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Economic Experiments and Neutrality in Internet Access

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Executive Summary

Economic experiments yield lessons to firms that can be acquired only through market experience. Economic experiments cannot take place in a laboratory; scientists, engineers, or marketing executives cannot distill equivalent lessons from simply building a prototype or interviewing potential customers and vendors. The historical record illustrates that economic experiments were important for value creation in Internet access markets. In general, industrywide returns from economic experiments exceed private returns, with several important exceptions. Those conclusions motivate an inquiry into whether regulatory policy can play a role in fostering the creation of value. The net neutrality debate is reinterpreted through this lens. A three-part test is proposed for encouraging economic experiments from both broadband carriers and providers of complementary services.

I. Introduction

While the commercial Internet today generates tens of billions of dollars in revenue a year, the passage of time gives a false sense of inevitability to this accomplishment. Learning and sheer serendipity shaped actions during the early days, while value remained uncertain. The firms that commercialized dial-up Internet access in the United States from the mid- to late 1990s did not follow a prescribed road map, nor did those who deployed Wi-Fi from 1999 onward. No firm in young markets such as these could have planned for all events.

The commercial Internet is far from the only market where learning activities played a role. Firms in technically-oriented markets frequently engage in learning as a necessary consequence of—or as the unintended by-product of—participating in markets for goods and services whose value undergoes change. *Economic experiments* pertain to any market experience that alters knowledge about the market value of a good or service (Rosenberg 1994; Stern 2005). Stated succinctly, firms engage in economic experiments to reduce uncertainties about market value.

The defining characteristic of this type of learning is that it involves experiences that cannot take place in a laboratory; scientists, engineers, or marketing executives cannot distill equivalent lessons from simply building a prototype or interviewing potential customers and vendors. Economic experiments involve more than just technical invention; they also lead to changes in business operations and organizational procedures that translate technology into economic value.

What role did economic experiments play in the development of commercial Internet access? Section II of the essay considers this question, and I conclude that economic experiments played an important role. That answer motivates the topic of section III, which investigates whether the private returns from participating in these experiments align with industrywide returns. I argue that industrywide returns exceed private returns, with several important exceptions. That conclusion motivates the topic of section IV, which investigates whether an emphasis on economic experiments provides insight about the specific types of policies that would encourage innovation over time in communications markets. Does this analysis hold lessons for Internet access policy, such as found in the net neutrality debate?

Outline of Themes

Highlighting the historical role of economic experiments leads to a shift in perspective on the creation of value in the commercial Internet. I argue that economic experiments encompass a range of market-based learning. They encompass many important activities related to the creation of value, such as when surprising sales reveal the previously unknown value of primitive technologies, when new designs make managers aware of broader uses for technologies invented for narrow applications, or when firms learn how to improve a business process with customer-suggested refinements.

This contrasts with most historical studies of the commercial Internet. By and large, most discussions of the rise of the Internet have focused on the evolution of technological experimentation, that is, the genesis of inventions from their unlikely origins. If experiments during commercialization receive attention, it is in the context of analyzing the exploitation of a small set of core technological standards (e.g., TCP/IP, HTML, etc.).

Highlighting economic experiments, in contrast, emphasizes how the environment allowed for a range of alternative commercialization strategies—in terms of pricing structures, marketing strategies, and the like—when market participants had choices among several options. This provided great leeway for a diversity of commercial outcomes.

Highlighting economic experiments leads to a refocusing of policy analysis. To date, there has been considerable analysis of regulatory actions pertaining to broadband, as well as analysis of the legal environment around participation in open-source communities and standardization efforts.[1] However, while some research has examined the policies for markets where exploratory behavior is prevalent, these are not articulated as issues about the creation of value or about nurturing economic experiments to support such creation.[2]

In contrast, because this framework focuses attention on the incentives of vendors, it concludes that the industrywide value—that is, benefit less cost—from economic experiments exceeds private value due to the presence of positive information externalities. There are two major exceptions to such a generality. The first exception arises when there is no link between costs and benefit, as when one firm incurs the costs of an economic experiment, while another gains the benefit. The other exception arises in settings where the negative externalities are present and large. Both circumstances can lead private and industrywide cost and benefit to be out of alignment.

That insight will highlight several challenging problems faced by regulators in communications markets. An example of the challenges this presents arises in the net neutrality debate. This debate has historical antecedents in policy decisions within telecommunications markets, where regulated firms—principally local telephone companies—acted as complements (in supply) to the innovative services of others with whom they also competed (for end users). More recently, policy has moved toward permitting discretion to broadband carriers, both telephone companies and other carriers, such as cable companies. Net neutrality advocates worry that carriers possess too much discretion.

I reinterpret the debate through the lens of economic experiments and show how this debate could focus on value creation instead of (or in addition to) focusing on the distribution of existing value, as it typically does. Policy could seek to raise incentives for value creation, either by raising incentives at carriers to undertake exploration or by reducing the negative externalities broadband carriers might impose on other economic experiments.

This refocusing leads to a proposal for incorporating economic experiments into the debate about net neutrality, discussed at length in the text. The proposal leads to a set of conclusions not typically found in the net neutrality debate. The proposal gives considerable discretion to broadband carriers if they act only as carriers, such as discretion for retail and wholesale price discrimination (within some binding limits applying to the latter). When carriers have economic interests in content markets, however, the proposal leads to a three-part test that limits carrier discretion within specific bounds, with the intent of nurturing incentives for investing in economic experiments from both carriers and content providers.

Comparisons

This model of economic experiments overlaps with another model for analyzing learning behavior: user-oriented innovation in communications markets.[3] As in that approach, the economic experiments framework explains how innovation becomes embodied in commercial form and highlights the links between the experience of market participants and the conceptualization of an idea. Related, this framework also resembles the examination of learning in user-communities, such as analysis of wireless Internet applications.[4] As in that approach, this essay also highlights the factors nurturing experiential-based learning about new value in newly deployed technologies.

In contrast to both literatures, this framework places less importance on user communities, instead focusing on how lessons spread—typically between vendors. To be clear, the framework also stresses the importance of user communities that aid the sharing of lessons, such as lead-user committees. However, the broader emphasis leads to other implications for firms and policymakers.

Also significant for policy, the emphasis from the lens of economic experiments differs with the emphasis found in the common "ladder model" (which Gomory labeled and critiqued in 1997). The typical ladder model begins with events in a laboratory and moves through stages into commercialization.[5] The model of economic experiments does not begin with events in a laboratory and is not a sequential model. Instead, the model of economic experiments emphasizes activities outside of a laboratory, such as innovations arising after experience in the market. It also focuses on the spreading of lessons. As a result, it develops insights the ladder model does not, such as how to think about regulatory issues for industries undergoing learning. In brief, there are situations in which both models provide useful insight, but policymakers should not rely exclusively on the ladder model because it overlooks some innovative conduct that improves the economic performance of society.[6]

Many observers have identified the need for a dynamic regulatory policy more attune with the innovation behavior found in modern communications. The key contribution of this essay is in the orientation. The model of economic experiments can yield quite different insights about the merits and drawbacks of specific proposals for communications policy. I review those differences with the extant (and extensive) literature later in the essay.

II. Economic Experiments in Internet Access Markets

Economic experiments are heterogeneous in practice. To organize the discussion, I begin with two broad types of experiments. The first type, *directed experiments,* occurs when firms deliberately invest in their own operations with existing customers in ways that allow them to learn something that benefits their businesses. The second type, *undirected experiments,* occurs when firms monitor the conduct of others, seeking to learn lessons from the experience of others and through the interplay of their activities with one another.

The practical distinction between directed and undirected economic experiments is not clear-cut in all circumstances, but general tendencies distinguish one from another. Directed experiments tend to be incremental in technical scope and ambition (with important exceptions described in the following). Motivated by the private desire to learn something, these economic experiments aim to learn lessons useful to the organization conducting the experiment. Undirected experiments also yield useful learning but do not arise in such a deliberate fashion. Rather, learning arises from the actions of many firms, yielding lessons whose specific features are not anticipated. In such circumstances, firms invest in learning lessons from unanticipated events.

In either case, market participants engage in economic experiments because they have a limited ability to imagine future (even near-term) economic activity in all its complexity and detail. Many choices among the details about operations to serve buyers cannot be learned except through trial and error. Even market participants with extraordinary imaginations still find it impossible to forecast, for example, how demand will change when prices decline drastically for complementary goods or how the majority of customers will react to different menus of products. Even if early versions of a technology have partially diffused to leading adopters, the rest of the population of adopters, who will be using the technology when prices drop and capabilities expand, may have different characteristics and needs from the first users. Planning activities can help, but they can never completely overcome these limitations.

An additional factor also shapes industrywide learning: any one firm faces difficulty forecasting the actions of all of its near competitors or business partners. For example, managers may not be able to resolve open questions about the actions of their business partners until they observe events in a market. What services are offered at what set of prices? What features are emphasized? To what specific user segments are other firms appealing? These decisions reveal considerable information about what managers at rivals and partners are thinking. In addition, the success or failure of certain activities (over time) reveals considerable information about which risks paid off and which did not. In brief, firms learn from observing one another's actions, that is, more learning takes place only after observing actions than after reading about plans.

What is the value of economic experiments? I will focus on the value associated with the creation of knowledge from experiential learning and the initial spreading of that learning. The private value gained from investing in an economic experiment is associated with the benefits the lessons yield. For example, lessons may increase revenue, reduce costs, or enhance the survivability of firms. Only some of these gains will be measurable.

The industrywide value from such experiments can diverge from private value as lessons spread. One firm's economic experiment may yield information that benefits another firm that did not conduct that experiment. Beyond that generality, the spreading of lessons exhibits enormous heterogeneity. Technical lessons tend to spread quickly, while complex business lessons do not. In later sections, I will describe why.

Directed Economic Experiments

This section uses the historical example of Internet access markets to flesh out the analytical framework and establish its relevance. This example illustrates the predominant features of a directed economic experiment: (1) many firms try similar experiments, but not every firm tries the same experiment; (2) not all experiments succeed, but valuable lessons are learned from both success and failure; (3) in retrospect, it may be possible to rationalize the purpose behind an experiment that turned out to be successful, but such certainty does not characterize the outlook at the time of the experiments; (4) the value of experiments changes over time, and firms alter their experiments in response to market conditions.

At the outset of the commercial Internet access market, value was uncertain due to a surprising sequence of events. The release of the Mosaic browser began in the fall of 1993. Netscape released its beta browser in the fall of 1994, gained publicity in the winter of 1995, and followed with its initial public offering (IPO) in August. Then Microsoft unveiled Internet Explorer in December 1995. Around the same time, a number of other entrants also began exploring new businesses, including Yahoo!, eBay, Amazon, Vermeer, and others.

Many Internet Service Providers (ISPs) wrestled with fundamental decisions about how to build a business around the browser. This innovation raised expectations about future demand for access to the Internet but did not generate certainty about how suppliers could best serve that demand. These events fueled expectations among industry insiders, futurists, and venture investors that substantial demand for the Internet among households and businesses would emerge quickly. That generated initiatives by firms to build ahead of the anticipated demand.

By 1996, ISPs offered service in every major U.S. city, and many large firms had begun building national networks. The growth was astounding to mainstream infrastructure firms in computing and communications.[7] By the fall of 1996, there were over 12,000 local phone numbers in the United States to call for commercial Internet access and more than 65,000 by the fall of 1998.[8] That build-out involved both scores of large national firms and thousands of small local firms.

The build-out of ISPs did not happen without considerable experimentation to resolve many open questions. A crucial question at the outset concerned the design of the opening page—or, as it was subsequently labeled, *portal*—that users would see when they first clicked on their browsers.[9] What should an ISP do? Should it design its own portal (potentially at great expense), default to another's (such as Excite or Yahoo!), or leave the decision to users altogether?

There were many contrasting strategies for addressing the question. Different ISPs made distinct choices and learned different lessons about the trade-offs between these choices. No single choice dominated, and as firms learned more, perceptions about the costs and benefits of each changed over time. Some ISPs maintained minimal home pages, which many marketed as a virtuous attempt to give users freedom to choose for themselves among Yahoo!, Excite, Lycos, and myriad other young portals then springing up. Of these, a portion succeeded with—or in some views, in spite of—this choice.

It is always possible to rationalize (after the fact) why a firm made the choices it made. For example, even though many new ISPs openly derided America On-Line (AOL) for its strategy, the company chose to continue activity it already performed in the era of bulletin boards, perceiving that its prior investments in community building would continue to have value as its users transitioned to using the Internet more frequently. Its portal decisions continued to nurture those communities. AOL supplemented those actions with other practices that some of its largest rivals, such as CompuServe, did not pursue, such as using login names and e-mail addresses using natural language labels instead of combinations of letters and numbers.

While AOL's choice may seem savvy in retrospect, many Internet enthusiasts then regarded it as risky. Indeed, AOL was the only firm among the existing large "online service providers" to succeed with its strategic choices in the medium term. For example, AOL was the only firm to attract the mass-market user with investment in a *walled garden* (i.e., an approach that protected content, or, in the eyes of technically sophisticated vendors, "spoon fed" content to users), which both controlled a large fraction of the user experience while sacrificing sophisticated users to other suppliers.

Not all of these types of experiments turned out well. As noted, CompuServe, Prodigy, and Genie all failed at an approach with similarities to AOL's, whereas Microsoft Network (MSN) attempted a similar strategy and, with the help of its marketing advantages and budgetary tolerance for operating losses, did not exit. Nevertheless, MSN was no better than a distant second to AOL in market share throughout the 1990s.

As a further example, in the mid- to late 1990s, some cable companies believed they did not understand Internet users requirements, so they ceded these decisions initially to others, for example, @home. Eventually, @home merged with Excite to gain access to the perceived advantage of owning a portal, a decision that was later regretted by several cable firms. When the cooperation between cable firms and @home/Excite ended, it produced a large amount of recrimination, and the transition was not smooth for users.[10]

Although this experiment was not financially successful, the surviving firms—cable companies, in this case—learned valuable lessons about how to structure their ISP services. First, certain useful investments were recreated, such as geographic caching of content, and, second, certain mistakes were avoided, such as not depending on advertising for revenue.[11]

Exploration focused on other fundamental determinants of value as well, such as the price paid for services. For example, throughout 1995 to 1998, many firms experimented with offering different contracting plans to households. Specifically, the earliest entrants into commercial ISP services borrowed the practices of bulletin boards, such as pricing per hour or per service. By 1995, there was a general movement among new entrants to offer unlimited monthly service for a fixed price, which was thought to accommodate browsing behavior and to be more acceptable to those using faster modems, such as 28K modems.[12]

After AT&T WorldNet announced its intention to enter the household market with a twenty dollars per month contract, this contractual form became the focal standard, eventually leading to the end of marginal pricing of services. AOL's conversion in early 1996 was the last, most publicized, and most difficult of these conversions among the largest ISPs at the time.[13]

It would be an error to think that AOL's well-publicized troubles were the end of experiments with prices. Experiments continued for years, but only the major successes received wide publicity. There were many attempts to give users choices among monthly hourly limitations in exchange for discounts.[14] There were also many attempts to learn how much firms could alter the definition of "unlimited" without generating a large user backlash.[15]

Most of these experiments with prices did not generate a significant reaction among a large set of users. In 1999, one such experiment did: a set of entrepreneurial firms experimented with formats that offered free dial-up access services in exchange for requiring users to view advertising. NetZero eventually was the most successful entrant of this form, though, arguably, that success arose because NetZero departed from its initial strategy and eventually charged for access.[16] In other words, the most fundamental determinant of value in the retail household market—the contracting terms and pricing norms for access—continued to evolve throughout the entire first decade of the commercial Internet.

Undirected Experiments

While directed experiments in Internet access markets might have partially motivated the actions of any single firm, it would be an error to regard *every* lesson learned as resulting entirely from only one firm's actions. Rather, the interplay of firms, their actions, and their economic experiments yielded a form of serendipity in learning—learning that resulted from the unanticipated combination of lessons learned from several actions or sources.

Though such learning does not come through a deliberate economic experiment, it does not necessarily arise without cost. A firm who seeks to learn it may need to invest in an array of learning activities, such as tracking the experience at other firms, monitoring other experiments, and engaging key personnel in information-gathering activities in industrywide conferences or organizations.

This section uses the historical example of wireless Internet access markets to flesh out the analytical framework and establish its relevance. This example illustrates the predominant features of an undirected economic experiment: (1) many firms benefit from the same market-based experience, but not all firms get the same value from the same undirected experiment; (2) valuable lessons arise from combinations of events; (3) it may be possible in retrospect to rationalize the direction pursued by a collection of experiments, but such direction does not characterize the outlook at the time; (4) from a private firm's viewpoint, the value of an undirected experiment involves some serendipity.

Futurists had predicted the rise of mobile computing even before the rise of the commercial Internet. After the boom in Internet access investment began in 1995, those predictions were made with additional urgency. Several related efforts arose, including several to design short-range data communications standards, such as HomeRF and Bluetooth.[17] In addition, because of the tremendous number of investments in technology made by cellular equipment providers and carriers to carry data over their infrastructure, a substantial number of futurists foresaw wireless data services emerging out of the cellular phone industry as part of a number of initiatives in 3G (third-generation) technologies. This large effort involved virtually every equipment firm and carrier in the cellular phone business, as well as many others.[18]

Most of those predictions turned out to be correct in a broad sense—that is, there was substantial demand for wireless data communication technologies. Yet, in the specific sense, HomeRF did not generate the enthusiastic sales that those who designed it predicted—even though the designers considered it technically superior to the alternatives.[19] In addition, after a slow start, Bluetooth eventually found its way into a variety of products, particularly attachments to cell phones and many other consumer devices, but largely not computing devices. The 3G products and services also did not grow as hyped, initially gaining little traction with U.S. consumers. It is only recently that 3G products have started to make a dent in the United States.

More surprising, a wireless fidelity technology—now popularly known as Wi-Fi—became dominant. Wi-Fi did not arise from a single firm's innovative experiment. Rather, Wi-Fi began as something different that evolved through economic experiments at many firms. The evolution arose from the interplay of strategic behavior, coordinated action among designers, deliberate investment strategies, learning externalities across firms, and a measure of simple and plain good fortune.

What eventually became Wi-Fi originated from discussions about a technical standard designed at the IEEE (Institute of Electrical and Electronics Engineers) Subcommittee 11 for Committee 802. The IEEE sponsors many committees to design standards. Committee 802 was formed in the early 1980s, before the commercial Internet was ever proposed. It was well known among computing and electronics engineers because it had helped design and diffuse the Ethernet standard.[20] By the mid-1990s, it had grown larger, establishing committees for many areas, ostensibly to extend the range of uses for Ethernet.

Subcommittee 802.11 was established in 1990. Like all subcommittees of this broad family of committees, it concerned itself with a specific topic, in this case, designs for interoperability standards to enable wireless data traffic using Ethernet protocol over short ranges. As with all such committees, any standards emerging from these discussions were not legally binding on industry participants, but the committee was formed with the hope that such a standard could act as focal point, helping different firms make products, such as routers and receivers, that were interoperable. As with most such committees, it tried to involve members who brought appropriate technical expertise and who represented the views of most of the major suppliers and users of the type of equipment in which this standard would be embedded.

There were many potential business applications for this standard—one of the earliest prototypes had been in wireless terminals,[21] and another had been in a large-scale wireless local area network for a university campus[22]—and focusing on any of them was not a bad idea. After all, it is often a smart strategy to focus development on valuable use or on users with a history of tolerance for the technical challenges affiliated with being an early adopter. At first, the group was comprised of enthusiastic designers focused on the needs of big users of local area network

(LAN) technologies (e.g., FedEx, United Parcel Service, Wal-Mart, Sears, and Boeing)—companies that they believed would have valuable uses for short-range wireless Ethernet (e.g., in large warehouses with complex logistical operations). More to the point, the original charter and motivation for this subcommittee was not focused on what eventually became a large market in the home and in public spaces (e.g., coffee shops).

Federal spectrum policy cooperated with these technical initiatives—indeed, nothing would have succeeded in its absence. The Federal Communications Commission (FCC) holds authority to license or bar companies from using spectrum. In late April of 1996, after several groups had begun discussing designs, the FCC initiated a "Notice for Proposed Rule Making" to make available unlicensed spectrum for what became known as Unlicensed National Information Infrastructure (U-NII) devices. After deliberating over that summer, the commission made spectrum available. It was understood from the FCC's order that the commission anticipated "short-range, high-speed wireless digital communications" and devices that supported "the creation of new wireless local area networks ("LANs") and . . . facilitate wireless access to the National Information Infrastructure ("NII")." Beyond that, however, little else was specified about the design or application. The order that emerged on January 9 1997, stated "we are adopting the minimum technical rules necessary to prevent interference to other services and to ensure that the spectrum is used efficiently."[23]

Subsequent events fit a category of unanticipated learning that Rosenberg (1995) labels (and I paraphrase here) an invention motivated by a specific application that unexpectedly finds broader use. Specifically, the Subcommittee 802.11 first proposed a standard in 1997 that received many beta uses but also failed to resolve many interoperability issues (among many). Learning from this experience, the committee rewrote the standard. What came to be known as 802.11a was ratified in early 2000. Just prior to that, in late 1999, the committee published Standard 802.11b, which altered some features (changing the frequency of spectrum it used, among other things). The latter caught on quickly and eventually widely, partly because it was licensed for usage in Europe and Asia as well as North America, while for some time 802.11a was only licensed in North America.[24]

Because many vendors had experimented with earlier variations of this standard, the publication of 802.11b generated a vendor response from those who were already making equipment—and others soon thereafter. As it turned out, it also generated a response from Internet enthusiasts, who at the time began using this equipment in a variety of settings, campuses, buildings, public parks, and coffee shops. Unsurprisingly, vendors tried to meet this demand as well.

Around the same time as the publication of 802.11b, firms that had helped pioneer the standard—including 3Com, Aironet (now a division of Cisco), Harris Semiconductor (now Intersil), Lucent (now Agere), Nokia, and Symbol Technologies—formed the Wireless Ethernet Compatibility Alliance (WECA). The Wireless Ethernet Compatibility Alliance branded the new technology Wi-Fi, which was a marketing ploy for the mass market as WECA's members believed that "802.11b" was a much less appealing label. The aim was clear: nurture what enthusiasts were doing, and broaden it into sales to a broader base of users.

The Wireless Ethernet Compatibility Alliance also arranged to perform testing for conformance to the standard, such as certifying interoperability of antennae and receivers made by different firms. This is valuable when the set of vendors becomes large and heterogeneous, as it helps maintain maximum service for users with little effort on their part. In brief, while the IEEE committee designed the standard, a different body performed conformance testing. The difficulties experienced with incompatible equipment in 1997 had taught participants not to ignore this activity.

Events then took on a momentum all their own. Technical successes became widely publicized. Numerous businesses began directed experiments supporting what became known as *hot spots,* which was another innovative idea. A hot spot in a public space could be free, installed by a home-owner, maintained by a building association for all building residences, or supported by the café or restaurant or library trying to support its local user base. Or it could be subscription-based, with users signing contracts with providers. The latter became common at Starbucks, for example, which subcontracted with T-Mobile to provide the service throughout its cafés.

A hot spot was a use far outside the original motivation for the standard. Yet because nothing precluded this unanticipated use from growing, grow it did. It grew in business buildings, in homes, in public parks, and in a wide variety of settings, eventually causing the firms behind HomeRF to give up. The growing use of Wi-Fi raised numerous unexpected technical issues about interference, privacy, and rights to signals. Nevertheless, they did not slow Wi-Fi's growing popularity.[25] Web sites sprouted up to give users, especially travelers, directions to the nearest hot spot. As demand grew, suppliers gladly met it. As in a classic network bandwagon, the growing number of users attracted more suppliers and vice versa.

Unlike the prior examples, no single firm initiated an economic experiment that altered the state of knowledge about how to best operate equipment using IEEE Standard 802.11b. However, like the prior examples, many firms responded to user demand, demonstrations of new applications, tangible market experience, vendor reactions to new market situations, and other events that they could not forecast but which yielded useful insights about the most efficient business actions to generate value.

Interplay between Directed and Undirected Experiments

Virtually all firms perform directed experiments, and sometimes these experiments lead to a product or service that generates an undirected response from other firms as they watch, monitor, and compete with each other. Some firms learn from another firm's directed experiment and consequently reap the benefits of the lessons learned without having to undertake the cost of performing the experiment. Although some firms might try (and ultimately fail) to keep their directed experiments private, most recognize that they are part of a broader interplay of firms. Thus, the original directed experiment leads to one or many undirected experiments. Similarly, the process of building directed experiments on top of undirected ones requires a firm to watch and learn and ultimately devise a directed experiment that takes advantage of that learning.

Later events in the development of Wi-Fi illustrate how directed learning can build on an undirected economic experiment. Specifically, reacting to the undirected experiment that generated Wi-Fi, Intel performed a directed experiment that led to the creation of Centrino, a large program that would install wireless capability in its notebook computers. It was officially launched in March 2003, though industry insiders knew about the plans much earlier.

This section uses the historical example of the Centrino program to flesh out the analytical framework. This example illustrates the predominant features of interplay between directed and undirected economic experiments: (1) many firms try experiments and build on each others' experiments; (2) lessons learned from both success and failure spread at the same time, seeding more experiments; (3) economic experiments can and do arise in the face of interfirm conflict; (4) the results from the interplay between economic experiments makes it particularly difficult to forecast value.

This Centrino program is easy to misunderstand. Embedding a Wi-Fi connection in all notebooks that used Intel microprocessors *did not* involve redesigning *only* the Intel microprocessor, which is the component for which Intel is best known. It involved redesigning the motherboard for desktop PCs and notebooks by adding new parts.[26] This came with one obvious benefit, namely, it eliminated the need for an external card for the notebook, which was usually supplied by a firm other than Intel and installed by users or original equipment manufacturers (OEMs) in an expansion slot. Intel hoped for additional benefits for users, such as more reliability, fewer set-up difficulties, longer-lived batteries (due to less need for heat reduction), thinner notebook designs (due to smaller cooling units) and less-frequent incompatibility in new settings.

Intel had crept into the motherboard business slowly over the prior decade as it initiated a variety of improvements to the designs of computers using its microprocessors. Years earlier, the firm had designed prototypes of these motherboards, and by the time it announced the Centrino program, it was making some motherboards, branding them, and encouraging many of its business partners to make similar designs. The wireless capabilities of a notebook had not been the focus on these earlier programs, so the announcement of the Centrino program represented a shift in strategic aims and direction.[27]

Intel hoped that its endorsement would increase demand for wireless capabilities within notebooks by, among other things, reducing weight and size, while offering users simplicity and technical assurances in a standardized function. The firm also anticipated that its branding would help sell notebooks using Intel chips and motherboard designs instead of using microchips from Advanced Micro Devices (AMD). Furthermore, antenna and router equipment makers anticipated that a standardized format for wireless notebooks might help raise demand for their goods.

Intel's motherboard designs could increase the efficiencies of computers, but that benefit was not welcomed by every OEM who assembled PCs or other industry players. Firms such as Texas Instruments and Intersil had lobbied earlier for different designs for the 802.11g upgrade, investing heavily in the efforts at committee 802.11. Neither of them had intended to help Intel's business, and neither of them wanted to see Intel increase its influence over the designs that were deployed to most users.

Moreover, as Intel's design became employed more frequently, it eliminated some differences between OEMs and other component providers. Many of these firms, including motherboard suppliers and card makers, in addition to the OEMs, resented both losing control over their designs and losing the ability to strategically differentiate their own designs. Other OEMs liked the Intel design because it allowed the firms to concentrate on other facets of their business.

Only Dell was able to put up any substantial resistance, however, insisting on selling its own branded Wi-Fi products right next to Intel's, thereby supporting some of the card makers. Despite Dell's resistance, the cooperation from antenna makers and (importantly) users helped Intel reach its goals. By embedding the standards in its products, Intel made Wi-Fi, or rather Centrino, easy to use, which proved popular with many users.

Intel ran into several crises at first, such as insufficient parts for the preferred design and a trademark dispute over the use of its preferred symbol for the program. However, as desired, management learned many things from the experience and met strategic milestones and, subsequently, refined a large companywide and industrywide strategy. They initiated several related follow-on projects, such as contributing to writing upgrades in IEEE Committee 802.11 (to design 802.11n) and writing an upgrade to a whole new wireless standard for longer ranges (to design 802.16, aka Wi-Max, and related, 802.20).

The Centrino example illustrates the array of deliberate firm activities taken during a short period that built on top of learning from an earlier undirected economic experiment. The activities in IEEE Committee 802.11 ended up affecting the activities of many other firms, such as equipment manufacturers, laptop makers, chip makers, and coffee shops, which then shaped new activities in Committee 802.11 as well.

This example also illustrates that economic experiments can—and do—happen in spite of overt conflict between firms. Those firms may be either direct competitors or participants in a value chain with diverging interests. Conflict transparently arises, as it did here, when all can forecast that the success of one firm's experiment adversely affects the business fortunes of another.

III. Creating Value

Firms expend costly resources on economic experiments, for instance, in assets and personnel to either conduct directed economic experiments or to learn from market events. In general, the private costs and benefits from economic experiments diverge from the industrywide costs and benefits, with industry benefits being higher than private benefits. There are exceptions to that generality, however, and I consider them after analyzing the determinants of the private costs and benefits.

Private Costs and Benefits from Conducting Experiments

By helping market participants learn about the nature of demand in quickly evolving environments, companies can more effectively position their offerings and pricing structures. Such lessons increase value by (1) generating more revenue through improvement of an existing service, (2) enhancing profits from lowering operation costs or avoiding higher investment expenses, or (3) enhancing pricing power through targeting services to customers better than rivals do. In an especially competitive setting, such lessons can (4) contribute to raising the probability of survival by teaching a firm to avoid outcomes where rivals can outmaneuver them.

In general, many of these benefits cannot be measured. If they can be measured—even partially—the private value of many lessons can be measured in terms of the additional revenue it contributes to a firm's business or the additional cost savings it generates.

Revenue might increase through one of several mechanisms. For instance, firms may learn to alter pricing practices, and those changes will alter total revenues. The history of ISP access pricing illustrates several examples. For example, the acceptable pricing norm among most users for hourly limitations changed over time, as ISPs learned about the reaction of different customer segments to distinct menus of choices. A similar statement could be made for the norms concerning whether it was appropriate to apply a separate charge for phone support or not to users who taxed the ISPs resources heavily.

Some changes can increase sales volume of sales or prices. That was seen during the upgrade from 28K to 56K. Some firms gained a premium in their pricing. Some aspired to gain new customers or reduce turnover among their existing customers. Over time, the market participants learned that the pricing premium was temporary, and the upgrade became part of a technological race among all firms.

Pricing experiments often coincide with experiments regarding the range of services offered. During the mid- to late 1990s, for example, virtually all ISPs experimented with changes to the standard bundle offered, such as default e-mail memory, instant messaging support, and hosting services in which the ISP maintained Web pages for clients. Also, in response to user requests, some local ISPs arranged for the availability of phone numbers in other locales for traveling clients. A wide range of regional ISPs experimented with performing services complementary to access, such as hosting services, networking services, and Web design consultations.[28] Some of these additional services offered immediate opportunities for ISPs to explore ways to raise revenue, while others simply enhanced customer retention rates, which indirectly shaped the elasticity of demand for access services.

Operational costs can be lowered as well. Firms might learn how to tailor investment, for example, how to allocate capacity of new modem banks to satisfy the targeted customer base. Firms also may learn about appropriate procedures for doing business with one another—for example, developing procedures between two peering firms when they experience issues handing data to one another.

Learning leading to cost reduction may be difficult to distinguish from learning that leads to enhanced revenue. For instance, as dial-up ISPs learned from one another about the efficient deployment of 56K modems, those who deployed it found they could charge a modest price premium for faster service (approximately five dollars), but that that premium disappeared in less than a year, after the modems became more common.[29] The ambiguities between costs and revenues also could arise with decisions about the scope of the firm. When ISPs chose to maintain minimal home pages, for example, it could be viewed as a cost-saving to the ISP. Yet a modest investment in helping users customize those pages to their needs (e.g., giving help with "My Yahoo!") could be an investment that leads to greater customer retention. Better customer retention eventually manifests as greater sales values and higher firm prices, but it may be difficult to attribute a specific change in price or volume to only that investment.

In general, the accumulation of experiments may support knowledge that plays a role in later economic experiments. In that latter sense, an economic experiment may be part of a broader positive cycle of experimentation.

Importantly, the lessons learned from an experiment may or may not have *any* comparative value—that is, in altering the value of a firm's service in comparison to rivals. It will have such value, generally speaking, if a firm uniquely learns a lesson and no other rival does. It will not when all firms have it, and, therefore, it does not support differentiation. The example of the upgrade to 56K modems illustrates this notion. When it was rare, firms with faster service charged a premium. That premium disappeared, however, as the upgrade became common.

Industrywide Benefits

Two additional factors shape the benefits and costs from economic experiments at the industrywide level but *do not* shape costs and benefits at the private level. Generally speaking, all of these are hard to measure. This section highlights two themes: (1) consumers reap some benefits from an experiment—in the form of lower prices and new services—and these benefits do not necessarily play any role in the benefits experienced by the firm who conducts a directed economic experiment. (2) One firm's experiment shapes the actions of another, an effect that can take many forms, and these do not directly show up in a firm's accounting. These are particularly hard to measure because one firm may benefit, while another incurs a substantial fraction of the cost.

Generally speaking, consumer benefits from economic experiments are difficult to measure except when it leads directly to a decline in price for an existing service. In practice, however, that is rare. Consumers may also benefit from higher quality goods, better supply of services that previously did not exist, or thicker supply of products tailored to niche demands, among many benefits for which no price may be recorded.

An especially difficult-to-measure benefit is the consequence from learning that takes place at all market participants. When a new service or improvement is reasonably permanent, the firm who commercializes it may see returns to the investment in the form of increases in final revenue or other strategic advantages. If a new product or service is quickly imitated by all firms, it quickly becomes a standard feature of doing business in a downstream market. The benefits from the new technology are quickly passed onto consumers in the form of lower prices or better products. In this case, the benefits to a firm do not appear as an increase in revenues but may not appear as lower prices, but they exist nonetheless, in the form of losses the business avoided or better quality services, which match the quality found elsewhere.

By traditional economic reasoning, at least two externalities shape the difference between private and industrywide learning. There is an information externality *between* firms, as when one firm's directed experiment teaches another firm a lesson or a set of actions interact in an undirected experiment and teach every industry participant a lesson. There is also an information externality *over time,* as when the lessons of prior experiments generate lessons on which further experiments are built. In practice, these two externalities are difficult to distinguish from one another.

The positive information externalities between firms take one of two forms. In one case, what worked for one firm becomes known and imitated by others—for example, success from an experiment at an ISP in one rural location in 1996 implied it might be profitable in another. Alternatively, what did not work for one firm becomes known and, therefore, avoided—for example, the difficulties with the first design for 802.11 become known from experiences in 1997, leading equipment firms to delay building plans until a more suitable design emerged and with institutional support for enforcing interoperability.

Negative information externalities take a common form. That is, a successful experiment for one firm becomes known and implies a loss for someone else—for example, Intel's Centrino success in 2003 implied a loss at wireless card makers. Similarly, NetZero's experience as an advertising-supported "free" ISP implied a loss at some incumbent ISPs, such as Earthlink or Juno. These examples imply that the industrywide benefits from an experiment combine the positive return to this lesson at one firm (Intel/NetZero) with the negative return at another (a card maker/Earthlink), as well as the incremental benefit that goes to consumers (in the form of greater capabilities, newer services, or lower prices).

Intertemporal externalities also lead to divergence between private costs and benefits and industrywide costs and benefits. One party (in a directed economic experiment) or several parties (in an undirected economic experiment) assume the cost of generating lessons, while many others gain the benefits later. That is, those who pay for lessons in an early market are not necessarily those who use them most profitably in a later market, but no contract between them governs the early investment.

An important feature of intertemporal externalities is the asymmetries to the costs and benefits of generating lessons about commercial failure. Lessons about how to avoid commercial failure can be as valuable as those who employ them, but the firm whose failure illustrates the lesson for others rarely, if ever, does so for that purpose and almost never under contract with the others who (later) gain the benefit of the lessons learned from the failure. In an extreme case, a firm may learn a lesson, teach others from its failure, but go bankrupt before it is able to use that lesson. Even though the lesson was expensive to the stockholders of the firm that initiated the experiment, it was inexpensive to the survivors.

The history of Internet access is littered with examples of failures from which all other firms learned. For example, it is now accepted wisdom that users did not desire only a browser and phone numbers presented as if it were packaged software—as first marketed by Spry networks in "Internet in a Box." Rather, users quickly migrated to ISPs who offer a different type of service with a different set of market features, combining local services with software tailored to their immediate demands (and tailored to some needs users did not know they had). It is also accepted wisdom that mass-market users do not desire login names with acronyms that are difficult to recall or do not relate to natural language names, as widely commercialized by CompuServe, for example. Most users also valued avoiding technically laborious set-up costs involving weeks of waiting, as embedded in early broadband services, such as the integrated services digital network (ISDN).[30] The list goes on and on.

These details of industrywide learning—both positive and negative externalities—are not just the flotsam and residue of inexorable technical evolution, but, rather, these lessons became the foundation for later operations. It is well known, for example, that AOL learned a tremendous amount from the successes and failings of CompuServe and AT&T Worldnet and many others and later implemented those lessons to some success, though they never paid the stockholders at CompuServe or Worldnet or any other ISP for new information—indeed, that was especially true when they bought what remained of CompuServe in 1999.

More generally, many of these externalities underpin the emergence of an undirected economic experiment. When lessons spread between firms, then it is possible for every participant to build on the lessons of others. The industrywide value from economic experiments exceeds private value due to the prevalence of spreading lessons, that is, the prevalence of positive information externalities between firms and over time.

There are exceptions to such a generality, and these are historically common enough to merit consideration in practice. The most interesting exception arises when there is the potential for a misalignment between costs and benefit, as when one firm incurs the costs of an economic experiment while another gains the benefit. That is especially potentially problematic when the negative externalities are present and large, that is, when one firm's private gain simultaneously reduces benefits for many, imposing a large burden on others.

Spreading Lessons

Do different types of lessons exhibit different patterns of spreading after an experiment? Answering this question provides an important step toward understanding when private and industrywide costs and benefits tend to diverge the most and least. This section will use the historical experience of ISPs and Wi-Fi firms to highlight three themes: (1) there are four different types of lessons; (2) they differ in their tendencies to spread; (3) most lessons are incremental in scope, but a few are transformative.

There are four distinct types of lessons. The first are *market lessons.* These pertain to norms and patterns of market-based actions, such as how to write a contract that users find acceptable, how to price services, and so on. Second, *technical lessons* pertain to the design of a piece of equipment—for example, knowing how to configure Wi-Fi so that it works in the type of space/location at all times that fits the supplier's needs. Third, *heuristic lessons* combine both technical knowledge with either market or operational knowledge about how employees behave in firms and how customers react to firm behavior—for example, knowing how to deploy Wi-Fi for a maximal set of users. Fourth, *complex lessons* are marketing and operational lessons that involve many functions inside an organization—for example, knowing how to integrate the use of Wi-Fi into a wide variety of other offerings.

Private incentives to generate economic experiments will be less than the industry benefits in situations where lessons spread quickly and others benefit, as occurs with technical lessons, market lessons, and some heuristic lessons. Several examples will illustrate these points.

In 1995 the technical and market lessons were often rather trivial for a former bulletin-board firm to learn. The technical steps between an ISP and a bulletin-board firm were relatively incremental—many firms just added a connection to the newly privatized Internet backbone.[31] Generally, these technical skills were common among those who operated bulletin boards. The related market steps were also incremental. Most bulletin-board firms already had procedures in place to, for example, implement billing, publicize their services to local users, or address user service calls. Though the market actions changed, these were relatively easy to execute within existing organizational procedures.

Technical lessons tend to spread easily because they tend to become codified quickly.[32] It is almost tautological that such codification leads to easier transmission of the knowledge. For example, lessons about the design for a modem bank, a server, or other modem equipment became codified almost immediately, and for sound economic reasons. Most equipment suppliers in competitive markets would not consider selling equipment if information about it were not codified because most buyers demand it as a condition of purchase. Related, vendors of equipment also would have developed a set of marketing parameters for their buyers, guiding them toward best-practice deployment.

Others lessons pertain to heuristic knowledge about how to operate that equipment efficiently. For example, lessons about how to manage a Wi-Fi router at peak usage levels might not be known initially after a new piece of equipment became available for use, but such lessons would be learned through trial and error. As it turned out, those lessons spread to different coffee shops through a variety of mechanisms—that is, franchises communicated with one another, bulletin boards emerged to support different types of users groups, and the Wi-Fi association invested in support activities as well.

Several factors affect the speed at which heuristic lessons spread. On the one hand, some heuristic lessons spread slowly because, as sources of potential competitive advantage, they are guarded by the firms that first discover them. For example, firms guard their strategies for how to deploy equipment efficiently, and they may also guard information that indicates details about their future designs. On the other hand, some firms, such as equipment providers, have strong incentives to spread lessons as their spread contributes to further sales. Such tension was inherent in the diffusion of Wi-Fi, for example. While numerous channels opened to provide information to support deployment of frontier applications, some equipment manufacturers guarded the coding that was relevant to the next generation of designs, called "mesh-networks."[33]

User and vendor organizations also shape spreading of lessons. Most dial-up ISPs used similar software tools for monitoring users, particularly after these showed up in the discussion boards at an Open Source project, such as Apache, the most popular Web server.[34] The community effectively coordinated many innovative efforts for dial-up ISPs in the mid- to late 1990s by sharing multiple upgrades and fixes to the source code among ISPs. This is far from the only example. Designs embedded in standards in many organizations also contributed to sharing of lessons. Organizations, such as the Internet Engineering Task Force (IETF) and the World Wide Web Consortium (W3C), for instance, also facilitated the movement of lessons.[35]

The variance in idiosyncratic factors also can slow the codification of such heuristic lessons. First, one community of users may differ from another. For example, peak ISP usage occurs around the same time of day in different locations, but the similarities end there. Surfing behavior varies according to gender, family status, age, education, and income of the members of the household, the sum of which varies across cities and even from one vendor to another within the same city. Such variety interferes with finding commonalities in, for example, marketing strategies (for a new feature) across locations or vendors.

In addition, a heuristic operating rule established to resolve other operational issues might interfere with the functionality of a new lesson. For example, most ISPs wanted a way to limit overuse of capacity, especially when users failed to log off after ceasing or delaying use. Some ISPs instituted rules for automating log offs after short periods of nonuse, while others did not because users resented it (and, as a result, would leave for other vendors). Some vendors instituted special clauses into their contracts that eliminated "unlimited use," authorizing them to charge penalties for exceeding especially high monthly usage (e.g., over 100 hours a month). Modem capacity usage differed depending on these rules. Any heuristic lesson about how to operate new equipment at capacity would have to take into account such rules, but such variety interfered with uniform rules for all operators.

Not all lessons can be reduced to simple heuristics—some are complex lessons. These might emerge, for example, from lengthy investigations by firms seeking to lower cost or generate extra revenue. They often are interdependent, where one operational goal reinforces the other, or associated with unique firm features, such as scale. In either case, complex lessons cannot be easily summarized by a simple heuristic rule of thumb or by an answer to a single question. Almost by definition, these lessons resist immediate codification and are the slowest to move from firm to firm.

As with heuristic lessons, ISPs hesitate to share complex business lessons. For example, they would not lightly discuss with other firms which lines of business best complemented their access business. Firms also hesitate to share information about what sort of costly activities build customer retention most effectively—for example, did users have greater willingness to pay incrementally for phone service or more free storage for e-mail, and which of these would users appreciate as a standard part of their contract?

The ISPs also were hesitant to share their assessments of the costs, user habits, and further prospects for new services. For example, AOL did not openly share the lessons it had learned about the value of the instant messaging service it operated before making a bid in June of 1998 to buy Mirabilis, operator of ICQ, which at that point was the largest freestanding unaffiliated instant messaging service in the Internet. AOL kept its views secret for obvious reasons. Had it discussed them openly, it would have affected the bargaining prior to the merger, possibly not in AOL's favor.

As with heuristic lessons, the same factors interfered with codification and the spreading of complex lessons, namely, idiosyncrasies arising from differences across communities and between other operating rules. That does not mean complex business lessons never spread. Rather, they spread with more effort and at greater cost. In general, they spread more slowly and to fewer firms at any point in time.

These examples support a modified version of the commonly stated canard that "all ideas are public goods." Rather, *some* ideas are public goods, and, due to the conditions shaping the spread of lessons, some remain privately held for a short period. Even while technical information and market lessons move quickly between locations and firms, the ability of a firm to prevent direct rivals from imitating its business actions immediately slows others. Some complex lessons do not tend to spread to others, at least for a short time.

These examples show that lessons differ in the extent of the benefit others receive from their creation. Most lessons involve incremental changes, so in most practical circumstances, the effect of spreading lessons becomes apparent only after accumulation of many. Yet that is not always so. Because some ideas spread quickly to others, a nonincremental lesson—either a market, technical, or heuristic lesson—can have high value to many industry participants, especially when that idea would not have arisen otherwise.[36] Call such an idea an "iconoclastic" one. It is nonincremental in scope and differs dramatically from common practice at the time of introduction. If it succeeds, it can be transformative for the industry, especially if it spreads widely. Almost by definition, it is rare to observe many firms with successful implementation of iconoclastic economic experiments in practice.

This type of economic experiment is important, rare, and valuable. When lessons spread from such experiments, their effect can be dramatic, yielding large benefits to many firms and end users. For example, bulletin-board providers played the role of iconoclast commercializer in the rise of the Internet, diffusing browser-based service into a market where many other large incumbents had considered such a service to not be valuable. The lessons learned by bulletin-board firms covered more than just technical advance (and they certainly developed those in abundance). The first generation of ISPs also developed economic experiments that resulted in numerous market and heuristic lessons. Because so few incumbent firms recognized the importance of the browser prior to its commercialization, I conclude that these innovations otherwise would not have arisen as quickly and put into practice in the economy had the experimentation by these ISPs not taken place.[37]

In general, I conclude that, though there is a range of possibilities, for the most part the industrywide cost and benefit from economic experiments exceeds the private cost and benefit. That conclusion motivates an approach to policy, one that focuses on creating value by encouraging economic experiments. The approach seeks to remove barriers to conducting economic experiments, with the general presumption that more economic experiments benefits society, most often incrementally and occasionally by a substantial amount.

IV. Reinterpreting Net Neutrality

Does an emphasis on economic experiments provide insight about the specific types of policies that would encourage innovation over time in communications markets? As an illustration, I consider issues found in a contemporary debate in communications policy that goes under the heading of "net neutrality." In practice, this debate has become quite broad.[38] Instead of examining every aspect of it, I concentrate on how policy shapes the rate and direction of economic experiments. Such a framing narrows the scope of the investigation but focuses it in a useful fashion. Rather than focusing on the distribution of value between market participants, as this debate often does, I focus on the links between policy, economic experiments, and value creation. This focus exposes strengths and weaknesses in the most common arguments as well as raises important open questions. In general, this approach motivates policies aimed at identifying negative externalities and tries to use policy to limit their occurrence.[39]

Origins of the Net Neutrality Debate

Many facets of the net neutrality debate find antecedents in recent history in Internet markets. In the late 1990s, cable firms began deploying Internet access over cable lines, and telephone companies began deploying digital subscriber lines (DSL), principally as asymmetric DSL, with different bandwidths for downloading and uploading content. Users began to adopt these options in large numbers after 2000. The fraction of Internet households with broadband grew from less than 5 percent in the summer of 2000 to approximately 30 percent of households in late 2006.[40]

To net neutrality advocates, the growth in the importance of broadband carriers raises issues about whether policies should allow broadband carriers to have the discretion to conduct economic experiments without restraint. These concerns need to be understood in context. The last major legislative initiative for communications was the 1996 Telecom Act. Numerous provisions regarding telephone regulation and competition took primary urgency during the writing and passage of the Act. The Act focused on introducing competition into telephony and designing a structure to replace the waning influence of Judge Harold Greene, who had presided over many regulatory rulings for the telephone industry for many years after the AT&T divestiture. The growth of the Internet was not ignored, but it was not central to the legislation.

Prior to the Act, an "information service" was exempt from common carrier regulation and obligations. In the past, such exemptions had supported robust economic experimentation in private equipment markets (e.g., telephone handsets or routers) and related services (e.g., bulletin boards). To make a very long story short, these exemptions also nurtured competition in the Internet access market, though a fair reading of history suggests this last outcome was an unintended but happy accident, not a deliberate regulatory goal.[41]

The Act borrowed many elements from these prior regulatory practices. After its passage, these policies were challenged, but questions about Internet policy were rarely considered in isolation from other policy issues about voice telephony (which is not a surprise because the latter involve much larger economic activity in terms of revenue). In that sense, litigation concerning the implementation of the 1996 Telecom Act over the next decade considered many open questions that touched on core features of regulation for Internet access markets, but typically those discussions became wrapped up in fights over, for example, access charges, rights to unbundled elements of a local telephone company's network, and the rights of local telephone monopolies to enter each other's territory.[42]

These developments allowed an open question to fester in the late 1990s: what regulatory obligations and defaults govern broadband carriers, if any, other than general legal obligations that apply to all firms, such as contracting law?[43] This question coincided with another issue in broadband regulation. Cable firms were already exempt from common carrier obligations throughout the 1990s, while telephone companies were not exempt. As cable firms and telephone firms came into competition for provision of broadband to households, it was apparent they faced different costs due to different regulatory obligations.[44]

By the late 1990s, federal policy could have taken one of two directions (away from the status quo). Either regulation could be imposed on cable firms so that they became regulated more like telephone firms, or regulation could be removed from telephone firms so that they became regulated more like cable. In the first type of policies, cable firms would be required to interconnect their networks to others. In the second type of policies, telephone firms would be exempt from interconnection obligations for Internet traffic carried over broadband lines.

As it turned out, federal policy moved a step toward opening up cable networks a bit (as a condition for the Time-Warner merger), but then moved in the opposite direction a short time later, under its new chair, Michael Powell, who sought to initiate a broad range of changes to the FCC's approach to regulating convergence between voice, data, and video. In 2002, the FCC ruled that Internet service over cable lines was an "information service." This ruling effectively allowed cable firms to keep their networks closed to ISPs beyond the specific agreements made for the merger. Though challenged in court, this ruling survived a Supreme Court review several years later (in a case labeled *Brand-X* for short).[45] Several years after the FCC adopted the Brand-X ruling, broadband services from telephone companies became classified as information services as well. The signal decision came in August 2005, when the FCC reclassified DSL facilities from local telephone companies.

This is not to say that the FCC stood silent about the regulation of carrier conduct. Rather, it initiated an approach that differed from the existing precedent. Michael Powell issued some guiding principles about how Internet carriers should behave, calling these the "four freedoms."[46] These underwent a change with the appointment of his successor chairman, Kevin Martin, who issued a set of declarations on September 23, 2005. These declare that users should be able to access the entire lawful Internet, along with a few other principles.[47]

Net neutrality advocates were motivated by the perceived lack of restraints on broadband carriers that emerged after *Brand-X* (and related decisions) and were particularly unsatisfied with Martin's principles. Unlike typical FCC rulings, these declarations of principles were, and are, just that—declarations. They have some force, but they do not have the weight of regulatory rulings or precedent behind them.[48] They also are vague on details. In particular, the principles do not describe minimal acceptable quality, how it will be enforced, or what process the FCC expects to use to adjudicate a dispute.

Despite such ambiguities, these principles have influenced key events. For example, near the end of its filings, AT&T (formerly known as Southwestern Bell Corporation, and later SBC, prior to its merger with AT&T) suggested conditions it would accept in exchange for the FCC's permission to merge with Bell South. It agreed to follow the set of FCC principles for DSL providers for the next twenty-four months after its merger.[49]

Reinterpreted through the lens of economic experiments, this brief history of broadband regulation shows a trend in the last half decade: regulatory rules have been changed to raise the incentives for directed economic experiments by telephone firms and cable firms when they act as Internet broadband carriers. Is this trend worrisome? Net neutrality advocates believe it is, though usually this concern is articulated in language that only partially overlaps with that used to analyze economic experiments. I next consider how to reinterpret this debate through that lens.

Reinterpreting the Starting Point for Debate

The usual starting point for the debate about net neutrality begins with an analysis of the state of demand behavior and supply conditions. These concerns get combined in the following open question: does a cable or local telephone firm have enough market power to retain or lose many customers when it fails to innovate, offer lower prices, or experiment with new services?

The answer matters for understanding the process of value creation because, if users can directly punish providers for higher prices or inadequate service, then broadband providers will be restrained by the usual discipline of the market. That is, when these firms take undesirable actions, grumbling customers will take their business elsewhere. If users tend not to leave their providers after higher prices and inadequate service, then the competitive incentives to innovate will tend to be weak. In other words, from an economics perspective, there is little to debate if competitive supply characterizes carrier markets.

As it turns out, the majority of customers—households and small businesses—do not reside in locations served by many providers. Moreover, the number of these broadband users should continue to grow in the next few years because adoption of broadband has not yet slowed—especially among households.

More specifically, despite a contraction in the provision of competitive telephony and data carrier service after the competitive crash of 2000, as of this writing, most *large* businesses in *central urban locations* in the United States can choose among many providers of broadband services. If there is an issue with market power in the provision of broadband service, it exists for everyone else—that is, small and medium enterprises and households outside of very dense city locations. For a variety of reasons related to the costs of building broadband, most of these potential users have access to no more than two broadband suppliers—a cable company and a local telephone company. In less dense settings, there is only one supplier, if any.[50] The next-best alternative, satellite, is much more expensive. Until further wireless devices deploy (such as Wi-Max), most observers expect it to stay this way.

While large businesses generate a large amount of traffic and, also, account for a larger proportion of revenue than their numbers, they are also *very* small in numbers. As of the last count, there are just over 150,000 establishments in the United States with 100 or more employees in the private nonfarm sector of the U.S. economy. In contrast, there were over seven million business establishments of smaller size (87 percent of those are under twenty employees) and 113 million households.[51] There are no hard statistics about business use of the Internet by all types of businesses, but most data indicates that businesses of all sizes have high rates of adoption.[52] More concretely, most recent statistics indicate that over 30 percent of households have a broadband connection at home.[53] Most analysts expect many households with dial-up connection will convert to broadband within the next several years.[54]

There is a related open question about the intensity of competitive behavior between cable firms and DSL providers as they compete for new customers. Does this type of competition for new revenue support strong incentives to innovate? There is disagreement among debaters. This disagreement survives because the current empirical evidence for or against any hypothesis is mixed. There is little information about consumer switching behavior or the cross-price elasticities between different modes of broadband.[55] On the one hand, there has been a recent and well-documented build-out of facilities to serve new adopters.[56] On the other hand, evidence about pricing does not find anything dramatic: there has been no significant drop in the official U.S. consumer price index for the component of Internet access devoted to broadband over the last eight years.[57]

There is an additional and distinct concern that often gets confounded with the preceding points—whether a firm with market power in its retail Internet markets can shape innovative behavior in other parts of the Internet. On questions about innovation, the emphasis on economic experiments yields new insights. The next section addresses that topic.

Future Scenarios for Economic Experiments

A focus on economic experiments identifies three overlapping concerns in the discussion about net neutrality. In general, few of these concerns apply to settings where carriers only inhabit carrier markets. Instead, most apply to settings where the scope of carrier interests extends beyond just data. Here these are labeled as concerns about the inequity scenario, the mixed incentive scenario, and the less-innovative content scenario.

The Inequity Scenario. Every futurist forecasts improvement in broadband technologies. Futurists foresee multiple tiers of service in retail markets: a low-price, low-quality option and at least one high-price, high-quality option. Users are expected to segment themselves among the options. Bandwidth hogs will pay more for the resources they use.

On the surface, this forecast would not seem to contain any features that stir controversy. Many markets work this way, so why not broadband? The debate becomes provocative with a couple additional pieces of speculation. First, many futurists forecast that access firms will imitate the marketing behavior of cable television firms. For example, the premium tier of Internet service might include proprietary Internet video on demand, other IPTV (Internet Protocol Television) of various forms, and instant messaging with proprietary webcams, all arranged and supplied by the access firm for high-tier users.

Net neutrality advocates argue that a carrier with market power has incentives to encourage purchases of the highest tier, where the profit margins are more lucrative. In this scenario, broadband firms will neglect the other tiers in comparison. That is, they will put together a bland basic bundle and invest all marketing and organizational resources in the more profitable high-priced bundles. Moreover, there is a concern that over time the firms will shift most of their budgets to economic experiments for the higher tier, improving it with each new lesson, and not performing the same activities for the basic tier.

Net neutrality advocates argue that the several years of investment at the upper tier will lead to an advanced Internet that remains available to only a small part of society. On the one hand, this is plausible on the surface. Mass-market users might not first experience new applications arising from new economic experiments. Fewer economic experiments will yield fewer lessons aimed at the mass market, resulting in a cycle of experimentation that reinforces the inequality.

On the other hand, many historical examples demonstrate that economic experiments aimed at one segment of users often spread to other segments. In other words, it is not obvious why lessons learned in the upper tier will remain exclusively there.

The concern about inequity motivates various policy proposals. For instance, the extant literature has debated the merits of proposals to prevent price discrimination at the retail level. Reinterpreted through the lens of economic experiments, such a proposal will introduce distortions to investment, such as economic experiments to develop other instruments for achieving similar ends—that is, directed experiments aimed at developing services for achieving price discrimination in spite of it not being allowed. For example, it would induce broadband firms to invent proprietary software applications that generate high margins and that sort between high and low bandwidth users. Generally speaking, such investments are wasteful because they would be motivated by a desire to undo the effect of a regulation.

In summary, the concerns of the inequity scenario receive little support in the economic experiments framework. Lessons learned in one segment likely would move to another, and imposing retail price regulation would induce distortions.

Mixed Incentive Scenario. This scenario begins from the premise that most broadband carriers have their own voice service. That motivates an open question: why would a broadband firm undertake an economic experiment that deliberately helps the market interests of another provider of voice over IP(VoIP) that competes with the access firm's own services? Wouldn't a broadband firm simply watch what another firm does, then imitate it by offering its own service, kicking the competitor off its own lines? These questions arise because broadband carriers are a complement to someone else's production of service that substitutes for the carrier's own service. That situation creates poor incentives for the carrier to support the other firm.

Net neutrality advocates see their suspicions confirmed in a recent regulatory case over the must-carry obligations of firms to VoIP providers (called *Madison River*).[58] If net neutrality advocates are to be believed, many such conflicts are just around the corner. Many are forecast after the expiration of the conditions imposed for telephone mergers.

Because the economics of this scenario are easily understood, this is the one case that most lends itself to traditional regulatory approaches, such as restrictions on incumbent behavior or limits to incumbent lines of business. Opponents say that the traditional approaches are too restrictive on incumbent action and move too slowly to permit carriers to conduct viable economic experiments. They say that *Madison River* is just such a case where the four principles worked well. The FCC did intervene to stop the blocking of VoIP.

In the economic experiments framework, these concerns receive attention for one primary reason: a broadband firm can adopt actions that reduce the imposition of negative externalities (on itself) by limiting economic experiments that others can generate. Had one firm been allowed to do this, then others would have followed. The otherwise unrealized industry-wide gains from the otherwise unconducted economic experiments could be large if a broadband firm adopts policies that have wide impact on many other firms. That concern justifies policy intervention if a suitable intervention exists.

Net neutrality advocates have argued that one way to regulate such mixed incentives is to specify acceptable network management practices. Acceptable practices include, for example, blocking viruses, authenticating customers, or managing traffic to give high-quality service to the greatest number of users by restricting the use of the network by bandwidth hogs. Unacceptable practices include, for example, blocking competitor traffic or prohibiting or restricting attachments from competitors if these provide a competitive advantage to the carrier's commercial interest.

There is an open question whether this list of acceptable management practices should include requiring broadband carriers to release information to other content providers if content firms claim to need it to mount an effective application that competes with those sponsored by the carrier. I return to this question in the next section.

Net neutrality opponents argue that lists of acceptable actions are easier to make in general than to enforce in their specifics, and many practices have ambiguous implications for learning behavior.[59] In addition, there is an argument that enforcing any set of rules will impose a laborious regulatory and legal process on all parties, reducing the extent of experimentation by everyone.[60]

In summary, the lens of economic experiments does not settle many of these debates in their specifics. Rather, this lens highlights one issue: there are settings where broadband carriers can take actions that impose negative externalities on many others. Seen in that light, this lens highlights a key open question: how could such negative externalities be addressed while also permitting or encouraging carriers to conduct economic experiments? I will say more about this question after addressing the third worrisome future scenario.

Less-Innovative Content Cycle. This scenario concerns the incentive of broadband firm to charge different rates to different content providers. It overlaps with concerns about a broadband carrier's incentives to create new applications or new business alliances. Net neutrality advocates worry about a firm with market power making such deals without restraint.

Net neutrality advocates often begin discussing this issue by quoting Ed Whitacre, chief executive officer (CEO) of AT&T (formerly SBC), who declared in an unchecked moment:

> Now what [many content providers] would like to do is use my pipes for free, but I ain't going to let them do that because we have spent this capital and we have to have a return on it. So there's going to have to be some mechanisms for these people who use these pipes to pay for the portion they're using. Why should they be allowed to use my pipes? (quoted in O'Connell 2005)

The extant literature has debated whether the basic economics of this statement apply in a wide range of situations or might be flawed in some circumstances. As it turns out, this debate has implications for an analysis of economic experiments.

Standard price theory suggests that if a firm can price discriminate at the retail level, it may not necessarily gain from charging content providers different wholesale rates. The reasoning is quite established: if there is only a finite amount of value available, there is no way to double up—that is, a firm cannot increase the amount of value available in the value chain. So goes this argument; firms will try to extract value by any means possible, and attempts to prevent it just lead to distortions. For example, a carrier might not be able to segment its population perfectly using only retail segmentation strategies, in which case wholesale pricing can be a useful instrument for supplemental value extraction.[61] This line of reasoning concludes that there is no reason to worry about whether a provider takes its value in the retail end or wholesale or connection charge; it is the same value in either place.

Farrell and Weiser (2003) challenge this line of reasoning, providing an extensive list of plausible reasons why a carrier might want to price discriminate both at the retail level and at the wholesale level. Of most relevant to the less-innovative content scenario, they provide reasons why wholesale price discrimination can play a strategic role to further a carrier's interest. It can be used to reduce the competitiveness of supply, raising a rival's cost by, for example, raising (directly) the costs of reaching end users for whom both the content provider and carrier compete. Such action is especially damaging to society when new entrants can commercialize service in ways that make it superior to the incumbents', an outcome incumbents might seek to delay.

Reinterpreted through the lens of economic experiments, the net neutrality debate thus takes issue with the premise behind the double-dipping logic. That is, economic experiments can lead to the possibility that total value (to be split among carriers and content providers) is not fixed. It can be higher or lower if carriers take action. Particularly worrisome are situations where carriers take actions that are privately beneficial—either to protect existing markets or related commercial investments and relationships—and have the consequence of reducing the incentives of other firms to conduct economics experiments that could create value.

This concern borrows themes from the prior analysis of mixed incentives. After signing deals with content providers, a carrier has an incentive to protect its own commercial interests and directed experiments, pricing in a way to disadvantage other potential providers of new Internet applications. In other words, a carrier takes the position as a complement in production to someone else's service that potentially substitutes for a service they or a business partner provide. Carriers also can choose to enter service markets where they can use their discretion to disadvantage a potential competitor.

Numerous hypothetical scenarios in the net neutrality debate spin variations of this concern. Once an access firm has an economic relationship with an adventuresome video site, what is to stop it from sharing revenue if it steers traffic to the partner? What is to stop the access firm from excluding from its enhanced tier any competitor to the preferred partner site, even a young YouTube? Net neutrality advocates worry that business will become more difficult for young experimental sites that do not (or cannot) prearrange contracts with broadband firms. They worry that the bargaining costs of making deals with carriers after demonstrated success will interfere with the incentive to innovate in the first place.

Seen through the lens of economic experiments, there are two concerns. First, a carrier can use preinnovation contracting to generate market conditions that limit entry of innovative content providers. Second, carriers can use postinnovation bargaining to strategically aid their competitive position. There are a variety of reasons why both of these are a general concern because the carriers may intend to imitate content providers, may intend to compete through provision of their own service, or may intend to compete with alliance with another content provider. And there are a variety of ways for a carrier to take such action.

This lens raises an important qualifying point. These hypothetical scenarios are not complete arguments unless they compare one counterfactual outcome against another appropriate counterfactual. In other words, while a broadband carrier might *discourage* some content firms, a complete analysis must recognize that carriers might use their discretion to *encourage* others with whom it can coordinate an economic experiment. That is, a broadband carrier has an incentive to use private contracting to generate economic experiments that benefit its business. Even if the worry about carrier contracting behavior is correctly placed, it has to be compared against the additional contracting carriers will conduct to support directed economic experiments. The comparison between industrywide experiments under these two hypothetical situations will involve both positive and negative results.

Advocates call for regulations requiring broadband carriers to give services to others at the same cost as they give their own divisions. This includes a ban on exclusive deals by carriers with content providers. Advocates also call for transparent policies from carriers about how they treat the traffic of other parties. As seen in other aspects of the debate, opponents to such provisions see such regulations doing more harm than good, and they anticipate that regulations will reduce a carrier's incentives to conduct direct economic experiments, with a concomitant reduction in benefits to their users and to others learning the lessons that spread.

Interpreted through the lens of economic experiments, the open question for this scenario is similar to that for the mixed incentives scenario: what policies will address concerns about a carrier's incentive to shape the learning behavior of others, and, simultaneously, what policies will permit or encourage a carrier to continue to conduct economic experiments?

A Proposal for a Three-Part Test

Policy can play a role nurturing economic experiments. Communications policy did in historical circumstances. However, it played this role as a happy accident in the past, as was seen with the Internet access market. The lens of economic experiments focuses attention on a key difference: it focuses on policy orienting toward that goal and explicitly committing to it.

Reinterpreted through this lens, what is the principal challenge faced by a deliberate policy? No market participant knows the best option for creating and delivering economic value, so it is in society's interest to have *both* broadband carriers and others conduct directed economic experiments. However, there is a difference between a situation where carriers are just carriers and when they involve themselves in many complementary markets. While broadband carriers do have incentives to support economic experiments when these raise the value for their carrier services, they do not have strong incentives to support economic experiments from firms who conduct experiments that have a potential to compete with their own (carrier) interests.

If this type of reasoning guides policy, what would it look like in practice? This is not a trivial detail in practice. Decision making could fall in the domain of several different agencies, and that alters the practical details behind policy formation and implementation.[62]

To keep the explanation focused on the trade-offs between competing principles for encouraging economic experiments, I will frame the answer as if the regulatory system the FCC has adopted in the last several years continues to operate (in a somewhat idealized form). Generally speaking, this is a system that grants discretion to broadband carriers, but within oversight of a federal agency that places broad limits on that discretion by announcing principles in advance, deferring interpretations until specific circumstances give rise to problems.

For purposes of this analysis, I will treat the FCC's declaration of principles as a step toward meeting such a commitment. For purposes of this reinterpretation, the fourth of Kevin Martin's principles is most pertinent. It states, "Consumers are entitled to competition among network providers, application and service providers, and content providers."[63]

The statement accommodates environments where carriers have incentives to support economic experiments from others, in which case there is no need for policy intervention. It does not provide much guidance, however, about regulatory policies for a setting where broadband carriers and others bargain, while each attempts economic experiments aimed at commercializing innovations.

If increasing economic experiments is a policy goal, then the following becomes the open question: what types of actions from broadband carriers impose negative externalities on the value creation of others, and can regulators identify these actions in a systematic manner as part of a strategy to prevent them? Because circumstances change one year to the next, it is impossible to try to develop a specific answer. Any specific proposal also risks becoming rigid and inappropriate as technologies change. Rather, policy must adapt an approach that helps all parties predict its application under different circumstances.

What might that look like? Any proposal would aim to make regulator and carrier behavior predictable for a targeted set of circumstances. That is, policy would aim to address a core concern of the net neutrality debate: that the threat of some carrier action that could be taken *after* a demonstration of a commercial experiment will, in practice, discourage another firm from ever making the investment in the first place. Simultaneously, the policy would seek to not discourage a carrier from undertaking an economic experiment.

I borrow insights from prior thinking about the role for competition policy in innovative industries where firms offer complementary services.[64] Such policies trade off the interests of the two parties—in this case, a carrier and a content provider, where one has market power—in this case, a carrier. These policies presume the preponderance of carrier behavior requires no intervention; that is, many actions *would be* allowed under this test. This is deliberate as the test seeks *not* to limit a carrier's economic experiments except in a narrow range of circumstances.

The policy takes the form of a test that delineates a set of alarming circumstances from all others. Following prior work, I propose a three-part test. These questions follow:

- Does the incumbent carrier possess market power and use it when bargaining with others?
- Are the scrutinized tactics closely affiliated with noninnovative behavior?
- Is there a rationale under which a reduction of user choice is in the user's interest?

What would this test permit? By way of illustration, consider that a broadband carrier can use almost any contractual requirement when it supplies services to business users in a dense urban market. Because business customers in dense urban markets have access to many providers and can move between them in the presence of poor practices, policy would not be concerned with contractual actions of carriers in this market.

It also permits considerable discretion if a carrier is just a carrier, even if the carrier has market power, as found in most residential markets. It would permit almost any contractual feature if that contractual feature has an apparent benefit for user choice, such as increasing the menu of options available to users (e.g., supporting multiple tiers of bandwidth), as well as a wide range of pricing actions in residential markets, such as retail price discrimination between low- and high-bandwidth services. It also permits a range of wholesale or connection charges in the same set of circumstances, with several important (and potentially binding) limitations to discretion described in the following.

What would this test not permit? As an illustration, consider applying it to the actions scrutinized in *Madison River.* First, the carrier had market power with its customer base. Second, the scrutinized tactic, blocking of VoIP, served no innovative purpose. Third, the blocking of an additional choice reduced user choice without any associated savings in cost or lowering of prices or increase in the quality of existing service from the carrier.[65] This three-part test would lead to a prohibition on blocking of VoIP, the result in that case.

The three questions also divide along familiar lines for identifying acceptable managerial practices. It would permit any carrier, even one with market power, to block viruses, authenticate customers, or manage traffic, as these actions support user interests in a functioning network. However, it would lead to scrutiny of a carrier with market power who blocks competitor traffic or prohibits or restricts attachments from competitors as such practices rarely benefit users seeking to try innovative new services.

Perhaps a more interesting illustration arises when carriers seek to offer more services than just carrying data. How would these three tests treat a carrier who proposes to make an exclusive deal—for example, to distribute a firm's content over their lines and ban traffic from competitors whose content competes with it? In this case, the proposed test leads to a ban on an exclusive deal when it serves no innovative purpose (which it usually does not) and reduces user choice (which it usually does). In some respects, this result follows the familiar reasoning in antitrust economics, which views with suspicion exclusive deals when an upstream firm possesses market power and downstream firms do not. However, the reasoning related to economic experiments differs slightly. There is a potentially large loss to the extent of industrywide economic experiments from reducing entry of innovative content, particularly when the value of a new entrant is unknown. There is an especially large potential loss to industrywide economic experiments from reducing the potential for an innovative entrant with a transformative experiment. The loss to society from allowing carriers to have exclusive deals seems too great.

One extension of a ban on exclusive deals is a proposal for must-carry provisions. Such a provision would prohibit a carrier with market power from blocking traffic over one tier, while making it available on another tier. The reasoning in favor of must-carry is similar to that for banning exclusive deals: a must-carry provision supports value creation by content providers by reducing most anticipated postentry bargaining problems. The test also highlights (practically-minded) exceptions to this reasoning as might arise, for example, if congestion on a low-bandwidth line is severe and, as in some cable Internet architectures, increasing use by one user may shape the experience of many. In such a case, targeted reduction of choice to relieve congestion issues could serve an innovative purpose. A different type of exception arises when a peer-to-peer application threatens the security of all network users. Once again, a ban on such an application could serve an innovative purpose.

In practice, this proposal only partially addresses two large open questions in the net neutrality debate, that is, about carrier requirements for sharing of information and about price discrimination of wholesale access. The proposed three-part test leads to an unambiguous answer in only extreme cases. An illustration can show why. For example, had Madison River refused to provide relevant technical information to the VoIP provider or charged an extremely high price to the VoIP provider, its actions would have been virtually equivalent to blocking the rival. This test would lead to the conclusion that extreme use of these practices should be banned.

On the other hand, the proposal does permit information secrecy when it serves a useful innovative purpose, such as assessments of the potential value of new applications for an existing customer base. It also would allow for wholesale price differences between applications that use high bandwidth when the broadband carrier has no economic business interest in the relevant application market, such as when a frontier peer-to-peer application heavily uses available capacity for one user's benefit and the carrier has no economic interest in any peer-to-peer applications.[66]

The difference between one extreme example, where a practice is forbidden, and one not-so-extreme example, where a practice supports economic experiments, highlights a drawback with this proposal: these three questions do not give a sharp answer for every relevant situation. While it would be a surprise for any single proposal to give a sharp answer to all open questions, this ambiguity leaves open opportunities for a market participant to push a boundary, inviting costly regulatory and legal wrangling about the definition of that boundary. The appropriate question to ask is whether that cost comes with a benefit that, on net, exceeds the cost or benefit of the present situation, as carriers with market power try to commercialize services, shape economic experiments nationwide, and simultaneously work out the meaning of the four vague principles governing the Internet.

The lens of economic experiments leads to a general policy approach that is not common within the extant net neutrality debate. It leads to a forward-looking set of guidelines to encourage value creation. As illustrated in the preceding, it would favor some must-carry provisions and ban exclusive deals when market power is present and a carrier has commercial interests in an application market. This is consistent with suggestions coming from net neutrality advocates. On the other hand, it leads to favoring discretion over pricing at the retail level and at the interconnection or wholesale level, limited primarily by the type of principles found commonly in the antitrust analysis of contracting practices. That is consistent with common suggestions among net neutrality opponents.

In summary, the lens of economic experiments sheds new insight on the net neutrality debate. It focuses attention on preserving the incentives of *both* broadband carriers and others to conduct directed economic experiments. It draws a distinction between settings where carriers choose to be just carriers and when they choose to do more. In the latter, it focuses attention on the role policy can play when broadband carriers do not have strong incentives to support economic experiments from firms who conduct experiments that have a potential to compete with carrier commercial interests.

V. Conclusion

Focusing on the role of economic experiments leads to a shift in perspective on the creation of value. Both directed and undirected economic experiments played a valuable role in the development of commercial Internet access. Generally speaking, many firms participated in economic experiments, and, though the participation took a variety of forms, many firms gained substantial private benefit from the lessons learned. Market, technical, heuristic lessons spread quickly between firms, while complex business lessons spread more slowly. As a result, the industrywide benefits from economic experiments were substantial, and though many of these gains were measurable, many were not.

There is an irony embedded below the surface of this analysis. Firms conduct economic experiments to resolve uncertainty about the underlying determinants of market value. Yet, as it typically turns out, no firm's experience can be viewed in isolation of others, and by taking actions, each firm teaches others lessons, which, in turn, lead to more experiments. While all this interplay is inextricably linked to the creation of value for the industry, the interplay between firms increases the possibility for the emergence of an undirected economic experiment, itself creating another barrier to making any near-term forecast about the creation of value at a specific firm. In other words, each firm may take action to reduce uncertainty, but together the actions may lead to more uncertainty, not less.

This environment raises many challenges for communication policy. Due to innate measurement challenges and the heterogeneity in experiences across firms, there is no way to say in any given instance whether costs from economic experiments exceed their benefits at a private or industrywide level. In general, however, historical examples suggest that in the preponderance of instances the industry-wide benefits from economic experiments exceeds private value due to the presence of positive information externalities between firms and over time. A major exception arises in settings where the negative externalities are present and large, a situation that a targeted policy would seek to address.

Those insights lead to a reinterpretation of the net neutrality debate. The central policy concern is that postinnovation bargaining by carriers can be used to strategically aid its competitive position. The carriers may intend to imitate content providers, may intend to compete through provision of their own service, or may intend to compete with alliance with another content provider. In all cases, carriers with market power have incentives to raise a rival's cost. Hence, carrier action can reduce incentives for investment by content providers to support an economic experiment. The lens of economic experiments focuses attention on preserving incentives to conduct economic experiments by *both* broadband carriers and others. It focuses attention on the role policy can play through targeted intervention against a few carrier practices.

Endnotes

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I am responsible for all errors.

1. There is considerable writing in these veins. See, for example, Lessig (1999), Sidak (2003), Crandall (2005), Neuchterlein and Weiser (2005). More will be discussed in the text.

2. See, for example, Blumenthal and Clark (2001); Alleman and Rappoport (2005); Clark et al. (2005); Clark et al. (2006); Goldfarb, Kirsch, and Pfarrer (2005); Bauer (2006); or Greenstein (2007). More will be discussed in the text.

3. This is a growing literature, starting with Von Hippel (1988). It also is labelled "lead user" studies.

4. See, for example, Sandvig (2004, 2007).

5. See Gomory (1997) for a discussion about why exposing this model to scrutiny would help eliminate the mental monopoly it holds on the actions of many managers.

6. For example, the original investment by DARPA (Defense Advanced Research Agency) in the fundamental science of packet switching led to events that broadly fit the stages in the ladder model.

7. Greenstein (2007) discusses why existing infrastructure firms were "surprised" by these developments.

8. See Downes and Greenstein (2002) for a description of the dial-up market or Downes and Greenstein (2007) for an analysis for why some areas had more entry than others.

9. For a review of technologies behind the browser and portal and an analysis of the factors that shaped their evolution, see Haigh (2007).

10. See, for example, Wagner (2002).

11. See, for example, Rosston (2007) for an analysis of the changing views of cable firms about the source of value from controlling or not controlling a portal and ISP.

12. For more on the evolution of pricing in this time period, see Stranger and Greenstein (2007).

13. See Swisher's (1998) account of this crisis. AOL's user base reacted to the introduction of unlimited pricing by increasing frequency of use and length of time per session. That behavior produced capacity issues, experienced by users as busy signals.

14. For example, many firms offered discounts of 50 percent in exchange for limitations of sixty hours per month (combined with penalties for exceeding this limit). This type of offer received a cool reception from most users even though over 90 percent of household users had use underneath such a limit. See the discussion in Stranger and Greenstein (2007).

15. For example, some firms imposed automated session termination after a fixed period when the account experienced no use. Other ISPs tried to put fine print into their contracts that imposed high penalties for use that exceeded extremely high use, such as 150 hours per month.

16. This strategy turned out to be effective for entry, but not for a sustainable business. Eventually, after growing a service for several million users, then merging with another firm, Juno, NetZero adopted a different pricing contract, one with a minimal monthly charge.

17. Both were founded in 1998. The former was organized by firms such as Motorola and Seimens, and at its peak involved over a hundred companies before it disbanded; while the latter was established by Ericsson, Sony-Ericsson, International Business Machines (IBM), Intel, Toshiba, and Nokia and currently still exists, involving thousands of firms.

18. For a review of many of these developments, see, for example, Aronson, Cowhey, and Richards (2007).

19. For speculation about why HomeRF failed, see, for example, http://www.cazitech.com/HomeRF_Archives.htm.

20. The story of the growth of a LAN market around the activities in committee 802 is well told in Von Burg (2001).

21. Vic Hayes, one of the earliest developers of wireless technologies and standards and chair of the IEEE 802.11 committee during the 1990s, first developed wireless technologies for National Cash Register, or NCR (a subdivision of AT&T then, today a division of Agere Systems). In that capacity, he first developed wireless terminals for stockbrokers. See Kharif (2003).

22. See the description of Hills (2005), who began developing the equivalent of a Wi-Fi network for the Carnegie Mellon campus in Pittsburgh, starting in 1993.

23. See the review of FCC policies found on http://www.cybertelecom.org/broadband/wifi.htm, a nonprofit site that links to the original FCC material and summarizes it. Subsequent clarifications and rules emerged several times thereafter, partly to promote equipment export to other parts of the world by aligning spectrum in the United States with similar policies elsewhere.

24. See, for example, Lui (2001) or Kharif (2003).

25. For example, in high-density settings, it was possible for there to be interference among the channels or interference with other users of the unlicensed spectrum reserved by the FCC, such as cordless telephones. The diffusion of so many devices also raised questions about norms for paying for access in apartment buildings, from neighbors, and others. See Sandvig (2004).

26. Specifically, it involves designing an appropriate chipset and wireless network adaptor, as well as the Intel Microprocessor.

27. For history and analysis of Intel's investments in different projects, including, but not necessarily Centrino, and why its management chose to invest heavily in some complementary technologies and not others, see, for example, Gawer and Cusumano (2002) and Gawer and Henderson (2007).

28. See, for example, Greenstein (2000).

29. For documentation of this, see Stranger and Greenstein (2007).

30. For example, in their estimates of demand for broadband, Savage and Waldman (2005) find that most users are willing to pay a considerable fee to avoid set-up hassles and achieve a reliable service.

31. Most of these vendors already knew how to operate the basic building blocks for a point of presence (POP) and support a basic service. The details of such a POP involved operating modem banks, servers, and managing traffic control.

32. In this context, "codified" refers to an idea put in a structured format that another technically trained individual can understand without having the author present—for example, words, mathematical formulas, plans, pictures, or professional drawings. See, for example, discussion in Nelson (2007).

33. Sandvig, Young, and Meinrath (2004) document the tension between equipment firms and mesh-network user groups. The firms guarded their code, delaying experimentation at user groups, because the firms were also anticipating that they would deploy such designs in the near future.

34. As the Apache founders make clear on their own Web page, in February 1995, they sought to improve and coordinate further improvements to the National Center for Supercomputing Applications (NCSA) server software, which had lost its key personnel. The NCSA tried to revive the software in April but then quickly cooperated with the Apache effort. See http://httpd.apache.org/ABOUT_APACHE.html.

35. See Simcoe (2006) for a general analysis of many of the actions at the IETF and a view about why resolution became more difficult over time.

36. The studies of lead users also highlight a related observation. That is, a lead user with an unusual enthusiasm or desire to push in a new direction may become the catalyst for exploring new designs and nonincremental business possibilities, which later grow into wide uses. See Von Hippel (1988) about lead users and Sandvig (2004, 2007) about wireless technology lead users in particular.

37. For more on this theme, see, for example, Greenstein (2007).

38. There are many opinions about which recent changes most inform the present debate. See, for example, Lessig (1999), Weiser (2003), Alleman and Rappoport (2006), Atkinson and Weiser (2006), Wu and Yoo (2006), Owen (2007) or Speta (2007). This is far from an exhaustive list.

39. Another approach, which I will not discuss, might argue for changes in intellectual property (or related mechanisms) to align the private incentives for conducting directed economic experiments with the industrywide returns. There are numerous challenges with implementing such a proposal in general or in this specific context. For discussion of one such proposal, see Abromowicz and Duffy (2007).

40. The first number comes from NTIA (2004), while the latter comes from Pew Charitable Trusts (2006).

41. Though that outcome arose out of specific regulatory cases and markets, these rules were not imposed with a vision of the Internet. See, for example, Cannon (2001), Noll (2002), or Owen (2007). For further analysis of how these contributed to innovative behavior of Internet access market participants, see Greenstein (2007).

42. This statement necessarily simplifies a complex history. For example, for ISPs and Internet access, the first large change of federal policy at the FCC concerned the practice of "reciprocal compensation" for Competitive Local Exchange Companies (CLECs), many of whom offered services to ISPs. This ruling was issued in early 1999. For various views of this and subsequent rulings, see, for example, Owen (2002), Sidak (2003), Goldstein (2005), Neuchterlein and Weiser (2005), Frieden (2006), Greenstein (2007), or Speta (2007).

43. There also was uncertainty about the legal obligations of ISPs and hosting companies for their content. Much of this was clarified by litigation involving the Digital Millennium Copyright Act, and, particularly, the Communications Decency Act, a section inserted as a part of the Telecommunications Act of 1996 that came under immediate court challenge after passage. Though the challenges to the latter Act originally involved principles of free speech, the relevant cases ended up clarifying the role of intermediaries. See, in particular, the summary in http://www.cybertelecom.org/cda/cda3.htm or the timeline of events in http://www.cybertelecom.org/cda/cdaref.htm.

44. None of this was a mystery. Many observers in the 1990s forecast the need to end this asymmetry. For a summary of this debate at the beginning of the millennium, see, for example, Hausman, Sidak, and Singer (2001); Noll (2002); Owen (2002); or Neuchterlein and Weiser (2005).

45. See the summary in http://www.law.cornell.edu/supct/html/04-277.ZS.html.

46. Specifically, these are (1) Freedom to Access Content: consumers should have access to their choice of legal content; (2) Freedom to Use Applications: consumers should be able to run applications of their choice; (3) Freedom to Attach Personal Devices: consumers should be permitted to attach any devices they choose to the connection in their homes; (4) Freedom to Obtain Service Plan Information: consumers should receive meaningful information regarding their service plans. See Powell (2004).

47. Specifically, these are (1) consumers are entitled to access the lawful Internet content of their choice; (2) consumers are entitled to run applications and use services of their choice, subject to the needs of law enforcement; (3) consumers are entitled to connect their choice of legal devices that do not harm the network; (4) consumers are entitled to competition among network providers, application and service providers, and content providers.

48. A useful summary comes from James Speta (2007, 8, n.25), who says, "A policy statement is a statement of how the agency intends to exercise its regulatory discretion. It is not binding on the agency, and any party against whom an enforcement action may be brought can defend by arguing that is action (even if contrary to the policy statement) did not violate the applicable statute and substantive regulation."

49. Similar conditions emerged from negotiations for the Verizon/MCI and SBC/AT&T mergers. These are due to expire in October 2007. The conditions for the AT&T and Bell South merger expire in mid-2009.

50. For a discussion of the reasons, see, for example, Greenstein (2005).

51. See Statistical Abstract of the United States, 2007, table 738, Establishments, Employees, and Payroll, and table 56, Households, Families, and Subfamilies.

52. Forman, Goldfarb, and Greenstein (2003) present estimates for Internet use by establishments with 100 or more employees at the end of 2000. They find rates of adoption close to 90 percent for simple applications, such as browsing and e-mail, with some variation across industries between 80 percent and 99 percent. They discuss likely adoption rates for

smaller businesses, noting, for example, surveys of households who "access the Internet at work" show levels between 60 percent and 80 percent, depending on the survey year. See NTIA (2004).

53. See information about broadband adoption in the United States in Pew Charitable Trusts (2006) or NTIA (2004).

54. See, for example, Pew Charitable Trusts (2006).

55. The literature supports a range of inferences. For example, see Rappoport et al. (2002) or Hausman, Sidak, and Singer (2001) for evidence that dial-up prices do not act as much of a constraint on broadband prices. Using a different approach, Savage and Waldman (2005) find a high willingness to pay for broadband among a certain set of users, but do not estimate elasticities for the marginal user.

56. Both the FCC surveys and the Pew Charitable Trust surveys find a large growth in Internet lines for households in which virtually all of that growth occurred after 2000. See, for example, Federal Communications Commission (2007, table 3) and Pew Charitable Trusts (2006).

57. This index focuses on households, not business expense, so it is only partially informative. Between the end of 1997, when the index first begins, and 2006, when the most recent annual data is available, the price index dropped 7.8 percent. The only dramatic change occurred in the late fall of 2006 and early 2007. However, this fall in the price index had nothing to do a drop in broadband prices in late 2006. It occurred because AOL, a dial-up firm with a large market share, dropped its subscription price by 100 percent.

58. See the review of this case in Atkinson and Weiser (2006) or Speta (2007). This case principally concerned the rights of a broadband firm to block Voice over Internet Protocol (VoIP).

59. A useful summary of some of these issues can be found in Bauer (2006).

60. For various articulations of this argument, see, for example, Noll (2002), Wu and Yoo (2006), and Owen (2007).

61. Or, in the event that regulation prevents retail price discrimination, charging different wholesale prices to different content providers could make up for some of the shortfall.

62. This question arises precisely because the FCC has declared broadband carriers to be information services and not be common carriers, and the *Brand-X* decision gives the FCC authority to reverse itself. Under the present declarations, it is not obvious what legal authority the FCC has to regulate conduct (though, to date, that has not stopped the FCC from intervening in a few select cases). This awkward state of legal authority has not gone unnoticed. For a discussion, see, for example, Speta (2007).

63. Martin is quoted at http://www.cybertelecom.org/ci/neutralfcc.htm, accessed May, 2007.

64. This proposal borrows from Greenstein (2002). For general discussion of these issues, see, for example, Arora, Fosfuri, and Gambardella (2001) or Gans and Stern (2003).

65. Notice that if the VoIP from another firm interfered with the ability of Madison River to manage its own service, then this principle does not give a clear-cut answer about how to trade off those costs. In that sense, it leans toward giving broadband firms discretion, subject to the natural concern that carriers cannot invest excuses to exclude others.

66. Once again, note the relevance of the qualification: if a carrier makes a deal with Yahoo! (e.g., to make Yahoo! its default portal) the carrier would have an economic interest in the relevant application market for Google and, as a result, would not be permitted to charge more to Google for use of its lines.

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