Spillovers and Network Neutrality

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(draft, comments welcome)

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1. Introduction

In September 2009, FCC Chairman Julius Genachowski proposed two new principles for Internet policy, nondiscrimination and transparency. Nondiscrimination is the key element of the policy known as "network neutrality" and declares that the telephone and cable companies (Internet Service Providers, or ISPs) that provide local broadband Internet service may not "block or degrade lawful traffic" or "pick winners." The ensuing rule-making process[2] has brought forth a vigorous debate, and one of the most prominent economic issues in that debate is the nature and extent of "spillovers" or "externalities" that come from household broadband Internet service.

If positive spillovers are large and can cause market failure – the question we discuss here – they become an important underlying economic justification network neutrality regulation. Spillover benefits do not accrue to those making the decisions, and thus the decisions may not be optimal from society's point of view. If ISPs begin new types of discriminatory practices, this would be a significant, discrete change in the economic configuration of the Internet. Among other things, this would cause large changes in the spillovers emanating from the Internet.

The nature of Internet spillovers is not so different from the spillovers from many older infrastructure services. Telecommunications and other networks have been

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[2] Federal Communications Commission, In the Matter of Preserving the Open Internet and Broadband Industry Practices, Notice of Proposed Rulemaking, GN Docket No. 09-191; WC Docket No. 07-52, October 2009.

regulated as common carriers to prevent their private interests of discrimination hurting their public benefits from spillovers. (Noam 1994) The relationship of open access and network neutrality regulations to common carriage is complex (Hogendorn 2005), but the basic purpose is still to prevent discrimination.

The practices addressed by network neutrality include (i) an ISP offering content providers the ability to have their traffic prioritized over other providers' traffic, (ii) an ISP preferring one service or one set of applications over others, or (iii) an ISP choosing to block or slow a service or set of services. Clearly any of these would be a large change from current practice, but the question is why that should be a public policy concern. The reason is that the ISP would choose it preferred services or its differential prices based on the *private* valuations of those services. That is, the ISP will base its preferred services and fees on what it can *privately appropriate* from the content provider's revenue (which could be advertising revenue or subscription or product prices to consumers).

There are a many standard economic results that suggest such preferences and pricing will be efficient, but they require that the private values be consistent with public values. That is, the preferences and prices set by the ISP would have to include any public values beyond the pure private revenue of the content provider including the *future* potential of the content.

This chapter suggests three main reasons for a divergence. First, the Internet is a *general purpose technology (GPT)*, which means that it is an input into a wide range of uses across the economy. This means that the applications of content providers often have public values in excess of their private value. Second, the Internet, as the name suggests, is a network of networks, which means that *network effects* are rampant throughout all Internet-associated products. These take time to grow and they accrue to users beyond the content provider, so the dynamic, public value is likely to be higher than the static, private value. Third, the Internet is an *innovation-spawning technology*, so that almost all of its content is rapidly changing and developing, adding new value. This means that the static value of content may be much less than the dynamic value, since successful development will cause a future increase in value.

The chapter is organized as follows. Section 2 discusses the relevant economic concepts of surplus and externalities, paying particular attention to the difference between *marginal* and *inframarginal* externalities which have sometimes been confused in the network neutrality debate. Sections 3, 4, and 5 address the three main sources of spillovers that are relevant here: general purpose technology, network effects, and innovation. Each of these sections establishes three main points about the spillovers: that they are relevant to the Internet, that they are likely to be large, and most important, that there is an inverse relationship between privately appropriable surplus and public benefits through spillovers. Section 6 discusses whether competition between ISPs ameliorates the market failures, and section 7 concludes.

2. Economic Approaches to Efficiency

In this section we briefly discuss some standard terminology and approaches to whether market outcomes produce the highest possible social welfare.

Efficiency – Marginal and Inframarginal. The case for government policy-making that affects markets often rests on *spillovers,* generally some type of direct effect of economic actions that is not mediated through the price system.
An *externality* usually refers to an exception to the marginal efficiency result. It is a case where, on the margin, too much or too little of an activity is done in a private market because the price of the good signals only the *private marginal benefit* or *private marginal cost* and not some additional social benefit or cost. (This is the approach pioneered by Pigou (1924) that is taught in most economic textbooks.) The concept of externality is usually taken to imply that an agent does indeed have *control* over the activity, but that "the effect produced is not a deliberate creation but an *unintended* or *incidental* by-product of some otherwise legitimate activity." (Michan 1971, pg. 2)

In the Internet context, externalities are often positive: for example, the contributors to Wikipedia create positive externalities to other Internet users by providing useful information, but they are not given monetary compensation for their efforts. In some cases it is possible to internalize an externality by finding a way to charge for a service that would otherwise be available for free. The most common method on the Web is to sell advertising; a second, less-common method is to charge a subscription fee and protect the website with a password. Usually when an externality is internalized, it is then simply referred to as an effect (see Leibowitz and Margolis (1994) for discussion of this in the network context).

In most economic literature, an externality only creates an inefficient market outcome if it meets two conditions. First, it must be possible to find an alternative pricing or advertising scheme that fixes the externality without prohibitively high transactions costs. Second, the pricing must actually change behavior on the margin relating to the externality. (Papanderou 1994) For example, computer networks may increase employee productivity at a firm, but a system for ISPs to charge for these effects would have prohibitively high transactions costs. Also, given limits in individual employees' ability to discern how the network affects productivity, it is not clear that such a system could be behavior affecting.

Nonetheless, there is a strand of economic thinking on this type of spillover effect that is important for understanding policies like network neutrality. This thinking goes back to Dupuit (1844) who was looking at *indivisible* decisions such as whether or not to build a bridge. He noted that while bridge tolls might be efficient on the margin, the large inframarginal surplus created by a bridge might make it socially desirable even if the tolls did not cover the cost.

One important implication of these *inframarginal externalities*, or more simply, *complementarities*, is that certain configurations of economic activity may be more desirable for an industry or a nation than others. This logic has been used both with respect to individual industries and whole economies of developing countries – for early and more recent reviews see Scitovsky (1954) and Azariadis and Stachurski (2005).

The other area where complementarities are important is innovation. Arrow (1962) emphasized that innovators often create large surplus (both on the margin and inframarginally) that is not easily *appropriable*. Since the surplus accrues to those other than the innovator, there is not enough incentive to create the innovation in the first place. More recently, Lipsey, Carlaw, and Bekar (2005) emphasized that the majority of spillovers caused by GPTs are not marginal positive externalities but instead what they term *technological complementarities.* The important difference between externalities and complementarities is that externalities can create inefficient prices, whereas complementarities only matter when considering discrete policy changes or outright prohibitions of certain activities. If, for example, an ISP decided to disable e-mail service, then all the complementarities that come from people using e-mail would be lost, and this would be a cost of the change in policy.

Because we believe that inframarginal externalities and technological complementarities are both very important in the Internet context, in addition to marginal externalities, we use the term "spillovers" throughout this paper to denote the sum of all these types of effects. Thus, our use of the word "spillover" is completely synonymous with the way "externality" is used in some economic studies but is more broad than the way "externality" is used in others.

In the following sections, we identify three main reasons why these effects may be large for the Internet: the fact that the Internet is a general purpose technology, the presence of network effects, and the importance of innovation.

Internalizing Complementary Externalities. Since Internet access causes such large spillovers, one might ask whether ISPs would do everything they could to stimulate the spillovers in hopes of capturing at least some of the surplus to themselves – Farrell and Weiser (2003) call this "internalizing complementary externalities" or ICE. ICE is clearly relevant to the arguments made here, but we see two separate reasons to be concerned that ICE may not hold in this case.

The first reason is that there are a set of circumstances under which ICE will not hold that Farrell and Weiser detail in their paper. If at least one of these conditions exists, then the private interests of an ISP will not be fully consonant with the public interests of maximizing total welfare. Among the reasons Farrell and Weiser give that an ISP might block or degrade certain services in violation of ICE include (i) it helps the ISP charge different prices to different customers in order to increase profits, (ii) it may make it harder for other firms to enter the market, either as ISPs or as application providers, (iii) there may be bargaining problems that prevent internalization, (iv) firms may not fully realize the benefits of all externalities, and (v) if Internet applications have other spillover benefits, it may make it easier to capture (but in the process reduce) those spillovers.

The second reason relates to appropriable versus non-appropriable spillovers. All of the value discussed in Farrell and Weiser is at least potentially appropriable, since the whole premise of their paper is to ask why there might be exceptions to the idea that a monopolist will naturally try to appropriate all the surplus it creates. But in this chapter we emphasize that there is in addition a great deal of non-appropriable spillover from the Internet, non-appropriable because it occurs either generally across the economy, or as network effects, or as innovation spillovers. All of these non-appropriable spillovers are beyond what is included under ICE. Thus, it is completely consistent for an ISP to follow ICE and nonetheless reduce non-appropriable spillovers. All this requires is that the ISP simultaneously increases appropriable spillovers while (inadvertently) decreasing non-appropriable spillovers.

3. General Purpose Technology

Internet as a GPT. Certain technologies, called *General Purpose Technologies* by Bresnahan and Trajtenberg (1995), are used very widely throughout the economy and thus have extraordinary impact. In their book *Economic Transformations: General Purpose Technologies and Long Term Economic Growth*, Lipsey, Carlaw, and Bekar

(2005, abbreviated "LCB") discuss the nature of GPTs and their effects. They provide a list of GPTs that includes electricity, railroads, the internal combustion engine, and the Internet.

LCB define a GPT as "a single generic technology, recognizable as such over its whole lifetime, that initially has much scope for improvement and eventually comes to be widely used, to have many uses, and to have many spillover effects." (98) We deal with the "scope for improvement" in section 5 on Innovation. In this section we concern ourselves with the "widely used" issue, and the resultant spillover affects. OECD (2009) gives a long listing of the various uses of the Internet and the spillover benefits.

General purpose technologies are inputs into many further activities which themselves create value. If those follow-on opportunities create value as producer surplus, it may be possible to appropriate it (at least partially) by charging the producers for use of the GPT. But if the follow-on value occurs as consumer surplus, it is typically not possible to appropriate it (unless the downstream firms are able to practice very effective price discrimination). Frischmann and Lemley (2006, pg. 117) put it this way: "If there is consumer surplus in the second transaction—and there always is—that consumer surplus is external to the original transaction, because neither the original buyer nor the original seller can capture it."

The implication is that allowing a GPT provider to discriminate between applications would tend to favor those applications that create more appropriable surplus, regardless of the level of total surplus.

Magnitude of GPT Spillovers. Several studies find that spillovers from GPTs, and from information technology (IT) in particular, are very large and affect entire economies. Jorgenson and Stiroh (1999) estimate that one sixth of the United States' productivity growth from 1990–96 was attributable to IT. Röller and Waverman (2001) find that up to one third of OECD economic growth 1970–90 is attributable to telecommunications infrastructure. Czernich et al. (2009) find that an increase of 10% in broadband penetration increases annual GDP growth by 0.9–1.5 percentage points. Jorgenson et al. (2008) show that U.S. productivity growth in the early 2000s was based on a wide variety of industries adopting new forms of IT in production. Indeed, most research on economic growth and GPTs suggests that economies need GPTs in order to grow. (LCB, Jovanovic and Rousseau 2005)

Appropriable versus Non-appropriable GPT Spillovers. The wide range of a GPT creates large inframarginal complementarities because GPTs create new markets, and these new markets create value for both consumers and producers. Bresnahan and Trajtenberg (1995, pg. 84) say that "GPT's play the role of 'enabling technologies', opening up new opportunities rather than offering complete, final solutions."

Since it is in the nature of a GPT to create new markets, they will be created whether the GPT producer is discriminating between different users or not. The question is whether total welfare is higher with the set of markets created by a technology whose providers discriminate versus the set of markets created by nondiscriminatory providers. A numerical measure is not possible, since we cannot know the counterfactuals – neither can we know the future path of the Internet, nor can we know the historical path-not-taken of unregulated and discriminating railroads or electricity providers.

The thrust of the literature on GPTs is that their widespread and not very appropriable benefits are the source of their influence on economic growth. Studies of GPTs often conclude with warnings that measures to increase appropriability may actually reduce the value of a GPT (Bresnahan and Trajtenberg 1995, pg. 94, LCB pg. 519). The International Telecommunications Union (ITU) makes a similar point in their *World Telecommunication/ICT Development Report 2006* (pg. 17): "both ICTs and electricity are 'enabling' or 'General Purpose Technologies', which means their use and their impacts are ubiquitous yet difficult to measure because they are mainly indirect. It is not electricity or ICTs as such that make the (bulk) impact on economy and society but how they are used to transform organisation, processes and behaviours."

Mowery and Simcoe (2002) point to several open and nondiscriminatory features of the early Internet that allowed it to become a GPT and they contrast these with efforts at computer networking in the UK and France that were more closed. Among the features they cite are neutrality with respect to commercial applications, liberal licensing and diffusion of AT&T technologies – especially UNIX, non-discriminatory treatment of dial-up ISPs by local telephone companies, and significant use of public domain technology – especially TCP/IP and HTTP/HTML.

4. Network Effects

Network Effects on the Internet. For many technologies, and especially for the Internet, the value of the network as a whole rises as the number of users increases. Furthermore, this is also true of many applications on the Internet which are themselves networks that connect users – whether for e-commerce, socializing, information retrieval, and so forth. Katz and Shapiro (1985) identified two ways this could happen, either a direct effect from user to user or an indirect effect operating through complementary goods.

When the effect is direct, the consumers get value directly from communicating with each other. The most famous early example of this was the telephone network, and many of the basic Internet protocols also involve direct communication – e-mail and chat for example. There has been a resurgence of Internet applications designed to create direct network effects, often under the label "Web 2.0." These allow users to directly share profiles and pictures (Facebook), current activities (Twitter), favorite news stories (Digg), speak to each other (Voice over IP, e.g., Skype,) and so on.

With an indirect network effect, users also value the system more as the total number of users rises, but through a different mechanism. Content providers offer various products on the system, and these are what users want. The more users, the more content providers will provide the products, and therefore the more value to the users.

Indirect network effects occur at several levels in the Internet. At the broadest level, the more Internet users there are, the more Internet-related applications will be developed, but this is more of an innovation effect which we discuss below. At a narrower level, many of the applications developed for the Internet are themselves platforms with their own user and content provider communities. For example, standards like html and xml have this property – the more users with web browsers or other applications that use the latest versions of these standards, the more incentive for programmers to develop new applications that use them. The same is true for some websites – for example, the more users of Facebook, the more incentive for developers to create new Facebook applications.

A cross-platform indirect network effect is a type of indirect network effect that happens through the (partial) compatibility of different platforms. (Hogendorn and Yuen, 2009) For example, suppose another Internet user joins a Web-based financial information service like Pageonce. This will increase the incentive for Pageonce to improve all of its product offerings, including the one available on the Apple iPhone, since the protocols used to provide the Web-based service are partially compatible with those used to provide the iPhone service. The improved iPhone version of Pageonce generates additional value for iPhone users. Thus we have an indirect network effect that creates a positive spillover for iPhone users even though it originated with a web-based user.

Magnitude of Network Effects. No one knows the total value of network effects emanating from the Internet. Since the Internet is a network of networks, and since many of the applications that run on the Internet are themselves networks, the total number of networks is huge. There is a well-developed body of research that estimates the value of network effects on just one network. A summary of this work, which is surveyed in Birke (2009) is presented in Table 1 below.

Table 1: Empirical Research on Network Effects

Authors	Topic	Spillover
Pashigian, Gould (1998)	Shopping mall rents	72–87% reduction in rent for large stores in shopping malls, controlling for sales per square foot
Rauch	Industrial park land prices	417–947% greater price appreciation

(1993)		in successful industrial parks compared with surrounding land
Brynjolfsson, Kemerer (1996)	Spreadsheet software	10% increase in installed base associated with a 7.5% increase in price
Gandal, Kende, Rob (2000)	Effect of CD titles on CD player sales	10% increase in CD titles is equivalent to a 5% price cut in CD player prices
Madden, Coble-Neal, Dalzell (2004)	Mobile phone adoption	10% increase in subscribers associated with 1.5% to 3.3% increase in growth rate of subscriptions.
Ohashi (2003)	VHS vs. Betamax VCRs	10% increase in installed base associated with a 9.6% increase in market share of one type of VCR. 1986 value of network externalities: $29 per US household. 1986 value of having VHS and Betamax be hypothetically compatible: $9.73 per US household.
Gowrisankaran, Stavins (2004)	Banks adopting ACH electronic payments	10% increase in share of banks adopting ACH associated with approximately 4–9% higher probability of a bank adopting ACH.
Miller, Tucker (2007)	Electronic health records	State privacy laws associated with 25% reduction in probability of a hospital adopting electronic records.
Prieger, Hu (2006)	Video game adoption	10% increase in game titles equivalent to a 10% decrease in console price.
Clements, Ohashi (2005)	Video game adoption	10% increase in game titles equivalent to a 3.6% decrease in console price.

Several of the papers study how much consumers value a 10% increase in the installed base of compatible users of a network. While the methods used vary, it seems that consumers typically equate this to about a 5% decrease in price of the network good. Thus, for example, a fall in the compatible installed base by 30% would harm a consumer the same as if the networked good (say, a social network website) raised its price by 15%.

Only one of the studies directly measures uninternalized network externalities from compatibility. Ohashi (2003) examined the well-known example of VHS and Betamax video cassettes in the 1980s. He estimated that if, hypothetically, these had been compatible in 1986, there would have been indirect network externalities equal to almost $10 per US household.

Appropriable versus Non-appropriable Network Effects. There has been some controversy as to whether network effects create market failures (Liebowitz and Margolis 1994). Direct network effects are widely accepted as a potential cause of market failure. All direct networks share the feature that users desire to communicate with one another, and the more possible pairs or groups of users, the more value the entire system has. Thus, when a new user joins such a network, all of the other users receive a positive spillover. Sometimes the network can encourage joining with introductory pricing or other incentives, but it is rare for all of the surplus to be appropriable in prices, so typically the network remains too small from a social point of view. Indirect network effects are a bit more complicated, since the pricing of the complementary products may make the effects fully price-mediated. However, Church, Gandal, and Krause (2008) show that under reasonable conditions there can be adoption externalities in the indirect case too.

The reverse of a network effect can be called a nonuser negative network effect, so that when a user either leaves or does not join a network, there is a loss of what would otherwise be the positive network effect. (Nagler 2009) Any impediment to a user joining the network therefore has a nonuser negative effect on all users. For example, suppose an ISP introduces a traffic management practice that forces users to pay extra for a voice application like Skype. Then some users will not feel the benefits of joining are sufficient to justify paying the fee, and they will not join. But this does not create a loss for that consumer alone. All of the other users of the network will also receive less value, even if they choose to pay the fee, because the direct network effect has been reduced.

Because the Internet is at the heart of a constellation of information and communication technologies, cross-platform indirect network effects are also quite important. They suggest a further cost to traffic management that differentially affects certain types of services. If these services are partially compatible across platforms, then there could be a nonuser negative effect outside of the Internet on other ICT platforms.

In addition, both types of network effects are often embroiled with the issue of compatibility, where two or more networks may not allow full interconnection. The theoretical literature is close to unanimous that competing platforms will not privately choose to be compatible with one another as much as socially optimal (Farrell and Saloner 1985; Chou and Shy 1993; Crémer, Rey, and Tirole 2000, etc.) In the case of network neutrality, measures such as blocking websites and applications, degrading them, or offering multiple classes or types of services are all forms of “virtual incompatibility” that could reduce social surplus.

5. Innovation

Innovation Spillovers from the Internet. Of the three sources of spillovers discussed in this paper, innovation is the one that most captures the imagination. Firms and other types of users throughout the economy make the Internet an input into new activities, and these in turn add value for society. Innovation spillovers fall into three general categories. Ordered from least to most dramatic, they are adoption of existing technologies, increases in productivity, and new applications.

The simple use of existing Internet applications by new businesses and consumers does not involve creation of new technology, but it is very important for increasing productivity. Every time a firm or consumer adopts an existing Internet technology, it faces its own unique problems and develops its own unique solutions. For example, a firm may adopt an Internet-based travel expense voucher system for its employees. Obviously many other firms have already done this, but since each firm has slightly different needs, flexible technologies are key to a successful adoption. LCB note that just because there is a "blueprint" for implementing a technology, this does not include all the "tacit knowledge" that goes with the blueprint. Thus, adoption of existing Internet technologies becomes a form of innovation, where each firm has to solve its own problems and implement the technology in its own way. The ability of a firm to accept and implement spillovers from another firm is called *absorptive capacity* (Cohen and Levinthal 1989), and firms that are more open to new technology and more experienced in developing it themselves are generally better at absorbing these spillovers.

In absorbing an Internet application, firms face a great deal of risk. There is risk relating to the costs of the project, the benefits of the project, and also the ongoing value of the application in relation to other Internet applications. This relation to other applications is important because most firms try to reuse their applications to perform multiple tasks; this is called *technological convergence* by Rosenberg (1976).

Another set of innovative uses of the Internet is to increase productivity of activities that were essentially already existing. This diffusion of the Internet throughout the economy takes time, as firms alter their production methods, using the Internet as an input. A bank, for example, can offer financial services with web-based or cell-phone-based updates. A trucking firm can use online GPS tracking to improve scheduling and delivery times. A firm like eBay may take a very old activity – running an auction house – and completely redefine it by using the Internet as an input. These are examples of extended technological complementarities of the Internet, where the Internet is the key driver, but the spillover takes place in another industry, like trucking or auctions. Diffusion like this is common with all GPTs – electricity for example took a long time to fully penetrate the economy, reorganizing everything from factory floor layouts to the hours of shopping and working. (David 1990)

Finally, the Internet gives rise to many new innovations. Some of these involve the Internet itself, such as developing new protocols and capabilities, while many involve new applications which usually piggyback on one another. In other words, the Internet is a platform for many innovations, some of which are platforms for innovations themselves. For example, the World Wide Web itself is an innovation built on top of the Internet that in turn ushered in countless additional technologies – first websites themselves, then search engines, social networking, and so on. Some of these tools might also be platforms for follow-on innovation; for instance, a firm like Zillow uses Microsoft mapping technology to provide real estate searching. In this way, innovation online is often "recursive" (Zittrain 2009).

Magnitude of Innovation Spillovers. The size of spillovers from innovation in general (and in a few cases from the Internet in particular) have been studied by several authors. In Table 2, drawn partly from Lemley and Frischmann (2006), we present the results of some of these studies.

Table 2: Empirical Research on Innovation Spillovers

Authors	Method	Results
Mansfield et al. (1977)	Survey firms, use results to estimate demand curve	25% private return, 56% social return
Deng (2008)	Patent citations	Spillover value of $0.6 to $1.2 million per citation
Jones, Williams (1998)	Average of 6 other studies of social return to R&D.	Social return 27% within industry, 100% across whole economy.
Goto, Suzuki (1989)	Data on Japanese R&D	Return from spillovers 3.14 times larger than return within an industry
Bernstein, Nadiri (1989)	Data on US industries	Social rate of return 1.30–2.23 times private rate of return.
Bloom, Schankerman, Van Reenen, (2005)	Data on US firms	Social rate of return 3.5 times private rate of return.

Generally the findings are that innovators do in fact earn high returns to the capital they invest, which is not surprising since innovation is a very risky activity. The estimated spillover returns to society as a whole are much higher, in many studies 2 or 3 times higher. The fact that these social returns are so much higher than most financial returns should not be surprising, since the financial returns to any investment only reflect the surplus the investor can appropriate to himself or herself, whereas the returns to society reflect all the spillovers discussed above.

Appropriable versus Non-appropriable Innovation Spillovers. The question of whether innovators can appropriate the full surplus of their innovations and whether they receive optimal incentives to innovate has been studied much more extensively than GPT complementarities and network effects. Arrow (1962) first noted the extensive appropriation problems in settings like this. The chain of innovation is so extensive that it is very unlikely that the owner of any one innovation fully appropriates all its surplus.

As in the previous two cases, the difference between externalities and complementarities is important. In many cases, innovation may not involve an externality on the margin. Probably more common, there are discrete innovation decisions that are indivisible. Either the innovator has access to crucial inputs or access to the market, or he or she does not. If not, then potential inframarginal surplus is lost since the innovation is not created. LCB say that these "technological complementarities" are myriad and go far beyond most definitions of externality. Relating this to overall economic growth, they claim that TFP growth measures changes in surplus from adopting new technologies, so those which simply earn a normal profit do not show up in TFP growth. Nevertheless, these new technologies are technological change, and they do prevent diminishing returns from setting in and causing a fall in productivity. So relative to the counterfactual, they produce an unobserved gain.

LCB's policy conclusions regarding innovation emphasize the difficulty of appropriating or even perceiving where the gains will come from. The conclude that "…any measure that slows diffusion will also slow the rate at which related downstream innovations occur. Thus, strengthening property rights does not unambiguously accelerate invention. Because it slows *diffusion of any pre-existing set of inventions,* its effects on future inventions, many of which depend on the diffusion of existing inventions, cannot be determined in the absence of detailed, case-by-case knowledge." (LCB, pg. 519)

Bresnahan and Trajtenberg (1995) also note that not only do appropriation problems exist, but that some types of appropriation may actually make things worse. In their model, there are "vertical externalities" between the providers of technology and the providers of applications, but there are also "horizontal externalities" between the various application providers. Strengthening the extent of vertical appropriation can actually lower growth because it can lessen the horizontal externalities.

6. Competition

It is often suggested that robust competition between ISPs, and ideally facilities-based competition, will solve any market failures and reduce the need for government regulation (see especially Yoo 2005). This may be true for traditional antitrust concerns related to market power. However, it is not clear that competition does much to alleviate the spillovers issues discussed above (Brennan (2010) also makes the points discussed here).

The positive effect of competition on spillovers is that competitive markets generally have a higher level of output than less competitive markets. In this case, one could expect that a competitive market would result in more households signing up for broadband Internet, and for those households to consume more hours of service due to lower prices. To the extent that the spillovers discussed above are related to underuse, the market failure is thus ameliorated by competition.

But this chapter is primarily concerned with the relationship of spillovers to discrimination, since preventing discrimination is the main goal of network neutrality. There the relationship of competition to spillovers is less clear.

In the first place, it is not clear that competition reduces the amount of discrimination – see Prescott (1975) and Dana (1999). Many industries, particularly in transportation, see extensive price discrimination even though there is also competition. Retail chain stores also practice extensive third degree price discrimination by offering different products that appeal to different groups of consumers.

Second, competitive firms are typically *more* concerned with appropriable surplus, because competitive pressure forces them to seek out every source of profit. To the extent that there are spillovers, they are usually *less* appropriable in a competitive market because spillovers typically accrue to the system as a whole rather than to one supplier. For example, in Bresnahan and Trajtenberg's (1995) model of GPTs, they specifically say that "monopoly pricing by the GPT is *not* the villain;" it is instead the fact that a prisoner's dilemma game is being played where the GPT and the various applications are complements. This is not to say that monopoly pricing does not cause conventional deadweight losses, but that it is not the only cause of market failure in GPT settings.

Competition has many benefits, and there are probably many reasons for policy to encourage competition in broadband. But the amount of competition seems to be largely unrelated to the amount or type of spillovers coming from household broadband Internet access.

7. Conclusion

The Internet's benefits to society and to economic growth are enormous, and this chapter has emphasized that most of these benefits come in the form of spillovers – benefits that accrue to third parties in the rest of the economy rather than directly to the ISP or its customers. Spillovers occur beyond the standard buyer-seller transaction represented by a consumer subscribing to an ISP. The essential question with respect to network neutrality policy is whether appropriable spillovers are related to unappropriable spillovers, and there are several reasons to think they are not. The relationship between competition and spillovers is also not robust. All of this suggests a role for government policy in preserving the spillovers from Internet access.

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