Building and Delivering the Virtual World: Commercializing Services for Internet Access

By Shane Greenstein*

June 9, 1999

This study analyzes the service offerings of Internet Service Providers (ISPs), the leading commercial suppliers of Internet access in the United States. It presents data on the services of 3816 ISPs in the summer of 1998. By this time, the Internet access industry had undergone its first wave of entry and many ISPs had begun to offer services other than basic access. This paper develops an Internet access industry product code which classifies these services. Significant heterogeneity across ISPs is found in the propensity to offer these services, a pattern with an unconditional urban/rural difference. These findings motivate estimation of models of the decision to offer non-basic access services, where the models distinguish between firm-specific and location-specific determinants. Most of the explained variance in behavior arises from firm-specific factors, with only weak evidence of location-specific factors for some services. There is a strong relationship between some, but not all, of the determinants of these services. This findings provides a window on the process of economic growth and business development in Internet infrastructure technologies.

---

* Associate Professor, Kellogg Graduate School of Management, Northwestern University. I would like to thank 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, Nancy Rose and Dan Spulber for useful conversations and to seminar audiences at the Federal Research Board Research Division in Washington DC, UC Berkeley, Northwestern and the conference on Competition and Innovation in the Personal Computer Industry. Angelique Augereau and Chris Forman provided outstanding research assistance. The results and discussion in this paper subsumes all discussion found in an earlier working paper entitled "Providing Access to More than Access: Services in the Commercial Internet Access Market." All errors are mine.

1. Introduction

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. While these events have unleashed media hype about new ways of doing business in the information age, little statistical research supports, refutes or documents how commercial processes translate Internet technologies into economic value.

This study sheds light on these processes by analyzing the services at 3816 Internet Service Providers (ISPs) in the summer of 1998. Commercial providers account for 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 three year old industry.

Services from ISPs, the focus of this study, are an excellent example of how Internet technology had to be packaged in order to provide value to commercial users. When the Internet first commercialized it was relatively mature in some applications, such as e-mail 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, a typical pattern for new information technology (Bresnahan and Greenstein, 1999). 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 less technically sophisticated user.

Many ISPs pursued distinct approaches to developing commercial opportunities, which industry commentators labeled "different business models." This variety arose because, 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. In every major urban area in the US hundreds of ISPs built, operated, and delivered Internet applications, tailoring their network offerings to local market conditions and entrepreneurial hunches about growing demand. Not surprisingly, in the first three years after the commercialization of the Internet, the products changed frequently, many firms

changed strategies, and the market did not retain a constant definition.

This study investigates the propensity of an ISP to offer services other than routine and basic access. These services represent the response of private firms to new commercial opportunities and technical bottlenecks. More generally, such behavior is part of what Bresnahan and Trajtenberg [1995] call co-invention, the complementary invention which makes advances in general purpose technology valuable in particular places at particular points in time. It is an essential part of translating technology into economic growth. Empirical studies of such behavior in IT markets are rare because of numerous challenges for empirical analysis.

I investigate four types of services: frontier access, networking, hosting and web design services. Because no government agency, such as the Census or the Bureau of Labor Statistics, has yet to completely categorize these services, this study is the first economic analysis to develop and employ a novel Internet access product code. This categorization establishes a common language for understanding experiments with new services, translating many technically obscure complementary commercial services into concrete terms accessible to a general reader. This classification leads to the first-ever documentation of two important patterns: first, there is no uniformity in ISPs' experiments with non-basic access services; second, the propensity to offer new services shows both a notable urban/rural difference and large/small firm difference. These findings are, by themselves, important to on-going policy discussions about the development of the Internet infrastructure market.

The paper next estimates several models of the determinants of an ISP's decision to offer non-basic services. Similar to the framework employed by Bresnahan, Stern and Trajtenberg, [1997], it views an ISP's choices as an attempt to differentiate from common competitors, where these returns may be temporary if competitors eventually learn to provide close substitutes. It goes further by dividing determinants into two classes, location-specific factors or firm-specific factors, a distinction which is relevant to policy debates about Internet infrastructure development and economic growth. In particular, the empirical model focuses on understanding why ISPs offer a variety of services. Does variety arise primarily from firm-specific or location-specific determinants? Stated simply, do ISPs offer different services because the determinants of these choices vary between services or between locations?

The findings have many implications for economic growth in internet infrastructure technologies and for policies guiding that growth. The analysis finds that firm-specific determinants are pivotal to the offering of non-basic services. These include measures of a firm's size, geographic scope, investments and

focus on non-technical users. It finds only weak evidence of location-specific determinants in the network maintenance and web design services, and very little with high speed access or hosting. Networking and web design share many common market features, while high speed access and hosting share other determinants. In sum, the explainable part of the geographic dispersion of ISP experimentation is largely determined by the geographic dispersion of the ISP-specific determinants of experimentation.

Explaining the variety of approaches firms take to developing technology-intensive markets has long been a topic of discussion in the economics of technology and economic growth. 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. It is also what studies of organizations label mediation services in fluid environments (e.g., Demsetz [1988], Spulber [1998]). Unlike Bresnahan and Greenstein [1997] or Brynolffson and Hitt [1997], which were among the first to empirically examine these adjustment processes in information technology markets, this study does not examine users' behavior. Rather, this study focuses attention on vendors' attempts to construct viable and on-going economic entities using new technology in an evolving market place. Seen in this light, this paper is among the first to classify and analyze the determinants of co-invention from third party vendors in Internet technology markets.

2. The Internet Access Business after Commercialization

Internet technology is not a single invention, diffusing across time and space without changing form. Instead, it is a suite of communication technologies, protocols and standards for networking between computers. This suite is not valuable by itself. It obtains economic value in combination with complementary invention, investment and equipment. How did Internet technology arise and how did these origins influence the commercialization of the technology?

A. The Origins of Internet Technology

By the time of commercialization, Internet technology was a collection of (largely) non-proprietary *de facto* standards for the development 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 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. 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 became 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 (though some alternatives were also under experimental use at the time). 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. Mosaic was widely circulated as shareware in 1993-94 and quickly became a *de facto* standard, exposing virtually the entire academic community to the joy of sending pictures. The commercial browsers that eventually came to dominate non-technical use, Netscape and Internet Explorer, sprang from these technical beginnings.

B. The Incubation of Complementary Internet Technology

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.

The explosion of activity in 1994-95 caught many mainstream and potential market participants by surprise, though it is easy to understand in retrospect. The early users were scientists and engineers, primarily in higher education and laboratories. The issues found in such a setting differs significantly from those found during the deployment in a business or at home.

The founding of Netscape highlighted the large commercial opportunity, ending all the doubts among fence-sitters in the computing and telecommunications industry.[2] 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 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 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-technical users. This involved building access for business and home users. It also involved solving problems associated with customizing TCP/IP to networks in many different locations running many distinct applications. 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 other services to users outside the academic or research environment? What services would users be willing to pay for and which services could developers provide at low cost?

C. Adaptation Activity in the Internet Access Market after Commercialization

As it turned out, 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 a toll free number) at different speeds, or direct access to a business's server using one of several high-speed access technologies. Within three years the

[2] While a commercial version of something such as the Internet had been under discussion by technology futurists for some time, the founding of Netscape made their predictions plausible to the mainstream computer and telecommunications industry executive. 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.

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 (see Downes and Greenstein [1998] for detail). As of 1998, less than 10% of U.S. households and virtually no business get Internet access from university-sponsored ISPs (Clemente [1998]).

In retrospect, several economic factors shaped this entry. 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.[3] Some familiarity with the non-proprietary standards of the web was required, but not difficult to obtain. Because so many students had used the technology in school, and because the standards were non-proprietary, anyone with some experience could use them or learn them quickly. As a result, a simple dial-up service was quite cheap to operate and a web page was quite easy to develop (Kolakota and Whinston [1997]).

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 in virtually any location.

By 1998 different ISPs had chosen distinct approaches to developing access markets, offering different combination of services. Why did this variance arise? Answering these questions provide a window on the factors shaping adaptation activity in Internet Technologies.

3. Determinants of Business Models in Technology-Intensive Markets

Standard economic analysis offers a number of explanations for why different firms pursue different strategies for adapting to the diffusion of a general purpose technology. As emphasized in Bresnahan, Stern and Trajtenberg, [1996], one way to frame such an empirical investigation 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

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

businesses and so on. Such differentiation may arise as a response to firm-specific or user-specific 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, though the framework also needs modification to account for important features of Internet infrastructure markets. Entry into many locations had extensively developed the "basic access" market, the first and most obvious adaptation of Internet technologies to commercial use. Due to this extensive entry, the private returns to basic access services in most locations had almost entirely been competed away by 1998. Thus, super-normal private returns, if they existed at all, existed in differentiating from basic access.

From the viewpoint inside a firm, what an ISP does in a particular market situation is an strategic question. In contrast, what all firms do across the country is an empirical economic question. This study uses the industry discussion of strategy as a basis for understanding market wide behavior. That is, industry trade publication distinguish between two types of activities other than basic access.

- *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. Accordingly, this type of type of commercial offering has generated much policy interest (Esbin, 1998).

- *Offering services that are complementary to basic access:* Providing additional services became essential for retaining or attracting a customer base. Many ISPs instead tried to develop additional services, such as web-hosting, web-design services and network maintenance for businesses. Any of these were quite costly, as they had to be properly assembled, maintained, and marketed. Because many of these services push the boundaries of existing telecommunications and computing market definitions, these too have generated much policy interest (Werbach, 1997).

Which factors determined the provision of non-basic access services? In their theory of general purpose technologies and co-invention, Bresnahan and Trajtenberg [1995] place emphasis on the dispersion of factors that change incentives at different locations, between firms, and over time. That is, many firms and locations face the same secular technological trends, hence they share similar technical factors. Suitably altered to this study's situation, this framework predicts that *differences* across firms at any point in time (or over time) arise when decision makers face different incentives arising from differences in demand conditions, differences in the quality of local infrastructure, differences in the thickness of labor

markets for talent, or differences in the quality of firm assets. These create a variety of economic incentives for adapting Internet infrastructure to new uses and applications.

How does one measure these determinants of variety? For all intent and purposes in this study, the theory of co-invention is consistent with two measurable classes of determinants of differences in the propensity to experiment:

- *Firm-specific factors:* Two types of theories highlight firm-specific factors. The "resource-based view of the firm" emphasizes that firms come to new market opportunities with different organizational strengths and experience. Different experience provides firms with differential abilities to develop new services. The literature on "mediation" emphasizes how 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. These two theories hypothesize a link between historical/idiosyncratic features of the ISP and differences in an ISP's propensity to experiment. That is, 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 investment commit the ISP to a specific size for a short period and commit an ISP to a specific geographic reach before market demand is realized or new commercial opportunities are recognized.

- *Location-specific factors:* Three theories highlight the importance of location-specific factors. "Demand-pull" theory predicts that firms customize their services to the prevailing needs of local users. Incentives will not be uniformly distributed across space because users with similar preferences are not uniformly distributed across space. Another set of theories, based on many studies of regional growth, emphasize that the costs of providing new services may 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. Third, "competitive-inducement" theories emphasize that the competitive environment faced by the ISP will influence behavior, and this too will differ across regions. These three theories hypothesize that there will be differences in ISP behavior linked to features of regions. That is, from the standpoint of an ISP, many of these local features of markets are exogenous, and place pressures on the ISP to provide services that meet local demand and to provide services similar to their nearest local competitor.

Notice that the ISPs who provides service at many urban locations across the nation all face the

same location specific factors, so the main determinant of their offering will be firm-specific factors. In contrast, when ISPs who only provides service for a small regional area may differ due to both firm-specific and location-specific factors. Each ISP may have factors unique to it, but there is also a possibility that differences in service offerings may be associated with services tailored to customers located in different types of areas.

A. Generating the Original Sample

To characterize the offering of service in a quantitative way, I and some research assistants examined the business lines of 3816 Internet service providers in the United States who advertise on *thelist* (see Appendix I and II for details). This site, maintained by Meckler Media, provides the opportunity for both large and small ISPs to advertise their services. ISPs fill out a questionnaire where the answers are partially formatted, then the answers are displayed in a way that allows users to compare different ISP services.

This group of 3816 ISPs will be called the "original sample." This study also contains additional information for a subset of them labeled the "analysis sample." This group has 2089 ISPs. Its construction will be described in detail below. Virtually every firm in the original and analysis samples 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.

From comparison with other sources, such as *Boardwatch*, *thedirectory* 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. The Downes and Greenstein [1998] sample of the ISP market in the spring of 1998, which is constructed primarily from information culled off *thedirectory*, found over 6100 ISPs in the United States. These 3816 seem to under-represent ISPs in small towns (e.g., where advertising on the web is not necessary) and quasi-public ISPs (e.g., rural telephone companies[4]). In addition, this sample does not examine firms who offer non-basic services but who do not offer basic access. That said, it does contain many observations from small firms,

[4] NTCA [1998] shows hundreds of rural telephone companies provide basic Internet services to their local areas, but it does not specify the extent of those services (for a further survey see, e.g., Garcia and Gorenflo [1998]). Some of these rural telephone companies do advertise their services in either *thelist* or *thedirectory*, but a substantial fraction (> 50%) do not.

from ISPs in rural areas and from virtually all the mainstream ISPs from whom the vast majority of Internet users in the United States get their access.

B. Classifying the Services of ISPs

The first goal is to classify the activities of Internet access firms. No product code exists for this industry, as it has grown faster than government statistical agencies can classify it. Based on trade literature and magazines, I grouped services into five broad categories: basic access, frontier access, networking, hosting, and web page design (See appendix II for the product code).

- *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; it also includes ISP who offer parts of their own "backbone" as a resale to others.[5]

- *Networking* involves activities associated with enabling Internet technology at a users 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. Note, as well, that some of these experimental services could have been in existence prior to the diffusion of Internet access; it is their offering by an Internet access firms that makes them a source of differentiation from other ISPs.

- *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 access 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.

[5] 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. Only a small number of firms in this data are offering these services and these are coincident with offering high speed access.

- *Web Design* may be geared toward either the home or business user. Again, many ISPs offer some passive assistance or help pages on web page design and access. However, some 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.

Other services were put into four other groups: traditional computing services (e.g., PC sales and service), traditional telecommunications (e.g., cellular phone sales and service), consulting, and miscellaneous services (e.g., copying, cafes and photography). While in practice these last four were less common, the non-access lines of business of ISPs will be useful. For the most part, if an ISP advertises this business service, this was this firm's primary business before the firm became an ISP.

Descriptions of each ISP's services on *thelist* was classified into standard "phrases" which are then mapped to particular services at particular ISPs. In other words, an ISP offers networking services if that ISP uses one of the “phrases” which corresponds to networking activity. Similar exercise followed for hosting, web design, frontier access and so on. An ISP could be in more than one service. Table 1 lists the most common phrases for each line of business. (The entire list of phrases and the correspondence table are available from the author on request. See the Appendix II for the product code.)

In general, these methods should *undercount* the offering of any particular service line since many phrases were uninformative. In other words, this method will only record a service line if the ISP clearly states it as such .[6] In addition, the lines between different services are often, but not always, sharp. This warrants a cautious interpretative approach, because ambiguities in definitions naturally arise.

By definition, every ISP has at least one useful phrase indicating activity in the access business. On average, an ISP had 8.6 useful phrases (standard deviation of 4.6, maximum of 40). The main statistical findings from applying the classification scheme are listed in Table 1 for three different samples, including the original sample. These findings are also illustrated by Figures 1a and 1b.

[6] The approach depended on the ISP describing in concrete terms the businesses they offer. For example, no additional line of business was assigned to a ISP who advertised "Call for details" or "We are a friendly firm." The vast majority of unused phrases were idiosyncratic phrases which only appeared once with one firm, defying general characterization. There were 1105 such phrases (and 6,795 unique useful phrases), which occurred 1406 times (out of 35,436 total phrases). In other words, most of the unused phrases occurred only once and described attributes of the firms which had nothing to do with their lines of business (e.g., HQ phone number, contact information or marketing slogans). The most common unused phrase was “etc.”

C. A First Look at the Service Lines of ISPs

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 do at least one of either networking, hosting or web design; 984 do only one of these three; 105 do all three and frontier access. The analysis sample has similar percentages. For such a cautious method, this reveals quite a lot of experimentation with non-access services by firms in the access business.[7]

The largest firms – defined as present in 25 or more area codes – experiment at slightly higher rates: 159 of 197 firms (in this sub-sample) are in either networking, hosting or web design – 60 do only one, 18 do all four. 115 provide high speed access, 59 networking, 63 web hosting, 94 web page design. That is a higher rate than the whole sample, but consistent with the hypothesis that urban areas (where large firms are disproportionately located) tend to receive higher rates of experimentation from its ISPs. This hypothesis receives further attention below in the analysis sample.

The above indicates that using the ISPs as the unit of observation may provide a partly distorted view of the geographic diffusion of new services. To develop the point further, Table 1 lists another column which weights experimentation – admittedly, coarsely – for geographic dispersion. The product line is weighted by the number of area codes in which the ISP provides service. Since this is the only data available about geographic dispersion for all 3816 ISPs in *thelist*, this is the most one can do. This weighting is coarse because not all area codes are equal in square miles, nor population.[8]

In the original sample, ISPs are in 7.6 area codes on average. There were 28,967 " ISP-Area Codes." Of these 17,343 (77.2%) have at least one additional line of business other than dial-up Internet

[7] One of the most difficult phrases to classify was general "consulting" -- i.e., consulting which did not refer to a specific activity. Of all these vague consulting cases, all but 12 arose in the 1836 firms who provide networking, hosting and web design. Hence, the vast majority of consulting activity is accounted for by the present classification methods as one of these three complementary activities, networking, hosting and web-design.

[8] Though there is, roughly speaking, a maximum limit on the total population associated with any given area code, this maximum only binds in a few locations. In general, therefore, area codes are not determined in such a way as to result in anything other than crudely similar population sizes and geographic regions.

access or routine direct access, higher than found in the un-weighted sample. Even emphasizing how cautious these methods are, this second way of representing the data reveals quite a lot of experimentation in non-access business. Table 1 shows that, using 28,967 as denominator, 15,846 ISP-area codes provide high speed access, 8334 networking, 8188 web hosting, 13,809 web page design. In all cases, these are higher percentages than the original sample; in the case of high speed access, this is a much higher percentage. Because the firms in a larger number of regions tend to do more experimentation, this suggests that most users, especially those in urban areas where the national firms tend to locate, probably have access to some form of experimentation.[9]

These first results do not seem to be an artifact of survey bias. There is not enough evidence here to suggest something artificial about the relationship between the results and the effort it takes to fill out the survey from for *thelist.*[10]

D. The Relationship Between Services

Table 2 examines the two different types of services other than basic access. Specializing in very high-speed Internet services is one type of service that distinguishes a firm from its competitors. As has been noted in many places (e.g., Kolakota and Whinston, 1997), greater and greater speeds are harder to obtain (as a technical matter) and costly to reliably provide (as a commercial matter). In contrast, specializing in hosting, networking service or web design can also distinguish a firm from its competitors. Many of these services requires trained personnel and may be difficult to do profitably. Hence, these two types of differentiation might be done by the same firms for commercial reasons, but there is no necessary technical reason for it.

[9] However, this is only a hint and not a concrete conclusion. Without a complete census of new services at all ISPs, it is not possible to estimate precisely how much of the US population has easy access to local provision of these services in the same way that Downes and Greenstein [1998] estimate the percentage of the population with access to basic Internet services.

[10] Extreme geographic firm size (i.e., the total number of area codes in which the ISP offers service) is a good measure of a survey bias because the ISPs must expend effort to indicate the extent of their geographic coverage. If the number of phrases was low due to ISP impatience with the survey format, one would expect a strong relationship between firm size and the number of phrases. Since the correlation is positive but small, which is plausible for many reasons having nothing to do with survey bias, I conclude that the numbers of lines of business does not arise as an artifact of ISP impatience with the survey or other forms of laziness by the ISP.

In the original sample the fraction of firms in networking, hosting, and web design is higher among those in high speed access, but the relationship is not very strong. Table 2 shows that in the original sample, of the 1059 in high speed access, 59.8 percent (633) provided networking, hosting or web design. By comparison, of the 2757 not providing high-speed access, 44.8 percent (1236) did so. Similarly, of the 1869 providing networking, hosting or web design services, 33.9 percent (633) provided high speed access. Of the 1947 not providing networking, hosting and web design, 21.8 percent (426) provided high speed access.

For comparative purposes, Table 2 also lists the same correspondence for the data in ISP-area codes and for the analysis sample. The same qualitative results remain. Comparison of different lines of business with each other is shown in Figure 1a and 1b. These reinforce the point that different firms carry different non-basic services. These determinants of these patterns are discussed further below.

E. Constructing the Analysis Sample

Additional data about local conditions is available for the analysis sample. However, this additional information comes at the cost of a reduced sample size and with a potential selectivity bias.

The analysis sample was constructed as follows: First, the original sample was restricted to 3300 ISPs in 20 or fewer area codes, as found in *thelist.* This isolates regionally dispersed decision makers. Second, the original sample was compared against a set of roughly 5400 ISPs in the Downes and Greenstein [1998] data set for ISPs, which were in five or fewer counties. Why 5 or fewer? The Downes and Greenstein [1998] dataset for small ISPs comes from 1998 spring/summer listings in *thedirectory*, another forum in which ISPs advertise. *Thedirectory* places emphasis on listing the local dial-up phone numbers for many ISPs,[11] which permits identification of the local points of presence (POPs) for ISPs, and, hence, the local geographic territories served by any ISP who offers dial-up service.[12] This is a much finer way to identify local service territories and local market conditions than using the area codes included in

[11] The other source of data for Downes and Greenstein [1998] is the *Boardwatch* backbone list, which concentrates mostly on national ISPs.

[12] This is an artifact of the US local telephone system, which tends to charge telephone calls by distance. Hence, the location of a local phone number from an ISP is an excellent indicator of the local geographic territory covered by the ISP. See Downes and Greenstein [1998] for further detail.

thelist.[13]

Third, an ISP was included in the analysis sample if the ISP listed the same domain name for the home page in both *thedirectory* and *thelist.* This strategy ensures 100% accurate observations. The emphasis on accuracy was deliberate. It was discovered that it is relatively common for several different firms to maintain similar company names and similar domain names, heightening potential confusion. In addition, many ISPs maintain several similar "home pages" with different domain addresses for a variety of reasons (e.g., tracking traffic from different sources, marketing under different organizational umbrellas, etc.). Since the dataset is large enough for the statistical purposes below (2089 observations) and there was no hope of getting a census of all ISPs, the benefits of absolute accuracy overwhelmed the potential benefits of a mildly larger sample which ran the risk of being inaccurate for a few firms.[14]

These 2089 ISPs are representative of small ISPs. Comparisons of the 2089 ISPs in the analysis sample with the roughly 5400 small ISPs in Downes and Greenstein [1998] showed little difference in the features of the service territories. In the analysis sample 83.5% of the ISPs are in urban counties, using the broadest definition of urban from the US Census. In Downes and Greenstein, only 81.1% are in urban counties. Other than this slight difference, there is no qualitative difference in the average features of the territories covered by small ISPs in the two data sets. Moreover, the number of small ISPs found in each county in the Downes and Greenstein dataset and in the analysis sample correlates at .94, as one would expect if the 2089 ISPs in the analysis sample were nearly a random selection of small ISPs from across the country.[15] In sum, the two known biases in the analysis sample are the slight over-representation of

[13] In some dense urban counties, the number of area codes exceeds the number of counties, but for most of the country the number of counties vastly exceeds the number of area codes. There are over 3000 counties in the US and less than 200 area codes.

[14] Because two sets of company names are maintained by two completely unrelated lists, *thedirectory* and *thelist*, each of whom uses different abbreviations and possibly different domain names, many ambiguities arose. It is certainly the case that many of the 1300 firms from *thelist* which are not included in the analysis sample are, in fact, in the Downes and Greenstein [1998] data. However, verifying these matches was tedious and potentially subjective, rendering it almost infeasible.

[15] The correlation between the ISPs per county in the two datasets is .94 when Downes and Greenstein [1998] only examine ISPs in five counties or less. The correlation is, not surprisingly, lower when we correlate the number of ISPs in the analysis sample per county with the entire Downes and Greenstein dataset, which includes all national and regional firms. In that case, the correlation is .82. This is because larger firms tend to disproportionately locate in urban areas.

urban areas, for which it is possible to control, and the sample bias towards small firms, which I choose deliberately so I could identify local conditions.[16]

Figure 2 presents a map where a county is blackened if it contains at least one ISP from the analysis sample. There are 905 such counties represented in this sample, with representatives from virtually every urban area in the US as well as several hundred rural counties.

F. A Second Look at the ServiceLines of ISPs

Tables 1 and 2 present comparable statistics for experimentation by ISPs in the analysis sample. These tables show patterns similar to those for the original sample. This evidence suggest that the analysis sample is not an unrepresentative sub-sample of the original sample.

The focus on small firms permits a close examination of differences in experimentation by urban and rural ISPs. The results are striking. In this sample of 2089, 1764 ISPs primarily serve urban areas.[17] Their propensities to offer services are slightly higher than for the whole original sample. Of those 1764 ISPs, 26.9% offer frontier access, 22.9% offer networking services, 23.5% offer hosting services, and 38.6% web design services.

The last column of Table 1 shows the contrast with rural areas. Of the 325 ISPs primarily found in rural areas, 12.0% offer frontier access, 11.0% offer networking services, 13.8% offer hosting, and 23.3% offer web design services. The propensities are between 40% and 60% lower across every category. A simple test for difference of means between urban and rural ISPs strongly rejects the hypothesis that the average rate of experimentation is the same between the urban and rural samples of ISPs. This holds for every type of activity.

The above findings are novel, as no previous research have ever examined services at such a detailed service and geographic level. They raise important questions about the distribution of economic growth in Internet infrastructure markets, issues which will be further discussed below. Before doing that,

[16] As noted in Downes and Greenstein [1998], there is also a subtle empirical bias in any study of ISPs. All inferences in this sample are conditional on observing the ISP in the access business to begin with. We do not observe those who considered this business, but did not choose it.

[17] Each county an ISP serves is designated urban or rural by the US census. In the rare cases where an ISP serves a mix of urban and rural areas, if the majority of counties are urban, then an ISP is said to be urban.

however, it is important to note that the above test is an unconditional comparison and says little about the determinants of outcomes. These findings do not control for urban/rural differences in population demographics, nor for urban rural differences in firm-specific traits. In other words, the geographic dispersion of the endogenous variable might be explained by geographic factors, but it might also be explained by the geographic distribution of firm-specific factors. Before making any inferences, the study estimates econometric models which measure the relative importance of both firm-specific and location-specific determinants.

4. The Determinants of Non-Basic Services

A. Model Selection

Table 1 provides definitions for the four different ways of measuring activity. Let i index ISPs where i = 1 through 3816. Let Y_{ni} = 1 if an ISP offers networking and zero otherwise. Let Y_{hi}, Y_{wi}, and Y_{fi} be defined similarly for hosting, web design and frontier access. These activities will be the sub-components for alternative specifications of the endogenous variable. Table 3 includes summary statistics for all endogenous and exogenous variables, all defined below. In the discussion below, the matrix of these variables will be listed as "X", where X_i represents a vector of variables for observation i, which refers to an ISP. For all observations X will contain information about the ISP. For some observations X will contain information about the area in which the ISP is located.

The study seeks to model the relationship between the exogenous variables and an ISP's choice to conduct specific activities. Several considerations determine the selection of a model. First, the activity of interest – offering non-access service lines – is never directly observed. At best, it is observed with error, as represented by Y_{ni}, Y_{hi}, Y_{wi}, and Y_{fi}. Second, the best available measure of this activity is discreet.[18] Third, due to the data-collection method, the boundary definition for "activity" is subject to measurement and classification error. Hence, the econometric method should characterize tendencies which do not depend on slight changes in the definition of "activity". Fourth, the econometric approach must use methods which are potentially robust to missing determinants, as well as different datasets.

[18] Some adaptation activity is also countable in the sense that one can coarsely measure whether an ISP offers any service, offers a few simple variations on it, or offers many different services. However, as noted below, count data did not reveal any additional information about the factors influencing the offering of service. Hence, I show the simpler econometric results.

Since this is the first analysis of this data, it focuses on questions which characterize basic patterns. These are questions such as: What factors determine the decision to perform any activity other than basic access, location-specific or firm-specific factors? Do ISPs choose to offer different complementary services because the determinants of these services are distinct? Do ISPs offer different services because the distribution of important determinants varies across ISPs? Below I employ and contrast two related approaches:

Model 1 -- a trivariate probit between three complementary services: It is reasonable to examine the relationship between services which are complementary to basic access. Let Y_{ni}, Y_{hi}, are Y_{wi}, be determined by distinct but related processes. Accordingly, there are three continuous latent variables, Y^*_{ni}, Y^*_{hi}, and Y^*_{wi}, which determine the choices to perform each of these non-basic activities. Let $Y^*_{ni} = a_i + X_iB_n + e_{ni}$ describe the latent variable. Let similar relationships hold for the other two activities. Here a is a random variable which is common to each activity but varies across ISPs within the panel. This captures an underlying and unobservable disposition to perform non-access services, reflecting underlying demand, entrepreneurial vision and competitive conditions which are common to different activities at the same ISP.[19] B is estimated as a trivariate probit. There are 11,448 observations (3 time 3816).

Model 2 – a bivariate probit between frontier access and complementary services: Let the endogenous variables reflect values shown in Table 2. For frontier access let Y_{fi} equal one or zero, depending on whether the ISP offers frontier access. An ISP gets a value of one if it offers frontier access and zero otherwise. An ISP also gets a value of one if it offers at least one complementary service among networking, hosting and web design. More precisely, define $Y^*_{ci} = 0$ if Y_{ni}, Y_{hi}, and Y_{wi}, all equal zero. In all other cases $Y^*_{ci} = 1$. Let $Y_{fi}{}^*$ be the latent endogenous variables. Then let $Y^*_{fi} = a_f + X_iB_f + e_{fi}$ and $Y^*_{ci} = a_c + X_iB_c + e_{ci}$, where a_f and a_c are potentially correlated, as noted before. There are 3816 ISPs making two choices (=7632 observations).

Both approaches focus on understanding the determinants of each service. After considerable exploration in early versions of this study, it was found that most of the importance of different

[19] Note that the correlation of the errors in this setting is, at best, only a weak "test" of whether the services offerings are complementary (see e.g., Athey and Stern [1998] for discussion).

determinants can be characterized with these two straightforward models.[20] Future work will explore related questions associated with the incentives to perform different combinations of activities. Future work will also explore models where market-wide activity is the unit of analysis.

B. Exogenous variables

This study uses a general framework for a situation where firms are responsive to both location-specific and firm-specific factors. A full explanation for each variable is included in the appendix.

! **Firm specific factors:** Several factors measure features of the ISP, such as its capital structure and its focus on particular types of users. DIALUP takes on the value one when an ISP offers any dial-up service; its absence indicates an exclusive focus on business customers. DEDICATED takes on one if the ISP offers any direct access; its absence indicates an exclusive focus on residential customers.[21] HANDHOLDING counts the number of "useful phrases" in the basic access category. Because this activity is largely unnecessary to do for sophisticated users (e.g., e-mail, filtering), this measures whether an ISP is trying to make basic access technology easy to use for some of its customers.

COMMUNICATIONS and COMPUTER are dummies which take on the value one if the ISP lists another line of business related to communications/computers (e.g., typically a retail outlet for purchases or service) and which does not use TCP/IP technology. MISCBUSINESS takes on one if the ISP maintains another business lines unrelated to computers or communications or TCP/IP technologies (e.g, retail outlet for photocopies or a cafe).

Thedirectory also provides limited historical information about ISPs, so it is only available for the analysis sample. EXPERIENCE is a dummy which takes on one if the ISP was listed in *thedirectory* in the

[20] Early versions of this study explored a related question: what factor determines the decision to extensively perform non-basic access activity? Using data on the number of different services an ISP offered, I estimated ordered probit and a negative binomial models. Since the estimates of the determinants were qualitatively similar to the results presented below, only results for the simpler model are presented for the sake of brevity.

[21] Both DIALUP and DEDICATED are, arguably, endogenous from an econometric standpoint, as these are decisions which may have been made at the same time as the decisions to experiment in frontier access and complementary services. To test whether the estimates are sensitive to their inclusion, I tried specifications with and without them and found that the estimates did not dramatically change. Hence, I only show the estimates with these variables included.

spring of 1997, more than a year earlier than the survey in *thelist.* Since there were a couple thousand news entrants in 1997 and 1998, this dummy measures whether a firm was an early entrant into the ISP business.

! **Firm specific factors which overlap with location-specific factors:** Many services other than Internet access mix firm-specific components with elements of location specific components (in terms of fixed capital structures, local retail outlets, and so on). ONEAREACODE takes on the value one if the ISP maintains service in only one area code, as indicated in *thelist*. MORETHAN20 is a dummy variable for presence in more than 20 area codes, indicative of national coverage. Both ostensibly measure firm size. However, as noted in Downes and Greenstein [1998], national coverage necessarily implies that the ISP has located its POPs in urban areas; that is, as ISPs become especially large, for all intent and purposes, they all locate in the same cities, facing the same demand and supply conditions.[22] Because the analysis sample focuses only on small ISPs, it is not possible to define MORETHAN20 for the analysis sample. However, it is possible to add an additional measure of size, ONECOUNTY. It takes on the value one if the ISP maintains service in only one county, as indicated in *thedirectory*.

Note that COMMUNICATIONS, COMPUTER and MISCBUSINESS may also partially reflect locations specific investments when these reflect the presence of local retailing establishments, but this interpretation is more plausible with the ISPs in the analysis sample (which only contains ISPs who have a local focus) than the original sample (which contains ISPs with local and national focus).

● **Location-specific factors**: The analysis sample includes several factors which measures the locations of the in which the small ISP locate. This paper only shows a some of the variables which were tried, those which summarize the main findings. The appendix discusses a number others variables which had little explanatory power or were collinear with those included.

URBAN takes on a value between zero and one. This reflects the percentage of urban counties in which the ISP offers local dial-up service or maintains a headquarters. Most of the time the number is just zero or one, as if it were a dummy variable. URBAN, by itself, supports several interpretations. This variable is not identifiably different from local market competitiveness, density of available customers for a fixed firm size, and the quality of local infrastructure – i.e., ISPs in urban markets face more competition,

[22] In other words, every national ISP offers services in the top 50 cities of the US. Thus, there is little (measurable) geographic variation between large firms and littlevariation in local conditions.

can reach more users for the same investment, and generally have access to better infrastructure.[23]

Next, FRACPROF is a fraction between zero and one which describes the fraction of the population in white collar work (see Downes and Greenstein [1998]). This ostensibly measures local differences in demand, though, once again, this variable supports several interpretations. FRACPROF is not identifiably different from other demographic measures in a region.[24] Areas with higher FRACPROF tend to have populations which have higher income, more education, more white-collar work and more PCs at home and at work.

The last variables are UNIVERSE1, UNIVERSE2 and UNIVERSE3, all of which are dummies that measure the presence of and the type of at least one university in the county in which the ISP provides service. These measure whether the origins of Internet technology has any influence on experimentation by commercial firms. See the appendix for detail.

- **The distribution of factors between urban/rural locations:** FRACPROF coincides partially with urban/rural in that it has a mean value of .41 for ISPs in urban counties, and a value of .32 for ISPs in rural counties. This is quite interesting since it can identify urban/rural differences which arise due to demand instead of other factors, such as competitiveness and size.[25]

A related pattern also arises in some of the firm-specific variables. There is more hand-holding in urban ISPs (1.03 vs .64 on average), more experience with computing (.01 versus .006), and more experience with other business (.012 versus .008). There are also differences in dedicated investments (.90 versus .93). This pattern raises the possibility that the distribution of firm-specific factors among urban/rural areas will explain behavior instead of the urban/rural variable by itself.

This discussion also motivates a similar comparison between the general features of the firm-specific variables for the local ISPs in urban areas in the analysis sample and larger ISPs in the original

---

[23] Entry of the number of ISPs is strongly correlated with urban/rural status (Downes and Greenstein, 1998). Hence, the number of other competitors and the competitiveness of the market was not identifiably different than urban/rural. See appendix.

[24] This includes measures of income groups and age groups form the census and PC and Internet adoption at households (Kridel, et al, 1997). Using census data, I also experimented with several measures of the strength of the local financial, insurance and real estate markets, but none of these had explanatory power with FRACPROF included.

[25] These populations do not differ in the standard deviations (both are approx .055), but they do differ in their minimum (.17 vs .22) and maximums (.49 and .59).

sample. As noted, larger ISPs (for whom MORETHAN20 =1) locate most of their points of presence in urban areas. Interestingly, no differences were found between the firm-specific variable means or variances for either group of ISPs. This suggests that some of the inferences about small ISP in urban areas may apply equally well to large ISPs who are otherwise similar and located in similar urban areas. Additionally, it suggests that differences in the coefficient estimates for URBAN and MORETHAN20 are informative about the effect of size on ISP behavior, independently of location.

5. Results

Table 4 and 5 presents estimates for the models for the original sample and the analysis sample, respectively. The first, second and third columns are the trivariate model (Model 1) and the last two columns are the bivariate probit (Model 2).

The absence of a dial-up capability reveals an ISP who focuses on a business market, while the absence of a dedicated capability reveals an ISP who focuses on a residential market. Hence, to avoid including perfect predictors of frontier access (i.e., no business focus = no frontier access) and complementary services (i.e., no dial-up = complimentary service), DEDICATED is dropped from the frontier part of the bivariate probit, and DIALUP is dropped from the complimentary side of the bivariate probit and all the estimates in the trivariate probit.

In addition, earlier studies tested whether the reporting date on *thelist* influenced results and found no evidence of any reporting bias.[26] As it reduces the sample size, it is not reported in the specification. Also, in Table 5 it was not possible to reject the hypothesis that all the university variables were jointly different from zero. For simplicity, these coefficients are dropped. See appendix.

A. Determinants of Non-Basic Services in the Original Sample

Firm-specific factors: Firm-specific factors do predict the offering of new services. DIALUP is negative in the frontier part of the trivariate probit, as expected. The absence of a commercial dial-up service indicates a business focus and a high likelihood of offering frontier direct access business services. It is a large estimate; only one other dummy variable predicts as well (see below). However, only 2% of the

[26] *Thelist* requires the ISP to provide a date of its last update. Some ISPs clearly update their information frequently, while a few had not done so in over a year. It is possible that the most recently reported dates might contain more reported experimentation.

sample has no dial-up capability, so it is a good predictor for only a small number of cases. DEDICATED is positive and significant in the complementary activity part of the bivariate, indicating that the investment in some dedicated capabilities predicts more experimentation. It particularly matters for networking and web design, but not hosting. Since almost 10% of the sample has no dedicated capability, it is a good predictor for a relatively large number of cases.

HANDHOLDING is a positive and significant predictor of new services including frontier access. However, HANDHOLDING is qualitatively unimportant in the frontier probit, consistent with the interpretation that it captures the marketing focus of the ISP and not just its propensity to "talk." HANDHOLDING matters for all the complementary services, with slightly higher estimates for hosting services. As its mean value is close to one, variance in HANDHOLDING is not too important except at extreme values. HANDHOLDING is a qualitatively important predictor for the 10% of ISPs with values above 3 . In other words, firms who are willing to make the effort to extensively explain even their basic access services are more likely to also offer complementary services. This is good evidence that many commercial firms are consciously trying to bridge the gap between the technical frontier and the needs of the less technically sophisticated commercial users.

The related lines of business predict an ISPs willingness to experiment with new Internet services. COMMUNICATIONS, COMPUTERS, and MISCBUSINESS are positive statistically significant coefficients on one half of the bivariate probit but not the other. Only COMMUNICATIONS matters for the frontier side of the probit. In other words, experience in any other line of business is a good predictor of more experimentation in at least one type of complementary service, but only business in communications influences experimentation with high speed access. This is consistent with expectations and quite sensible. The trivariate probit reveals some interesting differences among the three complimentary services. All three factors predict the offering of networking services, COMPUTERS and MISCBUSINESS predict web design, only COMPUTERS predicts the offering of hosting.

COMPUTERS is more than twice as large as either of the other two dummy variables in the bivariate estimates, while COMMUNICATIONS contributes much more to providing frontier access. COMPUTERS particular contributes to the offering of networking services and web design services. Again, this is consistent with expectations, a firm (or entrepreneur) that was selling or repairing PCs before the commercialization of the Internet is quite likely to expand their business into basic Internet access and related lines of services, such as network maintenance, hosting and web design, but not

necessarily high speed access. The one limit to all these inferences is that COMPUTERS, COMMUNICATION and MISCBUSINESS take on values of one for only a small percentage of the ISPs, so their predictive power only works for a small part of the sample of ISPs. While this is not definitive evidence of the importance of previous firm investments to the development of future services, it is consistent with an important role for previous experience linked to the experience of a firm in a particular product market.

Firm-specific factors which overlap with location-specific factors: ONEAREACODE is negative and significant in every estimate, and especially large in the frontier probit. MORETHAN20 is positive and significant.[27] It is particularly large in the frontier and hosting estimates. Two inferences arise from these estimates. First, the likelihood of experimentation is monotonic in firm size and geographic coverage. Second, the difference between the coefficients for the largest and smallest firms is 1.19 for the frontier probit, making this the most important predictor other than HANDHOLDING at extreme values.

Overall, this is evidence that frontier access tends to come from national firms, not local ones, echoing the discussion above of the unconditional relationship between size and experimentation. Similarly, the coefficients for complementary services are also monotonic. Again, this is evidence that national firms may have advantages in offering complimentary services, though it is not as striking as with frontier access. The biggest difference between small and large firms occurred in networking services with a difference of .48. Hosting is at .41 and web design at .38. While this is not definitive evidence of economies of scale in the provision of these services, either due to amortization of fixed costs in equipment/software or returns to national branding, it is suggestive that scale and size of ISP is important.

B. The Influence of Location-Specific Determinants in the Analysis Sample

Firm-specific factors: Despite differences in the sample, as well as the inclusion and exclusion of other exogenous variables, the qualitative features of the coefficient estimates for most exogenous variables common to Tables 4 and 5 do not change much. DEDICATED, DIALUP and HANDHOLDING have estimates with the same qualitative features in both the bivariate and trivariate probit. Similarly, the estimates for COMPUTERS, COMMUNICATIONS and MISCBUSINESS are virtually unchanged from

[27] I also tested specifications which interacted the area codes dummies with the other determinants and rejected the hypothesis that these interactions were significant. Hence, the much more parsimonious specification was used.

the previous estimates for the original sample. The coefficient on EXPERIENCE, which is new, is insignificant in all estimates except the estimates for networking. The coefficient is not very large (.22).

Location-specific factors: The evidence for the importance of location-specific factors is mixed at best. As before, ONEAREACODE also continues be a negative predictor of experimentation in all estimates, though the estimate is never large. However, ONECOUNTY suggests some interesting qualifications to that conclusion. An ISP who is in only one county is even less likely to offer frontier access. Together these are large (-.58-.18=-.76), reinforcing the importance of size as a predictor of offering this service. This results contrasts with the estimates for complementary services. The trivariate probit shows that ONECOUNTY makes an ISP more likely to offer networking services. The coefficient is not very large (.21), so it is only weak evidence of the possibility that local-specific factors may influence some repair and maintenance services for networking. ONECOUNTY is not different from zero for hosting or web design.[28]

The estimate of URBAN is not significant except in the networking probit. The coefficient is not very large (.16). These are striking estimates because they contradict the hypothesis that URBAN location induces entry into frontier access. Moreover, they differ from the simple inference done with the unconditional data. They also contrast with the finding for MORETHAN20, reinforcing the inference that size of firm matters.

Along with ONECOUNTY, the coefficient on URBAN is, at best, weak evidence that the provision of networking differs from hosting and web-design. More concretely, an early entrant (EXPERIENCE=1) into the ISP business who is only located in a single (ONEAREACODE=1) urban (URBAN=1) area is also likely to be in only one county (ONECOUNTY=1).[29] They are more likely to offer networking

[28] To further test for importance of location on size, scale and density effects, URBAN was interacted with ONECOUNTY and ONEAREACODE. That is, an ISP in one urban county can reach more people than an ISP in one rural county. Also, an ISP in one urban area codes covers a small geographic territory than one in one rural area code. This re-specification mildly influenced the estimates, showing that small ISPs in urban areas were more likely to offer frontier access than small ISPs in rural areas. However, it did not lead to any other inferences for the other services. Hence, the simpler specification is shown.

[29] One area code is a good predictor of one county. 88% of the 1067 ISPs in one area code are only in one county. Naturally, the converse is not as strong. Because most major dense urban areas have multiple area codes, only 56% of the 1658 ISPs in one county are in only one area code.

services (.21+.22+.16-.28=.31) than an inexperienced, rural ISP who is spreading service among counties and area codes. Yet, at best, this is weak evidence of a difference between networking and the other complementary services due to the small coefficient estimates.

FRACPROF is statistically significant in the estimates for frontier access, networking and web design, not hosting. That said, the size of the coefficients is relatively small. Only large swings in the exogenous variables, on the order of several standard deviations, influences any of the results to an important degree. In other words, an ISP located in an area with an extremely high fraction of professionals (e.g., .50), as compared with an ISP in an area with a extremely low fraction (e.g., .25), is more likely to offer frontier access (.25*1.37=.34), web design (.40), and especially networking (.62). This is important, to be sure, but only at the extremes. Thus, it is not especially strong determinant for most of the sample.

C. Overall Assessment of Estimates

The estimates for the original sample strongly suggest that frontier access and other activities are not similar. The estimates lead to a sound rejection of $B_f = B_c$ in the bivariate probit, consistent with the modeling decisions to treat these two decisions as interrelated but seperate. The estimate for the correlation coefficient reinforces this conclusion. It is 0.12 in the bivariate probit, indicating a small positive relationship between the unobserved determinants of experimentation.

Such a strong rejection is not possible between the three complimentary services. All three share some similar estimates in terms of signs and economic significance, though these similarities are stronger between networking and web design than between hosting and the other two. In other words, it is not possible to reject $B_n = B_w$ for most of the coefficients, while it is possible to reject a similar test for a subset of coefficients associated with hosting and the other two services, i.e., $B_n = B_h$, or $B_w = B_h$. The estimated correlation of errors contains further information about the similarities in services. In the trivariate probit, the correlation between the unobserved error in the networking and hosting probit is .18, between hosting and web design .35, and between networking and web design .57. Overall, there is an important correlation between the unobserved determinants of these choices, the most important correlation is between the activities of networking and web design. Indeed, .57 is so high as to raise the question of whether the industry's propensity to discuss these services as distinct is relevant as an empirical matter. However, the difference between the correlation of web design with hosting suggests some value in maintaining the distinction.

In the analysis sample, the estimates also lead to a sound rejection of $B_f = B_c$ in the bivariate probit, suggesting that frontier access and other activities are determined by different processes. The low correlation coefficient reinforces this observation. As before, hosting continues to look different than networking and web design. And, once again, the correlation coefficient is higher between hosting and web design (.32), than hosting and networking (.16). Finally, as before, networking and web design share many qualitatively similar coefficients and a high correlation coefficient (.58). However, enough differences emerged (i.e., EXPERIENCE, COMMUNICATION, ONECOUNTY, URBAN, and FRACPROF) to suggest weak evidence of differences between the determinants of these services.

From this analysis several provisional conclusions arise. First, there appears to be significant ISP-specific factors which influence the choice to offer services. In particular, size, geographic scope, key capital investments, focus on particular types of users and non-ISP lines of businesses all predict experimentation with new services. Second, frontier access is distinct from any other type of differentiation, and bears weak influence from location-specific factors. Third, while hosting is more similar to the other services than frontier access, it also has several differences. It is influenced by few location-specific factors. Networking and web design services have many similar observed and unobserved determinants. Fourth, networking and web design services have many similar observed and unobserved determinants, and both appear to be weakly influenced by location-specific factors. This seems to indicate a weak tendency for hosting and frontier access to become national products, while, in contrast, networking and web design may retain a structure with both some national and some local suppliers.

In general, variation in location-specific variables are not as important as variation in firm-specific variables across all the services. Variables measuring other location-specific features, such as FRACPROF and URBAN, do influence behavior, but in only a few instances. The variable measuring university spillovers was simply unimportant. Other measures of location-specific factors have been highly correlated with those included in Tables 4 and 5. Instead, some of the firm-specific variables – whose distribution does vary over geographic space – does help explain some of the observed variance. This includes HANDHOLDING, MORETHAN20, COMPUTING, MISC AND DEDICATED. This is not definitive evidence, but it is consistent with the view that firms in this young industry choose strategies for differentiating based on firm-specific growth strategies, much of which is conditions on previous experiences. It is also consistent with the view that the market has not yet settled down into patterns in which most firms differentiate in order to match a stable and known pattern of local demand.

D. The role of Co-invention and Location in the Growth in New Technology

The diffusion of a new general purpose technology is largely shaped by 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, the central mechanisms for translating technology into economic growth. This process is also a source of great policy concern in the telecommunications industry (Werbach, 1997 Esbin, 1998, Weinberg, 1999), as this relationship shapes the creation and targeting of subsidies associated with new services, as proposed in the 1996 Telecommunications Act.[30]

While these data tend to support the view that the lower propensity of new services in low-density areas is a function of some geographic factors, the conclusion has several important caveats. While the unconditional data document a difference in the propensity to experiment in urban and rural ISPs, the conditional estimates found a less stark relationship. The estimates highlight the importance of several distinct factors which produce geographic dispersion of outcomes.

Urban areas get more experimentation due to due two factors: (1) increased exposure to national firms, who experiment more often; and (2) the local firms in urban areas possess features that leads them to experiment at rates similar to the national firms. That is, high density entrants almost always get some ISP entry, while some low density areas get none or very little. High density areas see an especially large amount of entry because they experience entry from nearly all the firms with national ambitions. While little or no entry in a low density area virtually precludes availability of any complement to basic access, high density areas benefit from repeated exposure to many ISPs who offer such services. More entrants by itself will lead to more realized numbers of experimenters, raising the probability of finding one, two or three instances of experimentation in a specific location.

[30] 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 ISPs to expand from high-density areas to low density areas (where they would not otherwise be), or it must induce incentives/vision/investments from ISPs who are already located in low-density areas (but who would otherwise choose to offer such services). 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.

This is more so in the case when ISPs in urban areas have higher propensities to offer services, as in this data, where ISP-specific factors are not distributed independently of geography. There is more hand-holding in urban ISPs, more experience with computing, more experience with other business, as well as differences in dedicated investments, and differences in the fraction of the population which is professional. Except for the estimates for the propensity to offer networking, these other *observed* factors partly explain the observed difference better than a simple urban dummy.

Yet, an important caveat applies. The above models also estimate positive and statistically significant correlations between the *unobserved* determinants of the ISPs propensity to experiment. This estimated correlation can be a function of unobserved ISP-specific determinants of both activities or unobserved location-specific determinants of both activities. There is no way to tell which it is. Thus, it is possible that some of the unconditional differences in the propensity to experiment in urban/rural settings results from these unobserved location-specific factors.[31] Only if the correlation was zero – which it is not – could we rule out the role for location-specific factors completely.

These observations also raise a related and subtle question. The above econometric study is conditional on entry of an ISP in the first place, treating the ISP's features and its region as statistically exogenous. Yet, entry might be a function some unobserved and historical matching process between the individual employees and founders of the ISP and the local area. For example, low density areas have fewer entrants altogether, leading to fewer providers of access with the ISP-specific factors which lead to non-basic services, resulting in less experimentation. This observation does not undermine the conclusions above about the relative importance of ISP-specific factors over location-specific factors; it simply begs the question about whether the presence of some ISP-specific factors are exogenous in some dynamic and long run sense. There are a number of ways for this process to work. For example, it is possible that ISPs who were more likely to experiment (in 1998) decided to locate in urban areas (in 1996, say) in order to have that option later. This type of decision making could induce the geographic dispersion of ISP-specific factors seen in this data.

Finally, and on a somewhat different note, much policy debate has been concerned with redefining the distinction between traditional telephone services and computing services (e.g., see Weinberg, 1999, or

[31] A number of factors cannot be ruled out, such as location-specific spillovers across vendors, location-specific learning about demand, and other factors operating on a small geographic level.

Sidek and Spulber, 1998, for a recent summary and critique). This distinction is a key premise of the 1996 Telecommunications Act, engendering FCC review of whether ISPs were special services, exempt from the access charges of telephone companies. Many authors have correctly noted that ISPs have benefitted from this exemption. It is a matter of debate about whether this exemption is welfare enhancing or decreasing.

This study has several comments to add to this extensive debate. By 1998 many ISPs were pursuing business models with only a mild relationship to the regulatory boxes and previous business lines (This study had to create its own new product code for precisely this reason.). This fact alone raises the question about the wisdom of employing these legacy regulatory categories to their behavior. It is, therefore, further evidence in favor of the arguments for constructing a new and possibly *sui generis* regulatory approach to ISPs. That said, if the regulatory and political process insists on trying to fit ISPs into one side or another of the historical line between telecommunications and computing, this study's approach adds one reason to the case for some forbearance and one to the case against. For forbearance: these experiments by ISPs may become a key market mechanism for developing the complementary Internet services that translate technical advance into economic value. As yet, it is unclear what shape these experiments will take next year and where these all will lead. It is in society's interest to have these experiments develop and in society's interest to let them have sufficient time to generate potential information spillovers. For settling the issue soon: many ISPs are developing their business models around a particular cost structure for a key input. It is in society's interest to have the cost of that input incorporated into the ISP industry's investments and other strategic commitments, then the distortions can be minimized if those costs are announced sooner instead of later.

6. Conclusion

Markets for Internet access involve experimentation with new business models, new cost structures and new applications. Like any other economic activity, 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 should improve. Like much experimental commercial activity, providing access involves a mix of the general technical 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.

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 offering and their nearest competitor raise returns to innovative activity, inducing a variety of services from different ISPs.

Viewing the Internet access market in this way helps us to understand the explosive events just after the commercialization of the Internet. The technology underlying the Internet incubated in research laboratories but today's commercial industry has propelled it into common use. The economic value of ISP services is largely determined by the value commercial users place on it. This framework helps explain why the incubation of Internet technology in an academic setting lead to a lengthy set of adaptive activities in a non-academic setting. These adaptations are hard to do, as they reflect ISP-specific capabilities and entrepreneurial guesses about the appropriate services to offer and about location-specific demands for particular services. This framework also provides empirical guidelines for understanding the variety of new services found across the country. Some services are very responsive to previous ISP experience, while others are not. Some services are mildly responsive to local conditions, while most are not. The factors which lead ISPs to offer new services, such as size, previous investments and strategic focus, are disproportionately found in national firms and in local firms in urban areas.

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 communications. Now that it is here, a commercialized Internet may not be precisely what they had in mind. The economic benefits associated with new frontier technologies are diffuse, uneven and uncertain. Business use of the Internet is difficult and adaptation is time-consuming. Many new services do not employ frontier technology at all. Indeed, much commercialization involves bending frontier technology to the needs of commercial users, a process that often involves many non-technical issues. Some locations have access to the latest technology from commercial firms and some do not, creating the potential for a digital divide.

Because this activity is still quite new -- as of early 1999, the writing of this study -- it is still too early to tell whether Internet will lead to dramatic improvements in the daily lives of most end-users. Indeed, it is still plausible for Internet technology markets to follow one of two contrasting commercial paths. Today’s dramatic events could be part of a one-time transition into the Internet era, a transition

marked by a large adjustment to the new technology but disappointing later developments. In this scenario, Internet technology is an incremental improvement over the past, but its benefits are realized in a few years as complementary technologies quickly get invented. In the alternative case, today's dramatic events could be the threshold to a new series of promising disruptions marked by continual technical change and renewal of new commercial possibilities, unleashing seemingly unlimited sequences of co-invention downstream. The disruption is large and recurring, brought on by new technology which enables other unanticipated new complementary technology.

In the first scenario, the disruptions associated with Internet are welcome, but the economic gains associated with the introduction of Internet are fleeting or, at best, temporarily large. In the latter case, the economic gains associated with the introduction of Internet are also welcome and large, but the disruption is spread over many years, as are the economic benefits. In either scenario the market for Internet applications will undergo change before settling into a stable market structure. If it turns out that the market activity is simple (as when the changes are incremental), then the market should settle down soon. If it turns out that the technology changes a broad spectrum of market activities in surprisingly complex and unexpected ways, then the market may change many times until all participants understand the possibilities for more complementary invention which builds on top of what is already there.

References

Athey, Susan, and Scott Stern [1998], "An Empirical Framework for Testing Theories About Complimentarity in Organizational Design," NBER Working Paper No. 6600, June.

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.

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

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

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

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

Downes, Tom, and Greenstein, Shane [1998], "Universal Access and Local Commercial Internet Markets," Working Paper, skew2.kellogg.nwu.edu/~greenste/.

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

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

Greenstein, Shane, Mercedes Lizardo, and Pablo Spiller [1998], "The Distribution of Advanced Large Scale Information Infrastructure Across the US," NBER Working Paper 5929.

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

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 Taylor, Lester [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.

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.

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

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

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

Sidek, Gregory, and Spulber, Daniel [1998], "Cyberjam: The Law and Economics of Internet Congestion of the Telephone Network," *Harvard Journal of Law and Public Policy*, Vol 21, 2.

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

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	Analysis 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%)	2089 (100%) *Rural ISPs 325 (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%)	440 (21.1%) *Rural ISPs (11.0%)*
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%)	460 (22.0%) *Rural ISPs (13.8%)*
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%)	757 (36.2%) *Rural ISPs (23.3%)*
High Speed Access	T3, DSL, xDSL, OC3, OC12, Access rate > 1056k	15846 (54.7%)	1059 (27.8%)	514 (24.6%) *Rural ISPs (12.0%)*

* 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.

** Unit of observation is an ISP in small number of territories. See text for precise definition. Top number is for all 2089 ISPs in analysis sample. *Italicized* percentage is for the 325 ISPs found primarily in rural areas.

Table 2
Product lines of ISPs

Original Sample

		Network, Hosting, & Web		
		Offers	Does not	Total
High Speed Frontier Access	Offers	633	426	1059
	Does not	1236	1521	2757
	Total	1869	1947	3816

Weighted by Service Territory

		Network, Hosting, & Web		
		Offers	Does not	Total
High Speed Frontier Access	Offers	10822	5024	15846
	Does not	6521	6600	13121
	Total	17343	11624	28967

Analysis Sample

		Network, Hosting, & Web		
		Offers	Does not	Total
High Speed Frontier Access	Offers	314	200	514
	Does not	736	839	1575
	Total	1050	1039	2089

Table 3
Descriptive Statistics for the analysis sample
2089 Observations

	MEAN	STD DEV	MIN	MAX	SOURCE*
EXPERIENCE	0.712	0.453	0.000	1.00	*Thedirectory*
COMMUNICATION	0.009	0.095	0.000	1.00	*Thelist*
COMPUTERS	0.034	0.182	0.000	1.00	*Thelist*
MISCBUSINESS	0.009	0.092	0.000	1.00	*Thelist*
ONECOUNTY	0.794	0.405	0.000	1.00	*Thedirectory*
ONEAREACODE	0.511	0.500	0.000	1.00	*Thelist*
DEDICATED	0.905	0.293	0.000	1.00	*Thelist*
DIALUP	0.984	0.127	0.000	1.00	*Thelist*
HANDHOLDING	0.973	1.352	0.000	11.00	*Thelist*
URBAN	0.836	0.360	0.000	1.00	D&G, Census
FRACPROF	0.397	0.066	0.176	0.60	D&G, Census
UNIVERSITY1	0.489	0.500	0.000	1.00	D&G
UNIVERSITY2	0.626	0.484	0.000	1.00	D&G
UNIVERSITY3	0.534	0.499	0.000	1.00	D&G

* *Thedirectory* is www.thedirectory.com. *Thelist* is www.thelist.com. Census is the US Census. D&G is Downes and Greenstein [1998].

Table 4
Estimates for Random Effects, Bi-variate Probit models
Original Sample of 3816 ISPs
Standard Errors below Estimates

	Trivariate Probit						Bivariate Probit			
	Network		Hosting		Web		Frontier		Three Activities	
COMMUNICATION	0.46	**	0.01		0.29		0.44	**	0.43	*
	0.21		*0.22*		*0.20*		*0.22*		*0.24*	
COMPUTERS	0.95	**	0.48	**	0.70	**	0.15		1.15	**
	0.11		*0.11*		*0.11*		*0.12*		*0.14*	
MISCBUSINESS	0.49	**	0.22		0.61	**	0.01		0.43	**
	0.20		*0.22*		*0.22*		*0.25*		*0.21*	
MORETHAN20	0.17	*	0.28	**	0.17	*	0.55	**	0.16	*
	0.10		*0.10*		*0.10*		*0.1*		*0.1*	
ONEACODE	-0.31	**	-0.13	**	-0.21	**	-0.64	**	-0.27	**
	0.05		*0.05*		*0.04*		*0.05*		*0.04*	
DEDICATED	0.57	**	0.03		0.44	**			0.29	**
	0.09		*0.08*		*0.07*				*0.07*	
DIALUP							-0.96	**		
							0.12			
HANDHOLDING	0.16	**	0.25	**	0.20	**	0.06	**	0.37	**
	0.02		*0.02*		*0.01*		*0.02*		*0.02*	
CONSTANT	-1.44	**	-1.09	**	-0.89	**	0.5	**	-0.53	**
	0.10		*0.08*		*0.07*		*0.12*		*0.07*	
Rho									0.12	**
Frontier, Activities									*0.03*	
Rho	0.18	**								
Network, Hosting	*0.03*									
Rho	0.57	**								
Network, Web	*0.02*									
Rho	0.35	**								
Hosting, Web	*0.03*									

Table 5
Estimates for Random Effects, Bi-variate Probit models
Analysis Sample of 2089 ISPs
Standard Errors below Estimates

	Trivariate Probit						Bivariate Probit			
	Network		Hosting		Web		Frontier		Three Activities	
EXPERIENCE	0.23	**	0.00		0.01		-0.04		0.11	
	0.08		*0.07*		*0.07*		*0.07*		*0.07*	
COMMUNICATION	0.69	**	-0.01		0.03		0.76	**	0.34	
	0.34		*0.34*		*0.34*		*0.30*		*0.40*	
COMPUTERS	1.17	**	0.43	**	0.91	**	0.19		1.21	**
	0.15		*0.15*		*0.16*		*0.16*		*0.19*	
MISCBUSINESS	0.71	**	0.23		0.69	**	0.00		0.50	*
	0.31		*0.35*		*0.34*		*0.38*		*0.30*	
ONECOUNTY	0.21	**	0.10		0.02		-0.18	**	0.13	*
	0.09		*0.08*		*0.08*		*0.08*		*0.08*	
ONEAREA	-0.28	**	-0.08		-0.22	**	-0.58	**	-0.21	**
	0.07		*0.07*		*0.06*		*0.07*		*0.06*	
DIALUP							-1.00	**		
							0.24			
DEDICATED	0.50	**	-0.08		0.36	**			0.20	**
	0.14		*0.11*		*0.10*				*0.10*	
HANDHOLDING	0.16	**	0.26	**	0.19	**	0.04		0.35	**
	0.02		*0.02*		*0.02*		*0.02*		*0.02*	
URBAN	0.16	**	0.02		0.01		-0.02		0.07	
	0.07		*0.08*		*0.07*		*0.07*		*0.07*	
FRACPROF	2.48	**	0.23		1.60	**	1.37	**	1.42	**
	0.59		*0.54*		*0.50*		*0.54*		*0.50*	
Constant	-2.79	**	-1.15	**	-1.47	**	0.13		-1.20	**
	0.29		*0.25*		*0.23*		*0.33*		*0.23*	
Rho							0.14	**		
Frontier, Activities							*0.04*			
Rho	0.16	**								
Network, Hosting	*0.04*									
Rho	0.58	**								
Network, Web	*0.03*									
Rho	0.32	**								
Hosting, Web	*0.04*									

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

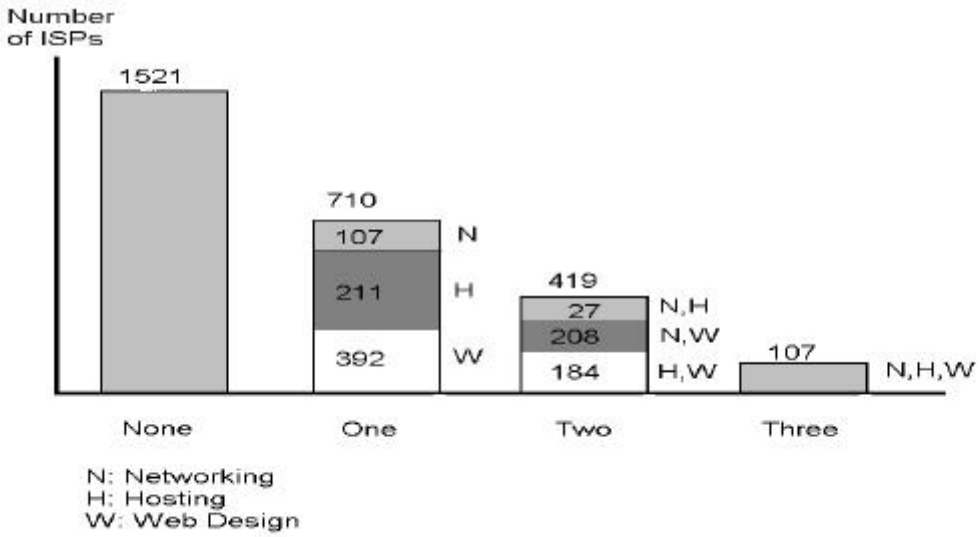
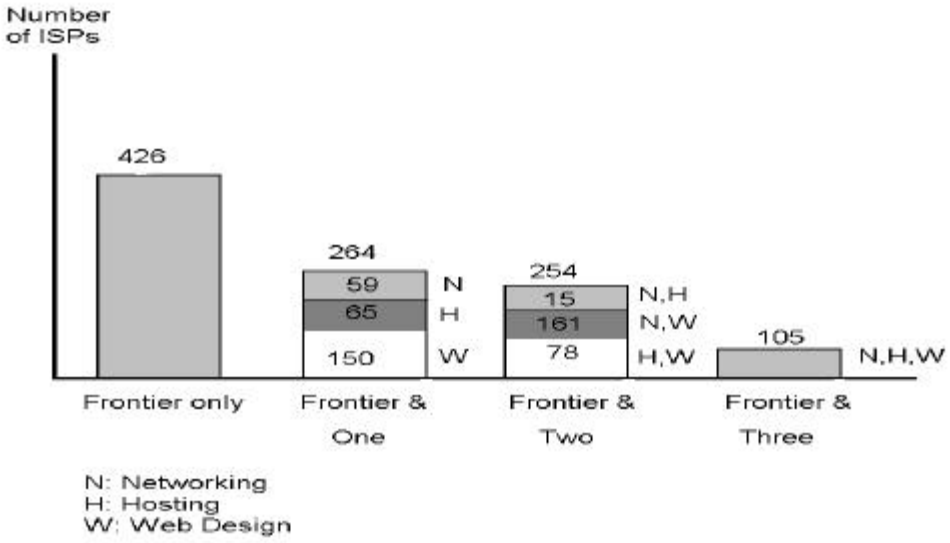
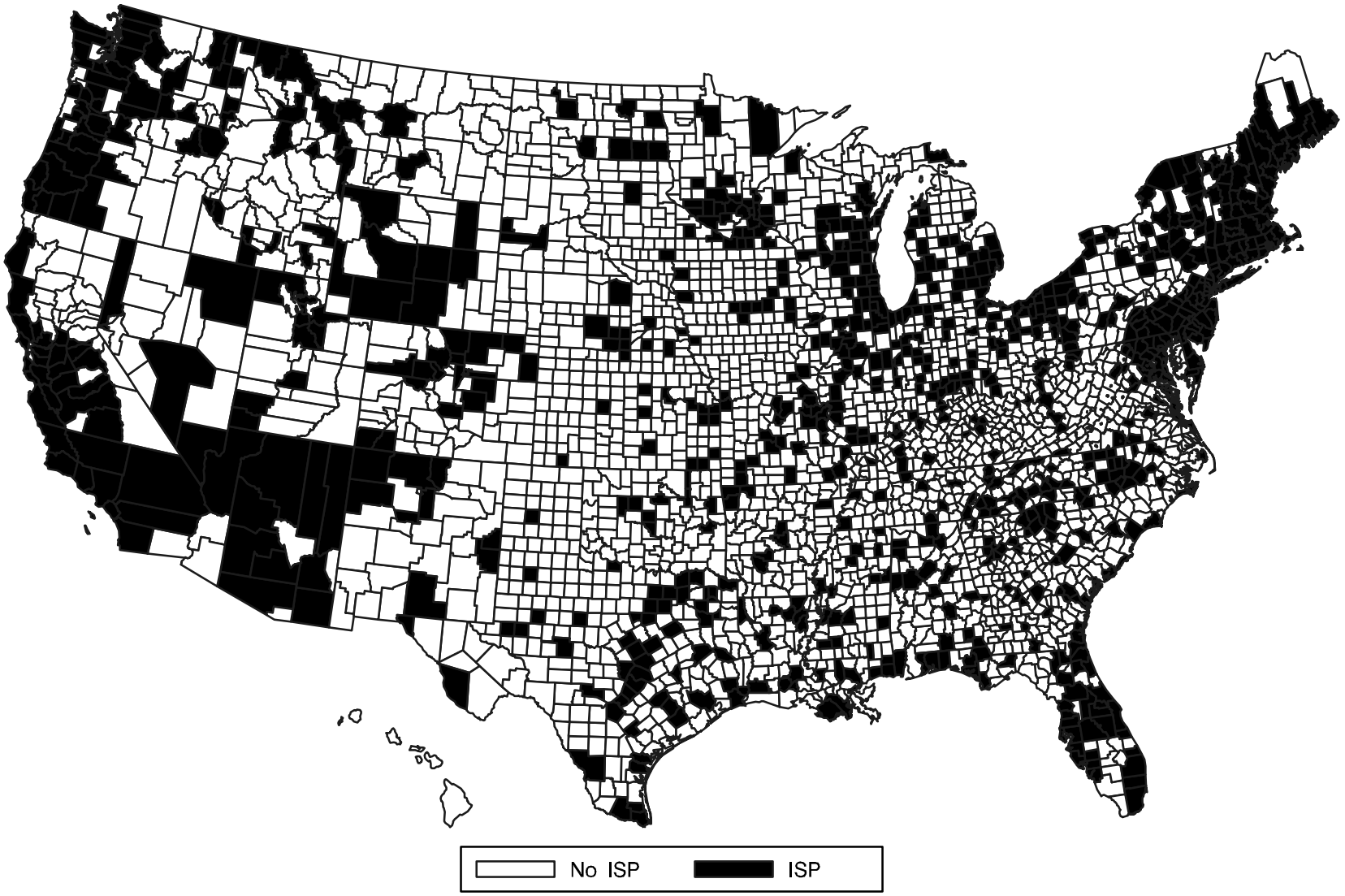


Figure 1b
Experiments with new services by ISPs with frontier access technology



Presence of ISPs in analysis sample



Appendix I: Data Definitions

A. Sample definitions

Basic dial-up and direct access were defined as either (1) dial-up access at speeds of 56k and slower or (2) direct access using T-1 lines and slower. Since almost all ISPs offer dial-up services and direct access to businesses,[1] an ISP was defined as providing frontier access when it offered T3, DSL, OC3, OC12, and any access rate above 1056k, and this included technologies that obtained such speeds with cable modems or wireless technologies.

Next I define networking services, hosting services and web design services, all of which are complementary to basic access. An ISP providing networking services, provides networking equipment on customer premises, WAN equipment, co-location networking services, LAN equipment, maintenance services, back-up services, networking software or groupware. Hosting includes generic hosting services (personal, business) and tailored services (anonymous ftp, bulletin boards, etc.). Web page development includes basic web functionality, active pages, design services, editing tools, security and firewall development, e-commerce design, or integration of web technology with a company's network.

Next, I and two research assistants examined all 3816 ISP's own advertisements about their lines of business. This method leaves room for judgement. When in doubt, I followed industry norms today, as represented in various industry technical dictionaries and on-line guides to technology. This approach has the virtue that it is replicable (e.g., the spread sheet describing this correspondence is available on request). It has the drawback that it required a novel "Internet access standard industry classification" scheme, analogous to the more familiar SIC code in GDP accounting, which requires some educated guesses about how to classify business lines.[2]

In total, my research assistants and I identified 6,795 unique phrases, many of which occurred repeatedly. Counting the repeats, a total of 35,436 such phrases was identified.[3] Since these phrases are self-reported by the ISPs, few norms organized the presentation of most phrases except for a few important exceptions.[4] We employed the common meaning of industry terms and then determined the line of business it represented, according to the categories listed above (e.g., frontier access, networking, hosting, web design, etc). All classifications used only displayed information, ascribing a line of business to an ISP when the determination was unambiguous (and throwing out the phrase otherwise). We were able to use 96% of all the phrases which appeared -- that is, 34,030 of

[1] As it turned out, it is the case that 3697 of the 3816 ISPs listed some type of basic dial-up service, while 3372 listed some type of basic direct access business. And every single ISP listed at least one of these. This initial finding further motivates the baseline comparison for frontier access.

[2] The issue in this type of work is over whether to group products and services together based on whether they are complements/substitutes in production or complements/substitutes in demand. In general, it is much easier to get information about complements/substitutes in production from interviewing ISPs and consulting trade dictionaries, etc. In addition, many ISPs themselves are unsure about complement/substitutes in demand for their users due to the immaturity of the market. Hence, this study tends to emphasize the production side.

[3] Identifying phrases is easier than it sounds since many ISPs do the same activities and almost always call it the same thing. Most ISPs listed their non-access activities in addition to the access activities, as well as listing their support for many of the same products and protocols. A "phrase" was typically delimited by a comma or a change in line, which also aided identification. We began with 7,893 phrases and reduced it to 6,795 by eliminating simple capitalization and punctuation differences.

[4] Access speeds are standardized for the most part, as are packaged software products. Less standardized are the phrases that accompany the activities of interest, such as educating users, providing advice about network design, and so on.

them.[5]

B. Exogenous Variables for the original sample

COMMUNICATIONS and COMPUTER are dummies which take on one if the ISP lists another line of business related to communications/computers and which does not use TCP/IP technology. I presume that an ISP who satisfies this requirement comes to the ISP business with prior experience in business lines other Internet access, a presumption that seems consistent with casual perusal of the data.[6] MISCBUSINESS takes on one if the ISP maintains another business lines unrelated to computers or communications or TCP/IP technologies. Most of these were copying, cafés and photography.[7] In all cases, the maintained hypothesis is that experience in other lines of business should make a firm more willing to experiment.

Other variables try to capture firm investments in durable assets which determine its disposition to experiment with new lines of business. Each set of estimates tries two different measures of geographic dispersion, which, as earlier noted, is the only available measure of firm size. ONEACODE takes on the value one if the ISP maintains service in only one area code, as indicated in *thelist*. Small geographic size indicates a focus on local customers and not a wide regional service territory. This may also indicate lack of access to financial capital to expand, which should discourage experimentation. MORETHAN20 is a dummy for presence in more than 20 area codes. This indicates a decision to provide services on a national scale, typically focusing on urban centers. This may also signal that the ISP is exposed to considerable national competitive pressures.

Each specification tries two dummy variables, DIALUP and DEDICATED. DIALUP takes on the value one when an ISP offers any dialup service, which 98.3% do in some form in the analysis sample. DEDICATED takes on one if the ISP offers any direct access, which 90.5% do in some form. The lack of any dial-up service is a sure sign that an ISP does not intend to offer service to a residential market, focusing exclusively on business users. The lack of any dedicated service indicates that the ISP is not likely to offer any high-speed service, rendering it almost impossible that they also offer frontier access other than cable modems and a few other highspeed wireless services. It may also signal the lack of technical expertise within the ISP. Hence, DIALUP should predict less experimentation with non-basic access and DEDICATED should predict more. In practice, every model except the bivariate probit includes both variables. In the bivariate probit, the frontier probit includes only DIALUP and the complementary probit includes only DEDICATED.[8]

Finally, I include a variable labeled HANDHOLDING. This counts the number of "useful phrases" in the basic access category. More precisely, an ISP's advertisements may refer to technologies and services that typically

---

[5] This high success rate is somewhat a result of the standardization which *thelist* imposes on the first part of their survey, which covers some aspects of the on-line and direct access businesses of ISPs. In classifying the non-access parts of the business, the success rate was between 80% and 90% depended on how one counts it. .

[6] COMMUNICATIONS includes selling cellular telephones, fax machines and long distance voice service. COMPUTERS includes selling PC hardware, software and repair services. Both of these are activities that firm likely did prior to entering the access business. Some ISPs also advertise services such as Internet fax, Internet telephony and so on. These latter offerings are not part of this measure because they are not plausibly exogenous.

[7] Indications about whether the ISP offers “consulting” services were also collected, though the phrases about consulting were often quite vague and lacked specifics. A dummy for unspecific consulting turned out to be almost a perfect predictor for offering at least one of the networking, hosting and web design businesses. This seemed to be an artifact of the data collection methods and hence, was not useful.

[8] Not surprisingly, DIALUP is a perfect predictor for experimentation in complementary services and DEDICATED is a perfect predictor for experimentation with high speed access. Hence, only one is included in each side of the bivariate probit.

accompany the provision of basic access, such as email, shell accounts, domain name registration, search engine registration, portal links, Real Audio and video, push technology, FTP, Telnet, Gopher, Archie and so on. Virtually every ISP has to support these technologies and services in some form as a requirement for being in the access business. Explicitly listing them indicates something about an ISP's willingness to make basic access technology easy to use for its customers (e.g., making them downloadable, offering to help with software installation, etc.). Since listing these services also involves advertising technology and services which all technologists will take for granted, this variable may also indicate an effort to market to first-time users who may not be familiar with the most basic features of Internet access. With either of these two interpretations, HANDHOLDING should positively predict the provision of all types of activity except the provision of frontier access. An alternative interpretation is that HANDHOLDING partially picks up an ISP's disposition to "talk" about itself in its advertisements, even when the subject is something mundane, such as basic access technology. With this last interpretation, HANDHOLDING should predict the provision of all activities including frontier access.

C. Exogenous Variables for Analysis Sample

COMMUNICATIONS, COMPUTER, MISCBUSINESS are defined as stated in the text. In addition, EXPERIENCE is a dummy which takes on one if the ISP was listed in *thedirectory* in the spring of 1997, more than a year earlier than the survey in *thelist*. In addition, EXPERIENCE is a dummy which takes on the value one if the ISP was listed in *thedirectory* in the spring of 1997, more than a year earlier than the survey in *thelist*. Over a year's experience in the ISP business could contribute to learning about local demand and about how to provide new service offerings. Because ISPs do not list their founding date, this is the only available measure of experience in the access business. In practice, since there has been so much recent entry, EXPERIENCE is virtually equivalent to "not a very recent entrant."

DIALUP, DEDICATED and HANDHOLDING are defined as stated in the text. ONEAREACODE is the same as before. ONECOUNTY takes on the value one if the ISP maintains service in only one county, as indicated in *thedirectory*. The latter is measured by where the ISP offers local dial-up service or maintains a headquarters (see Downes and Greenstein [1998] for detail). There was no *a priori* reason to favor one measure over another. Hence, both were tried.

There are five different measures of competitiveness which were tried, only a few of which are shown in the text. URBAN takes on a value between zero and one, where this number reflects the average number of urban counties in which the ISP offers local dial-up service or maintains a headquarters. A county is urban if it fits under the broadest definition for urban within the US census. For most ISPs this number is either zero or one. Downes and Greenstein [1998] show that urban areas have attracted many varied types of competitors. Thus, buyers in urban areas have access to more substitutes and ISPs have more competitors. This competitive environment should motivate any ISP in an urban area to experiment.

Second, THREENAT is a dummy that takes on one when there are more than three national firm in the same county as this ISP. Since national firms are likely to experiment, as noted in table 1, the presence of three virtually guarantees some competition for a local firm. In practice, since virtually every urban area has many national ISPs, this variable tends to strongly overlap with URBAN, but covers a slightly smaller set of urban regions. Because the population thresholds which induce entry of several national ISPs exceeds the population thresholds which induce several local and regional ISPs to enter, virtually every area with more than three national ISPs already has many local and regional ISPs. In such a setting, virtually all the small ISPs in the analysis sample will be "fringe" firms. Third, THREELOCAL is a dummy that take on one when there are more than three local/regional ISPs in the same county as this ISP. More than three competitors was chosen because three local firms approaches a degree of competitiveness where local market power declines. In practice, this variable captures the difference between counties with the thinnest demand in this data set and those with enough population to support at least a few ISPs.

RBOC and GTE are dummies which take on one if the ISP serves a county in which a regional bell operating company or GTE is the dominant local telephone firm (See Greenstein, Lizardo and Spiller [1998] for sources). These companies are both providers of backbone telecommunication services and potential competitors in

the Internet access market. If the RBOC and GTE offer better backbone services than independents telephone companies, then this might make it easier for ISPs to experiment, especially with frontier access. More likely, these companies serve as potential competitors for advanced data-transport services, which should motivate ISPs to get into frontier access as a competitive response. In practice, RBOC tends to strongly overlap with URBAN, while GTE tends to overlap with the areas for which URBAN is zero.

URBAN, NATIONAL, THREELOCAL, RBOC, and GTE overlap. There was no *a priori* reason to favor one measure over another, nor to rule out the possibility of cumulative effects. I favored testing these hypotheses in a flexible way, so all were included. It was found that URBAN was the only factor that ever obtained significance in any specification. Hence, the others were all dropped.

Several variables describe the county (or counties) in which the ISP locates. These variables attempt to capture population characteristics which influence the demand for Internet services. The specification of these variables was inspired by micro studies of household and business demand for computing, PCs and Internet services.[9] However, at best these measures only discuss average features of an area in which an ISP is located.

Four fractions between zero and one describe the demographic age of the population. One covers ages 22-29, another 30-39, another 40-64, and another over 65. Two fractions, PCHOME and PCWORK, describe the fraction of households who have adopted a PC at home and who use one regularly at work, as found by PNR associates in a 1997 survey of over 30,000 households (see, e.g., Kridel et al [1997]). These tend to be highly correlated with FRACPROF, a fraction between zero and one which describes the fraction of the population which works in white collar work (see Downes and Greenstein [1998]).[10] CSITE is the total number of respondents to a survey of large scale computer use in 1992 divided by population (see Greenstein, Lizardo and Spiller), which indicates the presence of many (presumably technically sophisticated) local MIS users. The maintained hypotheses is that more PC use at home and work supports a broad demand for many Internet services, both to the home and to businesses nearby. In practice, FRACPROF was the only variable that obtained significance in any of these specifications. Hence, the others, which were highly correlated with FRACPROF, were dropped.

The last variables are UNIVERSE1, UNIVERSE2 and UNIVERSE3, all of which are dummies that measure the presence of at least one university in the county in which the ISP provides service.[11] These variables test the belief (held by many within the research community) that universities have had a strong positive spillover on the commercial Internet industry. UNIVERSE1 takes on one if there is at least one research university in the county which maintains a PhD and graduate program, according to the Carnegie rankings of universities. UNIVERE2 takes on one if there is at least one university which maintains a graduate but not PhD programs. UNIVERSE3 takes on one if there is at least one university which maintains an undergraduate program, but no graduate programs.[12] Due to the non-commercial origins of the Internet industry, universities may still act as demanders for Internet services, may still act as competitors for the delivery of some Internet services, or may still act as supplier of employees and new entrepreneurial talent in the Internet business. Under the maintained hypotheses, these coefficients should be positive.

---

[9] For example, Bresnahan and Greenstein [1997], Downes and Greenstein [1998], Clement [1998], and Goolsbee and Klenow [1998].

[10] In practice, FRACPROF correlates highly with education, income and some types of white collar work in a region, rendering these other demographic measures redundant. I also experimented with several measures of the strength of the local financial, insurance and real estate markets, but did not find any of them useful.

[11] Special thanks to Tom Downes for collecting these data and bringing them to my attention.

[12] I also tested specifications that used the enrollment in engineering and computer science programs in these universities and found no qualitative difference.

Appendix II: Internet Access Industry Product Code

Endogenous Variables: **Basic Access = 110-115, High speed access = 116 -118, Networking = 210-234, Hosting = 310-325, Web Development = 410-422**

Exogenous Variables: **Hand holding = 121-127, Telecommunications = 510, Computers = 610-632, Misc = 810-850**

(100) Access set up, service, and maintenance

(110) Providing and servicing access through different channels

(111) Analog access
(112) ISDN access
(113) Nationwide and worldwide dial-up (800 numbers)
(114) WebTV access
(115) Wireless access
(116) Generic dedicated internet access (e.g., T1)
(117) Access through cable modems
(118) "Frontier" dedicated internet access (e.g., T3, DSL)

(120) Providing basic functionality associated with access

(121) E-mail and e-mail functionality
(122) Necessary complementary technology (e.g.,Shell accounts, PPP/SLIP/CSLIP)
(123) Domain name registration
(124) Internet search engine registration
(125) Links to portals and directories (includes Newsgroup access)
(126) RealAudio and Video
(127) Old access technology (e.g., FTP, Telnet, Gopher, Archie)

(130) Advanced functionality associated with access

(131) Online games
(132) Chat room
(133) Video conferencing
(134) Screening services

(200) Network, set-up, service and maintenance

(210) Providing and installing network equipment on customer premises

(211) WAN installation
(212) Network colocation services
(213) Network consulting associated with installation
(214) LAN installation

(220) Maintenance of network facilities on customer premises

(221) Network maintenance
(222) Dedicated line maintenance
(223) Backup/restoration of data

(230) Networking and server software

(231) Lotus Notes
(232) SQL
(233) Novell
(234) Windows NT (installation and service)

(300) Web site hosting

(310) Providing basic and generic hosting services

(311) Business/page Web page hosting

(312) FTP Server hosting
(313) Personal/undifferentiated hosting
(314) Ancillary hosting services

(320) Providing tailored hosting services (i.e., hosting customized to specific application)

(321) Advertising hosting
(322) Hosting a virtual mall/virtual stores
(323) Hosting a bulletin board
(324) Hosting a special interest information page
(325) Online catalog

(400) Web page development and servicing

(410) Providing generic and basic WWW functionality

(411) Activepages (e.g., Shockwave, ActiveX, NetShow, VR, QTVR, etc.)
(412) Basic design and programming
(413) Advanced programming, excluding Activepages (e.g., CGI scripting, Java, Perl)
(414) Editing tools for customers (e.g., Microsoft FrontPage)
(415) Security and firewall development

(420) WWW development and service tailored for business and administrative processes

(421) Internet commerce: retailing/procurement
(422) Business Stuff

(500) Telecom services

(510) Providing traditional communication services

(520) Providing traditional communications services using TCP/IP technology

(521) Internet telephony
(522) Convergent technologies

(530) Cable telephony

(600) Computer hardware and software sales, maintenance and service

(610) Providing computer equipment

(620) Servicing computer equipment

(630) Software design and service

(631) Software design and services, n.e.c. (includes custom software, programming)
(632) Packaged software installation and service

(700) Training

(800) Services not elsewhere classified

(810) Television services

(811) Cable television
(812) Satellite television

(820) Copy services

(821) Photocopying
(822) Faxing

(830) Multimedia services

(822) Document scanning
(823) Converting movies to films
(824) Convert catalog to CD-ROM format

(840) Cafés and meeting places

(841) Food and beverages
(842) Books

(850) Newspaper