Framing Empirical Research on the Evolving Structure of Commercial Internet Markets

By Shane Greenstein*

Written for:
"Understanding the Digital Economy:
Data, Tools and Research"
Washington DC, May 25-26, 1999

Preliminary and incomplete
Comments welcome
This draft: May 10, 1999

Abstract

This papers provides a framework for organizing empirical research on structural change in electronic commerce. The framework emphasizes three themes: that the technology underlying electronic commerce must change to be useful; that different firms pursue similar business opportunities with different approaches; and that a significant part of the activities of many firms in electronic commerce involves intermediary functions. The paper illustrates this framework on one example, the development of the commercial internet access market. It also organizes its discussion of future research using the same three themes, showing how these themes encompass many classes of open issues.

---

* Associate Professor, Kellogg Graduate School of Management, Northwestern University. I would like to thank the Institute for Government and Public Affairs at the University of Illinois, the Council on Library Resources, and the Consortium for Research on Telecommunication Policy at Northwestern University for Financial Assistance. Thanks to Oded Bizan, Tim Bresnahan, Barbara Dooley, Tom Downes, Mike Mazzeo, and Dan Spulber for useful conversations and to many seminar participants. Angelique Augereau, Howard Berkes, and Chris Forman provided outstanding research assistance. All errors are mine.

1. Introduction

Electronic commerce is an application of Internet technology, a suite of communication technologies, protocols and standards for networking between computers. This suite is not valuable by itself. Rather, it obtains economic value when embedded in equipment, software, and business processes, tailored by the firm providing it for the needs of a specific user.

Many technology enthusiasts have been waiting for the on-line revolution for a long time, welcoming the possibilities for new businesses, new services and new types of communication. However, use of the Internet has turned into something both easy and difficult, successful in some areas while stubbornly resistant to change in others. Much commercialization bends frontier technology to the needs of commercial users, a process that often involves many non-technical issues. These activities are exciting, frustrating and complicated. Hence, the growth of electronic commerce has unleashed media hype about new ways of doing business in the information age. It has also raised the fees of consultants who devise strategies for exploiting new commercial opportunities.

While there is no shortage of attention paid to the internet in popular media, few commentators provide frameworks and data for understanding how commercial processes translate Internet technologies into economic value. As a result, many fundamental research topics still remain unaddressed: for example, what is the typical empirical pattern by which commercial firms translate internet technology into private value and, more broadly, into sustained economic growth? Is there any evidence to suggest that the restructuring of electronic commerce imposes undesirable biases on economic outcomes of policy interest, such as the distribution of income or the ubiquity of essential services? What factors should policy makers measure – and what factors should they ignore – if they desire to track important change to the structure electronic commerce or measure its impact, more generally?

The issues are large and not digestible in a short essay such as this. At best, a short essay can provide a window on broad issues and it can frame questions. Accordingly, this paper does a bit of both. It provides a framework for organizing empirical research on structural change in electronic commerce, identifying three themes which have been important to commercial

experiences so far. First, Internet technology changes whenever there is an attempt to provide value to a new set of users. Second, many economic decision makers do not use the same approaches to developing similar commercial opportunities. Third, a significant set of activities of many providers in the commercial internet market involve intermediary functions. The paper argues that these three themes arise in most analysis of market structure and in most attempts to measure the factors shaping it.

The paper begins by using these themes to retell and reinterpret a familiar story, the rise of the commercial internet access market, a key element in the value chain of electronic commerce. In only a few years commercial providers now supply the vast majority of Internet access in the United States. While revenues, estimated between 3 and 5 billion dollars in 1997 (Maloff, 1997), are relatively small for the communication and computing industry, they are rather large for a four year old industry. The paper then highlights the untapped potential for additional research on many other related topics, emphasizing the need for the development of measurement methodologies, for more data and for policy assessment. It also organizes its discussion of future research using the same three themes, showing how these themes encompass many classes of open issues.

A short summary of the three themes is provided below:

! **Internet technology changes whenever there is an attempt to provide value to a new set of users.** When the Internet first commercialized it was relatively mature in some applications, such as email and file transfers, and weak in others, such as commercial infrastructure and software applications for business use. This was due to the fact that complementary Internet technology markets developed among technically sophisticated users before migrating to a broad commercial user base. The invention of the world wide web in the early 1990s further stretched the possibilities for potential applications, exacerbating the gap between the technical frontier and the potential needs of the commercial user. In other words, the commercial processes that translate Internet technology in valuable electronic commerce involve the customization and re-orientation of the technology to the goals of new decision makers. These processes are complex, on-going and not well understood; yet, they are essential for

understanding the creation of economic value.

! **Economic decision makers may not use the same approaches to developing similar commercial opportunities.** Unlike the building of every other major communications network, Internet infrastructure was built in an extremely decentralized market environment. Aside from the loosely coordinated use of a few *de facto* standards, (e.g., World Wide Web), government mandates after commercialization were fairly minimal. This means several things in practice. First, commercial markets did (and will continue to) develop some market opportunities sooner than others. Simply stated, not all buyers wanted the same thing at the same time. This is a well known pattern in other markets, though it has not been fully characterized here. Second, commercial providers of internet services attempt to differentiate from common competitors. The determinants of these choices vary between services and vendors, depending on many factors. Industry commentators label this process as the choice among "different business models." It is a process that is far from settled as long as commercial providers continue to operate under a flexible institutional umbrella, characterized by fungible market relationships and loose institutional constraints. In other words, there has not been, nor will there be, uniformity in the strategies that firms use to commercialize technology. These differences are largely undocumented outside the consulting world, and, yet, are essential determinants of the creation of private value.

! **A significant set of activities of many providers in the commercial internet market involve intermediary functions.** The technical frontier changes frequently, both in terms of maximum achievable engineering goals and in terms of viable commercial activities that generate revenue in excess of resources. Indeed, in every major urban area and many rural areas in the US hundreds of firms build, operate, and deliver Internet applications, tailoring their network offerings to local market conditions and entrepreneurial hunches about growing demand. These decisions often focus on reducing a gap between the provider and the end-user – a gap related to the difference between the state of technology and the costs of employing it at a point in time at a particular location. At its simplest level, this involves providing a user with their first exposure to a new technological possibility and educating them about its potential. More often it goes beyond

exposure, including the installation of equipment, provision of maintenance and training, as well as undertaking application development. In all cases, the vendor's business plan depends on the vendor being better educated about the technological capabilities than the user and, in effect, selling that general knowledge to the user in some form which customizes it to the particular needs and requirements of the user. Such activity may involve regular on-going business transactions, or it may involve periodic review of the user's state of technology relative to new frontier developments, needing periodic renewal and upgrade to user facilities. These types of activities involve a great deal of nuance, often escape attention, and yet, are essential to developing electronic commerce as an on-going and valuable economic activity.

2. The Internet Access Business after Commercialization: An interpretation

The "commercialization of the Internet" is shorthand for three nearly simultaneous events: the removal of restrictions by the NSF over use of the Internet for commercial purposes, the browser wars initiated by the founding of Netscape, and the rapid entry of tens of thousands of firms into commercial ventures using technologies which employ the suite of TCP/IP standards. Not surprisingly, in the first few years after the commercialization of the Internet, the products changed frequently, many firms changed strategies, and the market definition adjusted . How did Internet technology arise and how did these origins influence the commercialization of the technology? The purpose of this section is to tell this familiar story in light of the paper's larger themes.

A. Changes to Internet Technology

Internet technology changes whenever there is an attempt to provide value to a new set of users. The origins of Internet technology contain the seeds for understanding why Internet technology, and internet access in particular, had to change for commercial users. Like many new inventions in information technology (Bresnahan and Greenstein, 1999), this one incubated among technical users. When the technology migrated away from these users and into wider use, some

capabilities were obviously valuable, such as e-mail. Other desirable capabilities – for example, software for reliable and secure order-processing using internet protocols which integrated with legacy investments in inventory management systems – required considerable development before the emergence of services of value to non-technical users.

How did this come to be? By the time of commercialization, Internet technology was a collection of non-proprietary *de Facto* standards for the development of communications between computers. These arose out of DARPA (Defense Advanced Research Projects Agency) experiments aimed at developing communications capabilities using packet switch technology. In 1969 DARPA began the first contracts for ARPANET, which involved a few dozen nodes. The first email message arrived in 1972. After a decade of use among a small group of researchers the protocols that would become TCP/IP were established and in regular use. By 1984 the domain name system was established and the term Internet was used to describe the system. In the early 1980s DOD began to require the use of TCP/IP in all Unix-based systems which were in widespread use among academic research centers.

In 1986 oversight for the backbone moved to the NSF, leading to a dismantling of ARPANET, and the establishment of a series of regional networks. The NSF pursued policies to encourage use in a broad research and academic community, subsidizing access to the Internet at research centers outside of universities and at non-research universities. In pursuit of goals to encourage growth within the academic community, the NSF also worked with a wide variety of private companies, including IBM and MCI and others, to develop practical network backbone communication standards which could be deployed on a large scale (e.g., routing protocols and addressing systems). The NSF policies had the intended effect of training many network administrators, students and users in the basics of TCP/IP technology. The NSF also sponsored development of changes to TCP/IP that enabled it to apply to more varied uses. Thus, this period saw the development of a variety of disparate technologies, most of which embodied non-proprietary standards, reflecting the shareware, research or academic culture in which they were born. Most of these would soon become necessary for the provision of basic access.

The unanticipated invention of the world wide web associated a new set of capabilities,

display of non-textual information, with Internet technology. This was first invented in 1989 for the purpose of sending scientific pictures between physicists. After a few years, many Internet users knew how to employ these technologies. By the time the Internet was commercialized, a new set of experiments with browsers at the University of Illinois had developed the basis for Mosaic, a browser using web technology, something which made the whole suite of web technologies easier to access. Like most other technologies associated with the world wide web, this browser was widely circulated as shareware in 1993-94. It quickly became a *de facto* standard , exposing virtually the entire academic community to the joy of sending pictures.[2]

The NSF always retained policies restricting use of the Internet backbone – i.e., no advertising and no sales of products. Plans for commercializing the Internet were put in place in the early 1990s. These plans called for lifting the NSF's restrictions on commercial activity while leaving a quasi-academic organization in place to govern daily operations. These plans were implemented independently of the invention of web technology and the diffusion of the browser. It would be fair to characterize these plans as minimalist in regards to commercial developments, deliberately taking a hands-off approach to the development of complementary Internet technologies by commercial decision makers, trying not to forecast or unwittingly pick winners.[3]

The explosion of commercial activity in 1994-95 caught many mainstream and potential market participants by surprise. The founding of Netscape highlighted the large commercial opportunity, ending all the doubts among fence-sitters in the computing and telecommunications

[2] These experiments served as the inspiration for Marc Andreeson, the technology officer at Netscape, who was part of the team at the University of Illinois laboratory which wrote Mosaic. This browser experiment also served as the technical basis for licenses from Spyglass to Microsoft, who put TCP/IP in Windows 95 and sold a browser soon thereafter.

[3] By the late 1980s the Internet offered an alternative or complement to existing on-line services. Would it be an alternative for Prodigy, CompuServe and America On-Line (Meeker and Dupuy [1996])? Would it enhance the services of the on-line database industry (Ventresca et. al. [1998])? Would it change business-to-business electronic commerce (i.e., such as EDI)? Would it change the direction of the client/server revolution (Bresnahan and Greenstein [1999])? These were among the many open questions.

industry.[4] Netscape's first browser rapidly diffused to several million early adopters who had used similar technology as students at universities. In addition, this diffusion coincided with the arrival of several more million computer users who tried the Internet/Web for the first time. Thus, the rapid diffusion of the browser highlighted the unmet demand which existed as an artifact of the restricted access to Internet technologies until then.

In summary, the early users were scientists and engineers, primarily in higher education and laboratories. The set of issues found in such a setting could differ significantly from those found during the deployment at organizations in a business setting or at home. There were many commercial opportunities to bring internet technology to non-technical users, but it was hard to see them until the Internet had been demonstrated as something of practical use. It is not surprising, therefore, that every extension of that suite to new uses opened questions about the adaptability of the technology. More concretely, by 1995 there was an economic opportunity to create value by translating the basic pieces of Internet technology into a reliable and dependable standardized service for non-academic users. This involved building access for business and home users, as well as solving problems associated with both customizing TCP/IP to networks in many different locations running many distinct applications. The value of the technology depended on how well it adapted to different computing environments, different computing applications and different types of computing users.

B. Multiple Approaches to Commercialization

Not all economic decision makers use the same approaches to developing new commercial opportunities. It was not a foregone conclusion that many firms would pursue internet technologies with different approaches. Yet, that is what happened. By 1995 the primary open issues were commercial, not technical. Was this commercial opportunity fleeting or sustainable? What business model would most profitably provide Internet access, content and

[4] For example, TCP/IP received almost no attention in Bill Gates' 1995 book, "The Road Ahead," which ostensibly provided a detailed look at Microsoft's vision of the future. Indeed, Microsoft did not publically place the Internet in a central position until late 1995, during Gate's "Pearl Harbor" speech.

other services to users outside the academic or research environment? What would users be willing to pay for and what could developers provide at low cost? As it turned out, no single answer dominated each of these questions.

The first surprise to many observers was that market-based transactions quickly became the dominant form for delivery of on-line access. Commercial ISPs developed a business of providing Internet access for a fee. Access took one of several different forms: dial-up to a local number (or 1-800 numbers) at different speeds, or direct access to a business's server using one of several high-speed access technologies. Within three years the commercial providers almost entirely supplanted their academic parents. By the spring of 1998 there were scores of national networks covering a wide variety of dial-up and direct access. There were also thousands of regional and local providers of Internet access that served as the links between end-users and the Internet back-bone. The most recent surveys in 1998 found that no more than 10 percent of US households got their Internet access from university-sponsored ISPs (Clemente, 1998), with almost all of the remainder going to a commercial provider. Virtually all businesses get their Internet access through a commercial ISP.

Several economic factors determined this entry pattern . Technology did not serve as a barrier to entry, nor were there prohibitive costs to hiring mainstream programming talent. Providing basic access required a modem farm, one or more servers to handle registering and other traffic functions, and a connection to the Internet backbone.[5] Some familiarity with the non-proprietary standards of the web was required. However this was not much of hurdle. Many students had used the technology in school, and the standards were non-proprietary, so anyone with some experience could use them or learn them quickly. As a result, a simple dial-up service was quite cheap and a web page was quite easy to develop. Even providing direct access (e.g., T-1 lines) was not outside the grasp of many of the same firms.

Maps 1 and 2 (Downes and Greenstein, 1999) illustrate the extent of entry into the dial-up

[5] For example, see the description in Kalakota and Whinston [1996], Lieda [1997], Rybaczyk [1998], Northrup [1998], the accumulated discussion on www.amazing.com/Internet/faq.txt, or Kolstad [1998] at www.bsdi.com.

commercial internet access market by mapping the points-of-presence for commercial firms into geographic space. The first shows the density of suppliers in the fall of 1996 and the second shows the density of suppliers in the fall of 1998. The contrast is dramatic. By 1996 there were already over 3000 ISPs in the US. Most urban areas had competitive dial-up markets but large parts of rural America still had no local access available. By 1998 there were close to 6000 ISPs and most incumbent firms had expanded their network size and reach. At least 95 percent of the US population had access to a competitive market. (See Downes and Greenstein, 1999, for caveats and statistical detail).

These patterns had obvious consequences for profitability. The amateurs of 1995 soon learned that cheap and easy entry did not necessarily translate into a profitable on-going enterprise. The major players from related markets who opened large access services, such as AT&T, also learned that the basic access market had small margins. By 1998 basic access was not generally regarded as a very lucrative part of the ISP commercial market.

By 1998 different ISPs had chosen distinct approaches to developing access markets, offering different combination of services and different geographic scopes. Why did this variance arise? As emphasized in Bresnahan, Stern and Trajtenberg, [1996], one way to understand this behavior is to view an ISP's choices as an attempt to differentiate from common competitors. Firms may try to push technical frontiers, develop local or national brand names, combine recent technical advances with less technical businesses and so on. Such differentiation may arise from firm-specific invention or firm-specific unique assets, and these returns may be temporary if competitors eventually learn to provide close substitutes.

The 1998 Internet access industry can be understood in these terms. Entry after 1995 had extensively developed the "basic access" market, the first and most obvious adaptation of Internet technologies to commercial use. Due to extensive entry, the private returns to basic access services had almost entirely been competed away by 1998. Thus, the possibility of super-normal private returns, if it existed at all, existed in differentiating from offering only basic access. That said, what a technology-intensive firm does in a particular market situation is an empirical question. Several types of strategies were commonly stated in industry discussions:

- *Offering technically difficult access:* High-bandwidth applications present many technical difficulties which challenge the skills and capital constraints of many ISPs. The slow diffusion of commercially viable high-speed access markets is widely regarded as a major bottleneck to the development of the next generation of Internet technologies (Kalakota and Whinston, 1996, Esbin, 1997).

- *Offering services that are complementary to basic access:* Providing additional services became essential for retaining or attracting a customer base. Many ISPs tried to develop additional services, such as web-hosting, web-design services and network maintenance for businesses. These were quite costly, as they had to be properly assembled, maintained, and marketed. Many of these services push the boundaries of existing telecommunications and computing market definitions.

- *Offering services in a proscribed geographic region:* There was much debate among ISPs about the value of providing geographically dispersed service. Some ISPs deliberately chose to focus on small geographic region and develop a reputation at that local level. Other ISPs attempted to create national brand names, focusing their attention on expanding their franchises or geographic reach.

In summary, the first few years of commercialization opened up a number of commercial opportunities. In the internet infrastructure market commercial firms quickly moved to fill the first of these, providing basic Internet access to business and homes. Rapid entry quickly arbitraged most of the large returns, raising many questions about the direction of change in the delivery of internet access. The open questions generally involve commercial issues about the viability of different business models, about the presence or absence of demand for specific services, and about durability of commercial opportunities for delivering new services. Due to the complexity and variety there is no single pattern for characterizing new Internet businesses. Moreover, the Web is inducing a great deal of new application development. Whole new business models are emerging for delivering and using data-related services.

C. Intermediation and the delivery of new services

A significant set of activities of many providers in the commercial internet market involve intermediary functions. Intermediary functions are activities where a vendor stands between unique user needs and a menu of uses for advancing or new technology. It is what studies of organizations label mediation services in fluid environments (e.g., Demsetz [1988], Spulber [1998]). This type of activity is also frequently labeled "adaptation."[6]

What activity comprises adaptation? Adaptation services involve one of several activities: Monitoring technical developments, distilling new information into components which are meaningful to unfamiliar users, and matching unique user needs to one of many new possible solutions enabled by advancing technical frontiers. Sometimes adaptation involves heavy use of the technological frontier and sometimes not. It depends on the user, their circumstances, their background, their capital investments, the costs of adjusting to new services and other factors which influence the match between user needs and technological possibilities. It involves both the general and the specific since it matches the technical frontier to specific needs of particular users in a unique location.

Adaptation does not happen on its own. In information technology, the agents of change typically come from one of several groups: end-users within an organization, professional staff (such as the MIS group) within an organization, or third party vendors outside the organization (Bresnahan and Greenstein, 1999). If the end-user or their staff does much of the adaptation activity, it becomes an extension of other operations and investments. In contrast, if third parties sell related services to users, adaption may take several different forms: equipment, consulting about business processes, or both.

What determines the rate and direction of adaptation activity by third parties, such as ISPs? In their theory of General Purpose Technologies (GPTs), Bresnahan and Trajtenberg [1995] place emphasis on the dispersion of access at locations, firms, and over time. That is, many

[6] Adaptation has long been a topic of discussion in the economics of technology and economic growth (Bresnahan and Trajtenberg [1995]), as well as in the management of technology (Hagerdorn, 1998). Studies of this behavior have antecedents in classic studies about diffusion and learning by Griliches [1957], Rosenberg [1977], Nelson and Winter [1982] and many others.

firms and locations face the same secular technological trends, hence they share similar technical factors. *Differences* across firms at any point in time, therefore, arise when decision makers face differences which create a variety of economic incentives for adapting Internet infrastructure to new uses and applications. These differences are associated with unique (and slow-to-change) location characteristics and unique (and usually historical) firm features.

More concretely, ISPs must purchase and install their own capital equipment, publicize brand and service agreements, and make other long-lasting investments. Many of these investments rely on firm experience and strength in other lines of business. Many of these investments depend on a firm's growth strategies, because they commit the ISP to a specific size, and to a geographic reach before market demand is realized or new commercial opportunities are recognized. Similarly, from the standpoint of an ISP, many of these features of local markets are exogenous, and place pressures on the ISP to provide services that meet local demand and to provide services similar to their nearest competitor. Notice that when an ISP only provides service for a small regional area, there is a sense in which locations-specific factors are not distinct from ISP-specific factors. For example, features of ISPs and the local region will both determine the value of the match between unique customers and new opportunities.

Some statistical evidence can be brought to bear on these patterns in the Internet access market. To characterize experiments in business models in a quantitative way, I and some research assistants examined the business lines of 3816 Internet service providers in the United States who advertised on *thelist* in the summer of 1998.[7] By definition, every ISP in this group provides some amount of dial-up or direct access and basic functionality, such as email accounts, shell accounts, IP addresses, new links, FTP and Telnet capabilities. These 3816 seem to under-represent both very small and quasi-public ISPs (e.g., rural telephone companies[8]). In addition,

[7] This site, maintained by Meckler Media, provides the opportunity for both large and small ISPs to advertise their services. See the appendix to Greenstein, 1999.

[8] From comparison with other sources, such as Downes and Greenstein [1998], *Boardwatch Magazine* and the National Telephone Cooperative Association directory on Internet Services in rural areas [NTCA, 1998], it appears that these 3816 ISPs are not a comprehensive census of every ISP in the country.

this sample does not examine firms who offer non-basic services but who do not offer basic access.

I grouped services into five broad categories: basic access, frontier access, networking, hosting, and web page design.[9] Table 1 includes lists of activities associated with each cateogory. These are:

- *Basic access* constitutes any service slower than and including a T-1 line. Many of the technologies inherited from the pre-commercial days were classified as complimentary to basic access, not as a new service.
- *Frontier access* includes any access faster than a T-1 line, which is becoming the norm for high-speed access to a business user. It also includes ISPs which offer direct access for resale to other ISPs or data-carriers.[10]
- *Networking* involves activities associated with enabling Internet technology at a user's location. All ISPs do a minimal amount of this as part of their basic service in establishing connectivity. However, an extensive array of these services, such as regular maintenance, assessment of facilities, emergency repair, and so on, are often essential to keeping and retaining business customers.
- *Hosting* is typically geared toward a business customer, especially those establishing virtual retailing sites. This requires the ISP to store and maintain information for its customers on the ISP's servers. Again, all ISPs do a minimal amount of hosting as part of basic service, even for residential customers (e.g., for email). However, some ISPs differentiate themselves by making a large business of providing an extensive array of hosting services, including credit-card processing, site-analysis tools, and so on.

[9] No product code exists for this industry, as it has grown faster than government statistical agencies can classify it. Greenstein [1999] defines such a code based on trade literature and magazines. See the appendix to that paper for precise definitions and several caveats.

[10] Speed is the sole dimension for differentiating between frontier and basic access. This is a practical choice. There are a number of other access technologies just now becoming viable, such as wireless access, which are slow but technically difficult. These were not many commercially available examples of them as of the summer of 1998.

● *Web Design* may be geared toward either the home or business user. Again, all ISPs offer some basic assistance in web page design and access. However, many offer additional extensive consulting services, design custom sites for their users, provide services associated with design tools and web development programs. Most charge fees for this additional service.

The main statistical findings are listed in table 1 for three different samples, including the original sample. These findings are also illustrated by Figures 1a and 1b. Table 1 also lists the most common phrases for each line of business. Of the 3816 firms in the original sample, 2295 (60.1%) have at least one line of business other than basic dial-up or direct Internet access. Table 1 shows that 1059 provide high speed access, 789 networking, 792 web hosting, 1385 web page design. There is some overlap (shown in Figure1): 1869 are in either networking, hosting or web design; 984 do only one of these three; 105 do all three and frontier access. Table 1 also shows the same propensities weighted by geographic size of firm, clearly showing that firms with greater geographic scope also tend to provide more services other than basic access. This reveals quite a lot of experimentation with non-access services by firms in the access business. (See Greenstein, 1999, for further detail).

These activities contain much more complexity and nuance than Table 1or Figure 1 can display. Firms come to new market opportunities with different organizational strengths and experience, and develop new services which complement those strengths. Firm founders make unique forecasts of demand for new services, take on idiosyncratic risks and develop new commercial opportunities, matching unique customer needs to new technical possibilities. Firms customize their services to the prevailing needs of local users, either in a business or residence. The costs of providing new services vary by region because necessary infrastructure, such as the quality of telecommunications switches and lines, or the thickness of labor markets for technical talent, differs by region.

More generally, ISPs customize Internet technologies to the unique needs of users and their organizations, solving problems as they arise, tailoring general solutions to idiosyncratic circumstances and their particular commercial strengths. Sometimes ISPs call this activity consulting, and charge for it separately, sometimes it is included as normal business practices. In

either case, it involves the translation of general knowledge about Internet technologies into specific applications which yield economic benefits to end-users. In all cases differences between their offerings and their nearest competitor's raise returns to innovative activity, inducing experimentation.

In summary, markets for Internet access involve experimentation with new business models, new cost structures and new applications. Like much other economic activity in high technology markets, not all firms are alike. As firms learn more about the relationship between the technical frontiers and user needs, their activities change, their services expand, and their efficiency improves. Like much experimental commercial activity, providing access involves a mix of the general technical knowledge, entrepreneurial guess work, and specific circumstances facing a particular firm in a particular place. If the economic opportunities are fleeting, then businesses grow quickly and die fast. If the economic opportunities are renewed frequently, then businesses can grow and adapt to take advantage of them.

3. The research agenda moving forward

There is considerable room for original and fundamental empirical research about the changing structure of electronic commerce. While this environment raises many challenges for future research, there is a regularity to patterns of behavior. This regularity helps frame many empirical research issues about changes to market structure. Sets of issues are summarize below under each of the three themes.[11]

A. Internet technology changes

Measuring changes to the technical possibilities frontier and to pricing: There is a well known literature in econometrics associated with hedonic estimation. This has been frequently employed to measure computing industry outcomes. This method provides some

[11] I am grateful to Tim Bresnahan for bringing some of these issues to my attention over the course of many years. These set of issues partially overlap with our literature review of user-oriented and valuation studies in information technology, as found in Bresnahan and Greenstein [1999].

insight into the rate of technical improvement in hardware across a class of products. It has also been useful for describing several complementary markets.[12] Since the internet equipment industry, like the rest of computing, has experienced a dramatic decline in price per unit of features, hedonic curves are a simple way to summarize that change over time. Hedonic techniques also account for changes in prices along the entire product line. This is one tool for focusing attention on improvement in upstream equipment and transmission facilities-- along a wide spectrum of sizes, applications and firms – which almost everything is getting better and cheaper. There has been less attention paid to product turnover – i.e., entry and exit of new designs as a transmission mechanism for diffusion of new technology – leaving considerable room for further empirical research on product cycles, generally.[13] These methods have yet to be applied to the wide class of equipment underlying electronic commerce.

Changes in the Geography of the provision of Internet Infrastructure: There is wide interest in understanding the Internet's geographic features, as they have consequences for the development of a "universally accessible" Internet, and for the locus of growth and economic development in a region.[14] These issues need data collection and new frameworks. The most commonly cited information on the geographic diffusion of the Internet comes from the Matrix Information and Demography Services (MIDS) of Austin, Texas, which has been analyzing the location of 'hosts', computers connected to the Internet. Yet, it is not clear that there is any relationship between location of host computers and access to Internet technologies for business and personal use, nor is there any necessary relationship to degrees of economic advance in the

[12] There are many estimates of price changes in computing using hedonic estimates (e.g., Triplett [1989], Dulberger [1989], Gordon [1989], Berndt et al [1995]]. Recent research suggests that many of the same trends are found in PC software [Gandal [1994], Brynolffson and Kemerer [1996], Groehn, 1999] and disk drives (Lerner, 19950. On communications and transmission equipment see Flamm, 1989, 1998 and also Aron, et al., 1998. For some reservations on the use of hedonic estimation, see Bresnahan and Greenstein, 1998 or Triplett, 1989, especially.

[13] For example, see Stavins, 1995, Greenstein and Wade, 1998, de Figueiredo and Kyle, 1999.

[14] See, e.g., Moss and Townsend [1996, 1998], Moss and Mitra [1998], Greenstein, Lizardo and Spiller [1997], Downes and Greenstein [1998].

region. Considerable more work is possible here, which geographers have begun to investigate.[15]

B. Variation in economic activity

Variation in business models: Does the availability of new services differ across regions of the United States? Across time? Investment in digital infrastructure induces entry of complementary goods or it produces demand-enhancement which differs by company and region. Aside from those identified in the example above, there is room for many more studies of the determinants of differences in the form of commercializing electronic commerce. This topic is difficult partly because the key issues resist data-collection, requiring that researchers measure adaptation expenses, how the benefits from new technology get captured by the business, and how these benefits are distributed to the purchasers of the final products. There seems to be opportunities to arbitrage between the broad knowledge of consultants and the specific needs of academics and policy makers.[16]

Variation in user requirements at the home: Some statistical research has analyzed the patterns of adoption of IP technologies for non-business use.[17] This is clearly an important determinant of industry structure in electronic commerce, as the diffusion of so many business models and new applications presumes ubiquity or an experienced user base. Yet, adoption and use of the internet at home depends on historical or previous investments, particularly in such key infrastructure such as PCs, cable lines and local digital phone equipment. That is, the diffusion of

[15] See http://www4.mids.org/. Also, see http://www.cybergeography.com/atlas/atlas.html for cyber-geography and for international commercial statistics, see http://www.telegeography.com/.

[16] There is a long list of commercial firms with active research programs in characterizing business models in electronic commerce at a national or international level, including Juliussen and Juliussen, Forester, the Maloff group, Jupiter Communications, Ziff-Davis, IDG, Boardwatch, Meckler Media, Gartner Group, and many more.

[17] Some recent contributions include Kridel, et al [1997], Goolsbee and Klenow [1999], or Goolsbee [1999]. Also, see Clement [1998] or Maloff [1997].

electronic commerce is "nested" within a family of other diffusion[18], which had historical determinants only loosely connected to the diffusion of electronic commerce. These were determined by many factors, such as the age, income and profession of residents of a household, as well as the conditions of schools, libraries and retail service facilities in a local region.

Variation in user requirements in business: The literature has made interesting progress on the determinants of adoption of new IT in business.[19] These studies could be extended to many of the open questions about the relationship between the diffusion of electronic commerce and its benefits/costs to specific users, especially in different types of business activities. Some buyers may be waiting for adaptation costs to decline, which occurs as the supply of complementary goods increases. In computing, for example, the costs of transition from old technology to new were much higher in complex organizations with idiosyncratic applications. These costs slowed adoption of new technology by some of the very firms who could benefit most from it, inducing a potentially long lag between the invention of new capabilities and their use. These explanations may provide a framework for understanding development of new services in such key industries, such as financial services, transportation and print and publishing.

C. The evolution of intermediary functions

Markets for adaptation services: It would also be interesting to examine the pricing, business models and success of the custom software and related services in a variety of applications to electronic commerce – how effective are they in making adaptions to local conditions and why? Did national firms need to change their sale, service and organizations to try to commercialize this new opportunity? Similarly, there is a need to examine the ability of companies to find and use programmers in their local markets, or enterprises' ability to deploy

[18] See, e.g., Jimenez and Greenstein [1998].

[19] See, e.g., Brynjolfsson and Hitt [1997] on the degree of centralization or decentralization within corporation, Hubbard [1998] on the use of computing and global-position-systems for coordination benefits, Bresnahan and Greenstein [1997] examine the idiosyncratic factors slowing down/speeding up diffusion of networked IT at mainframe users.

managers in the kinds of roles required by new IT. While most data do not directly measure adaptation activity, such activity may leave shadows in features of software, labor practices, management policies, changing job definitions, wages and output qualities. Further studies of the organization of the software industry, training, labor practices, and other adaptation activities would be very useful.[20]

Intermediaries, local economic growth and subsides: The diffusion of an internet technology is largely shaped by the geographic diversity of local markets and the heterogeneity of firms who commercialize that technology. This dispersion shapes the customization of technology to new users and established businesses. This process is central to the understanding of economic growth, especially as electronic commerce influences information-intensive activities within firms, such as inventory management, sales and distribution and other coordinative activities.[21] It is also a source of great policy concern in the telecommunications industry, as this relationship shapes the creation and targeting of subsidies associated with new services at schools, libraries and hospitals, as proposed in the 1996 Telecommunications Act.[22] If the lower propensity to find new services in low-density areas is due to an absence of local firms with appropriate skills, then policies might either induce commercial firms to expand from high-density areas to low density areas, or they must induce incentives/vision/investments from other stake-holders who are already located in low-density areas If, on the other hand, the absence of new services in low-density areas is due to an absence of local demand for these services or the absence of local infrastructure, subsidies run the risk of not changing the propensity to experiment in such areas. Indeed, in that case, the subsidy can be very wasteful if it induces the offering of services which few want.

---

[20] For example, Mowery [1998], Siwek and Furchtgott-Roth[1998], Autor [1999], are steps in this direction.

[21] For recent contributions, see, e.g., Roller and Waverman [1997], Moss and Townsend [1998, 1999], Greenstein, Lizardo and Spiller [1998], Greenstein [1999].

[22] This is a growing literature and a topic that is far from settled. For recent contributions, see Werbach [1997], Esbin [1998], Weinberg,[1999], and for the perspective of rural telephone companies, Garcia and Gorenflo [1998].

Restructuring of intermediary functions: Many observers forecast that TCP/IP will lead to radical restructuring of the formats for, and delivery of, final goods which are information-intensive, such as music or radio, telephony, broadcast television, video gaming, newspapers, magazines and other print media. Some of this restructuring is symptomatic of the upheaval that is typical of high-technology industries, raising many strategic issues for investors and managers, but no substantive issues for policy makers. Some of it raises issues where regulated monopolies interact with otherwise competitive market environments. There is a need for frameworks and data to understand the key determinants of market structure: the entry and exit of new firms; the vertical ownership over, and horizontal concentration of, key assets; the persistence of old services and resistance of incumbent firms to new services, and so on. However, unlike many of the other topics just raised, this area has already attracted considerable attention from researchers, as it overlaps with traditional regulatory concerns regarding the ownership of key assets in the delivery and transmission of information. Indeed, this literature is too large to summarize here. That said, if the past is any predictor of the future, the demand for empirical research on related topics will exceed the supply for the foreseeable future.

4. Conclusion

This paper provides a framework, illustrative example, and a guide for future empirical research. Viewing the Internet access market with this framework helped us understand the explosive events just after the commercialization of the Internet. The technology underlying Internet incubated in research laboratories but today's commercial industry has propelled it into common use. The incubation of Internet technology in an academic setting did not totally prepare it for the set of activities in a non-academic setting. These adaptations are hard to do, and the translation into commercial use requires many adaptative activities. These reflect firm-specific capabilities and entrepreneurial guesses about the appropriate services to offer and about location-specific demands for particular services.

This paper has taken just one of many steps towards framing empirical guidelines for analyzing the developments in electronic commerce. The papers' themes provide a framework for

summarizing key issues for empirical research into structural change in electronic commerce. The study identifies many different areas where fundamental research is possible and desirable.

In closing it is also worth noting that the nexus of this paper's three themes identifies a particularly vexing and important set of policy issues. That is, electronic commerce will undergo considerable change in the next decade as firms respond to better information about demand and the emergence of new technical capabilities. Society benefits from the intermediary activities that firms pursue and from the variety of ways different firms try to meet user needs. In other words, it is precisely that juncture of variety and mediation which keeps observers guessing about the direction of structural change in commercial markets, and which raises the value of empirical research that tries to understand it.

References

Aron, Debra, Ken Dunmore, and Frank Pampush [1997], "The Impact of Unbundled Network Elements and the Internet on Telecommunications Access Infrastructure," Working paper for the Harvard Information Infrastructure Project, http://ksgwww.harvard.edu/iip/Papers/

Autor, David H. [1998], "Why do Temporary Help Firms Provide Free General Skills Training?" unpublished dissertation chapter, Harvard University, 1998.

Berndt, Ernst R; Griliches, Zvi; Rappaport, Neal .J [1995], "Econometric estimates of price indexes for personal computers in the 1990's," *Journal of Econometrics*; July.

Boardwatch [1997], *March/April Directory of Internet Service Providers*, Littleton, CO.

Bresnahan, T. F. [1987], "Measuring the Spillover from Technical Advance: Mainframe Computer in Financial Services," *American Economic Review*, March. pp 742-755.

Bresnahan, Timothy, and Shane Greenstein [1997], "Technical Progress and Co-Invention in Computing and in the Use of Computers." *Brookings Papers on Economics Activity: Microeconomics*, Pp. 1-78.

– [1999], "Technological Competition and the Structure of the Computing Industry," *Journal of Industrial Economics*, Winter.

– [1998], "The Economic Contribution of Information Technology: Value Indicators in International Perspective." Organization for Economic and Cooperative Development. Also available at http://skew2.kellogg.nwu.edu/~greenste/research.html

Bresnahan, Timothy, Scott Stern, and Manuel Trajtenber [1997], "Market Segmentation and the Source of Rents from Innovation: Personal Computers in the late 1980s," *Rand Journal of Economics*, 28, pp. s17-s44.

Bresnahan, Timothy and Manuel Trajtenberg [1995], "General Purpose Technologies: Engines of Growth?" *Journal of Econometrics*, 65, pp. 83-108.

Brynjolfsson, Erik and Lorin Hitt [1996], "Paradox Lost? Firm-Level Evidence on the Returns to Systems Spending", *Management Science*, v 42, n 4, pp. 541-558.

Brynjolfsson, Erik, and Lorin Hitt [1997], "Information Technology as a Factor of Production: The Role of Differences Among Firms", Mimeo, Cambridge, MA., Massachusetts Institute of Technology.

Brynjolfsson, Erik, and Kemerer [1996], Network Externalities in Microcomputer Software: An Econometric Analysis of the Spreadsheet Market," *Management Science*, 42(12), pp. 1627-47.

Clemente, Peter C. [1998], *The State of the Net: the New Frontier*, McGraw-Hill, New York.

de Figueiredo, John, and Margaret K. Kyle [1999], "Product Entry and Exit in the Desktop Laser Printer Industry," mimeo, MIT Sloan School of Management.

Demsetz, Harold [1988], "The Theory of the Firm Revisited," *Journal of Law, Economics, and Organization*, **4**, 159-178.

Downes, Tom, and Greenstein, Shane [1998], "Do Commercial ISPs Provide Universal Access?" in (Ed) Sharon Gillett and Ingo Vogelsang, *Title?*, Lawrence Elbaum Press.

– [1999], "Universal Access and Local Commercial Internet Markets," mimeo, http://skew2.kellogg.nwu.edu/~greenste/research.html

Dulberger, Ellen R. [1993], "Sources of Price Decline in Computer Processors: Selected Electronic Components", in Foss, Murray F.; Manser, Marily E.; Young, Allan H., (eds.), Price Measurements and their Uses.

Dulberger, Ellen [1989], "The Application of a Hedonic Model to a Quality Adjusted Price Index for Computer Processor," in (eds), Dale Jorgenson and Ralph Landau, *Technology and Capital Formation*, MIT Press, Cambridge MA.

Flamm, Ken [1990] chapter in, Robert W. Crandall and Kenneth Flamm, eds., *Changing the Rules: Technological Change, International Competition, and Regulation in Communications.*

Esbin, Barbara [1998], *Internet over Cable, Defining the Future in Terms of the Past*, FCC, Office of Planning and Policy Working Paper 30, August.

Gandal, Neil [199], "Hedonic Price Indexes for Spread Sheets and a Test of Network Externalities," *Rand Journal of Economics*, 25(1), pp. 160-70.

Garcia, D. Linda and Gorenflo, Neal [1997], "Best Practices for Rural Internet Deployment: The Implications for Universal Service Policy," Prepared for 1997 TPRC, Alexandria, VA.

Goolsbee, Austun [1999], "In a World without borders: The Impact of Taxes on Internet Commerce," mimeo, University of Chicago.

Goolsbee, Austin, and Peter Klenow [1999], "Evidence of Learning and Network Externalities in the Diffusion of Home Computers," Mimeo, University of Chicago.

Gordon, Robert J. [1989], "The Postwar Evolution of Computer Prices", in *Technology and Capital Formation*, edited by Dale W. Jorgenson and Ralph Landau, MIT Press.

Greenstein, Shane, Mercedes Lizardo and Pablo Spiller [1997], "The Evolution of the Distribution of Advanced Large Scale Information Infrastructure the United States". NBER Working Paper #5929.

Greenstein, Shane [1999], "Building and Developing the Virtual World: The Commercial Internet Access Market." http://skew2.kellogg.nwu.edu/~greenste/research.html

Greenstein, Shane and Jim Wade [1998], "The Product Life Cycle in the Commercial Mainframe Computer Market, 1968-1983," Rand Journal of Economics. Winter.

Griliches, Zvi. [1957], "Hybrid corn: An exploration in the economics of technological change," *Econometrica*, 25, 501-522.

Groehn, Andreas [1999], "Network Effects in PC Software: An Empirical Analysis," Mimeo, National Bureau of Economic Research, Cambridge, MA.

Hagerdorn, Andrew B., [1998], "Firms as Knowledge Brokers: Lessons in Pursuing Continuous Innovation," *California Management Review*, Volume 40, No 3, Spring.

Hubbard, Thomas [1998], "Why are Process Monitoring Technologies Valuable? The Use of Trip Recorders and Electronic Vehicle Management Systems in the Trucking Industry", Mimeo, UCLA.

Jimeniz, Ed, and Shane Greenstein [1998], "The Emerging Internet Retailing Market as a Nested Diffusion Process," *International Journal of Innovation Management*,V2, N3.

Juliussen, Karen Petska, and Juliussen, Egil [1998], *The Internet Industry Almanac*, Austin, TX: The Reference Press.

Kalakota, Ravi, and Whinston, Andrew [1996], *Frontiers of Electronic Commerce*, Addison-Wesley, Reading, MA.

Kolstad, Rob [1998], "Becoming an ISP," *www.bsdi.com.* January.

Kridel, Donald, Rappaport, Paul and Lester Taylor [1997], "The Demand for Access to Online Services and the Internet", Mimeo, PNR Associates, Jenkintown, PA.

Leida, Brett [1997], “A Cost Model of Internet Service Providers: Implications for Internet Telephony and Yield Management,” mimeo, MIT, Departments of Electrical Engineering and Computer Science and the Technology and Policy Program.

Lerner, Josh [1995], "Pricing and Financial Resources: An Analysis of the Disk Drive Industry, 1980-88," *Review of Economics and Statistics*, 77, pp 585-98

Maloff Group International, Inc.[1997], “1996-1997 Internet Access Providers Marketplace Analysis,” Dexter, MO, October.

Meeker, Mary, and Chris Depuy [1996], *The Internet Report*, Harper Business, New York.

Mitchell L. Moss and Steve [1998], "Mitra Net Equity: Class Divisions Emerging on the Net," Taub Urban Research Center, New York University, http://www.nyu.edu/urban/research/internet.

Moss, Mitchell L. and Anthony Townsend [1996], “Leaders and Losers on the Internet”. Taub Urban Research Center, New York University, http://www.nyu.edu/urban/research/internet.

– [1998], "Spatial Analysis of the Internet in U.S. Cities and States," Taub Urban Research Center, New York University, http://www.nyu.edu/urban/research/internet.

Mowery, David [1996], *The International Computer Software Industry: A Comparative Study of Industry Evolution and Structure*, Oxford University Press, New York.

Nelson, R.R. and S.G. Winter [1982], *An Evolutionary Theory of Economic Change*, Cambridge, MA: Belknap Press.

Northrup, Anthony [1998], *NT Network Plumbing, Routers, Proxies and Web Services*, IDG Books Worldwide, New York.

NTCA [1998], *Membership Directory and Yellow Pages*, National Telephone Cooperative Association, Washington DC.

Roller, H. and L. Waverman [1996], “Endogenous Growth and Telecommunications infrastructure Investment”, mimeo, Organization for Economic Cooperation and Development, May 1994.

Rosenberg, Nathan [1977], *Perspectives on Technology*, Cambridge University Press, Cambridge, UK.

Rybaczyk, Peter [1998], *Novell's Internet Plumbing Handbook*, Novell Press, San Jose.

Siwek, Stephen E., and Harold W. Furchtgott-Roth [1997], *International Trade in Computer Software*, Quorum Books, Westport, CT.

Spulber, Daniel [1998], *The Market Makers, How Leading Companies Create and Win Markets*, McGraw-Hill, New York.

Stavins, Joanna, 1995, " ", *Review of Economics and Statistics*, November.

Trajtenberg, M. [1990], *Economic Analysis of Product Innovation*, The Case of CT Scanners, Harvard University Press, Cambridge MA.

Triplett, Jack [1989], "Price and Technological Change in a Capital Good: A Survey of Research on Computers," in (eds), Dale Jorgenson and Ralph Landau, *Technology and Capital Formation*, MIT Press, Cambridge MA.

Ventresca, Mark, Rodney Lacey, Michael Lounsbury, and Dara Szyliowicz [1998], "Industries as Organizational Fields: Infrastructure and Formative Dynamics in U.S. Online Database Services," A Working Paper in the "Business and Government" Series of the Institute for Policy Research, Northwestern University.

Weinberg, Jonathan [1999], "The Internet and Telecommunications Services, Access Charges, Universal Service Mechanisms, and Other Flotsam of the Regulatory System," *Yale Journal of Regulation*, Spring.

Werbach, Kevin [1997], "Digital Tornado: The Internet and Telecommunications Policy," FCC, Office of Planning and Policy Working Paper 29, March.

Table 1
Product lines of ISPs

Category definition	Most common phrases in category	Weighted by service territory *	Original Sample
Providing and servicing access though different channels	28.8, 56k, isdn, web TV, wireless access, T1, T3, DSL, frame relay, e-mail, domain registration, new groups, real audio, ftp, quake server, IRC, chat, video conferencing, cybersitter TM.	28967 (100%)	3816 (100%)
Networking Service and maintenance	Networking, intranet development, WAN, co-location server, network design, LAN equipment, network support, network service, disaster recovery, backup, database services, novell netware, SQL server	8334 (28.8%)	789 (20.6%)
Web Site Hosting	Web hosting, secure hosting, commercial site hosting, virtual ftp server, personal web space, web statistics, BBS access, catalog hosting	8188 (28.2%)	792 (20.7%)
Web Page Development and Servicing	Web consulting, active server, web design, java, perl, vrml, front page, secure server, firewalls, web business solutions, cybercash, shopping cart, Internet marketing, online marketing, electronic billing, database integration	13809 (47.7%)	1385 (36.3%)
High Speed Access	T3, DSL, xDSL, OC3, OC12, Access rate > 1056k	15846 (54.7%)	1059 (27.8%)

* Unit of observation is ISP-Area codes, as found in *thelist.* For example, if an ISP offers local dial-up service in 29 area codes, it will be 29 observations. If that same ISP offers high speed access then it will count as 29 cases of high speed access.

Figure 1a
Experiments with new services by ISPs without frontier access technology

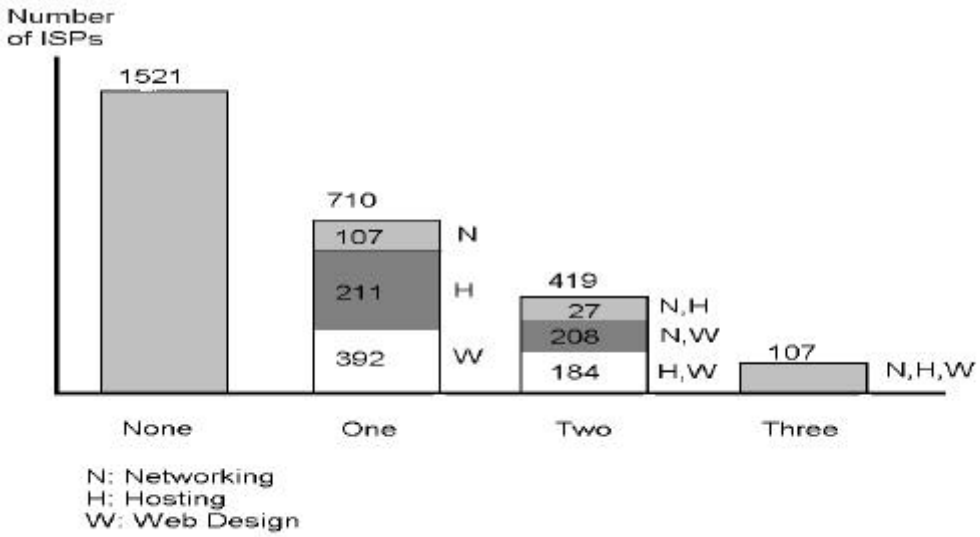
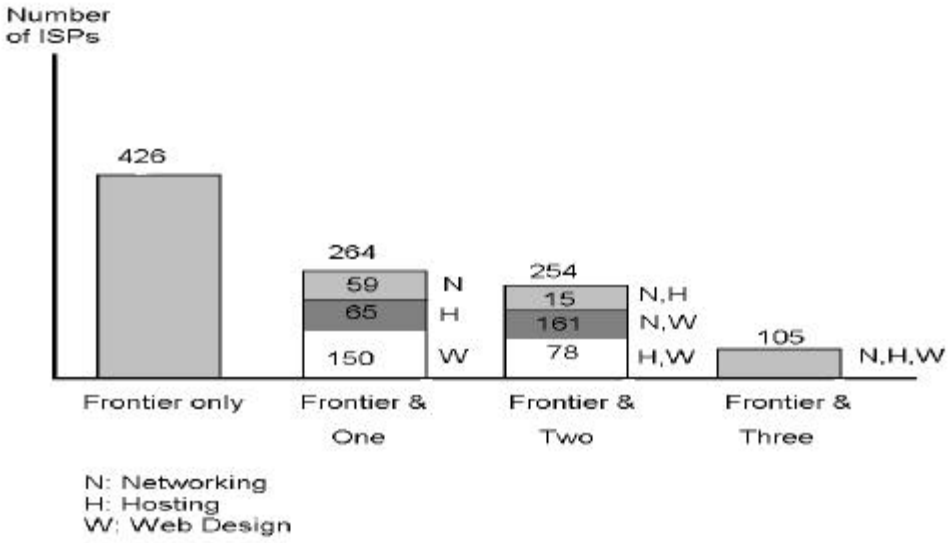
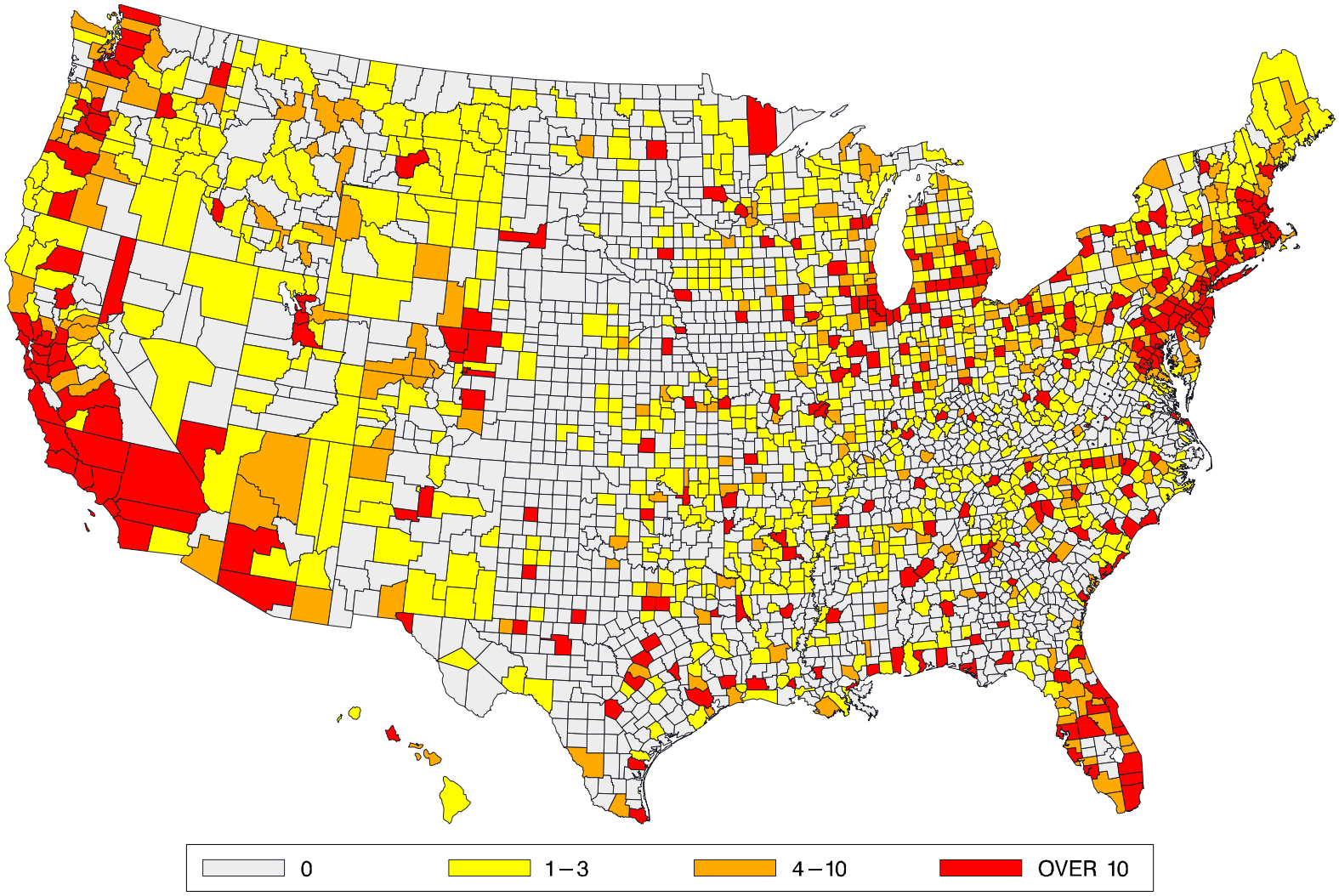


Figure 1b
Experiments with new services by ISPs with frontier access technology



Distribution of ISPs
September 1996



Distribution of ISPs
October 1998