting, ISPs have been treated as common carriers since the 2015 Open Internet Order. In principle, this framework allows the introduction of network service tiers at different prices (as has historically been done in the telephone markets). These approaches principally provide flexibility to adapt the regulations to changing market conditions. However, they subject innovations that are not compatible with the default rules to prior regulatory screening, reversing the fundamental trust in entrepreneurship that governed the Internet during its early decades. Moreover, they increase uncertainty about whether innovations might be challenged by regulatory agencies or in courts. All these factors slow experimentation and innovation in the Internet. Because the FCC has greatly limited regulatory interventions in broadband markets (e.g., unbundling), network neutrality in the United States also serves to safeguard access to bottleneck facilities (Gilroy, 2017). In contrast, the EU has retained other regulatory means to deal with essential facilities, so that market power can be addressed at the root (Knieps & Zenhäusern, 2010). If the market power of all-IP broadband infrastructure providers is addressed with effective policy measures, competition constrains traffic service providers. Thus the "internalizing complementary efficiencies" argument (e.g., Farrell & Weiser, 2003, p. 89) holds. The danger that the downstream application markets could be disturbed strategically may arise only if a broadband infrastructure provider can transfer market power to a traffic service provider. However, relying on net neutrality policy to safeguard competition is the wrong policy choice, because it introduces unintended side effects on the innovation dynamics. If traffic markets are not organized competitively, other forms of regulation should address potential abuses of market power.

Much of the received research on Internet-based innovation focuses on the historical architecture of the Internet and its implications for innovation. There is indeed considerable evidence for the benefits of an open Internet that allows "permission-free" innovation experiments at the application and services levels (Greenstein, 2015; Greenstein, Peitz, & Valletti, 2016; Lee & Wu, 2009; van Schewick, 2010, 2016). Yet, not all types of Internet-based innovation fit into this framework. The growing relevance of video, cloud computing, and Internet of Things (IoT) applications requires that innovations in traffic service networks meet QoS needs, which cannot be met in the historical, best-effort network. Because such innovations will become more important in the future, the provision of differentiated QoS in traffic networks becomes a precondition for expanding the innovation opportunities for applications and services in higher layers. Several recent papers have compared the effects on the innovation of policy frameworks that allow QoS differentiation with approaches that prevent it (e.g., Reggiani & Valletti, 2016). These contributions typically use the M/M/1 queuing model to assess the effects of policies and provide highly stylized innovation indicators (e.g., the number of competitors). As we will discuss in more detail, a broad range of emerging innovations cannot be captured using such models. Therefore, we use a different approach, which draws on evolutionary theories of innovation and the notion of general-purpose technologies (GPTs). This allows an exploration of how innovational complementarities have played out during different stages of Internet development.

For the purposes of this paper we are interested in how network neutrality regulations affect the innovation opportunities of participants in the Internet ecosystem and the innovation dynamics of the entire system. We are also interested in how analytical models capture the technological capabilities of the infrastructure and the information flows supported by it. To understand these matters, we examine the interactions between network neutrality regulations and different network architectures. Network neutrality regulations strengthen or weaken the innovation incentives of individual players, depending on their position in the Internet ecosystem and the type of innovation. For example, strict network neutrality stimulates modular innovation at the content and application layer because it reduces coordination costs and hence the cost of innovation and thus renders more projects profitable. Early discussions of innovation in the Internet have examined this as a benefit, because applications and services were considered a key driver of innovation (Lee & Wu, 2009; van Schewick, 2010). At the same time, strict network neutrality may impede innovations that require differentiated or higher network QoS to succeed, because such differentiation typically is not allowed in a strict network neutrality regime.

Since the 1980s, the Internet Engineering Task Force (IETF) has made efforts to support QoS in the public Internet (claffy & Clark, 2016). Because of coordination and measurement issues, they have not been implemented except in virtual and private IP networks. Virtual networks create a logical separation of available network capacities and are typically treated as separate markets from the public Internet. Such market splits complicate or even prevent integrated resource management for network traffic. Consequently, network neutrality policies may inadvertently limit innovation experiments by privileging or implicitly subsidizing some types of innovation experiments over others. Moreover, they may influence whether an innovation is realized in the public Internet or in more limited virtual or private IP networks that allow QoS control.