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BUILDING AND DELIVERING THE VIRTUAL WORLD: COMMERCIALIZING SERVICES FOR INTERNET ACCESS*

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This study analyzes the service offerings of Internet Service Providers (ISPs), the commercial suppliers of Internet access in the United States. It presents data on the services of 2089 ISPs in the summer of 1998. By this time 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. Most of the explained variance in behavior arises from firm-specific factors, with some evidence of location-specific factors.

I. INTRODUCTION

HOW DO VENDORS CONSTRUCT viable and on-going economic entities in an evolving and technically-intensive marketplace? This study sheds light on these processes through analyzing the services at 2089 Internet Service Providers (ISPs) in the summer of 1998. This study investigates the propensity of an ISP to offer services other than routine and basic access.

II. 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.

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The NSF worked toward commercializing the Internet, completing this in 1992. By 1993 the Internet connected more than one million hosts, though lack of a user-friendly interface meant that its use was confined largely to sophisticated users in scientific, educational, and military institutions. The World Wide Web protocol, allowing easy exchange of data between computers using a graphical interface, began a few years earlier with the invention of the URL and html. Browser software became available in 1993 beginning with Mosaic, the ancestor and model for Netscape, Internet Explorer and other browsers.[1]

Commercial Internet Service Providers began publically quoting prices in Boardwatch magazine in 1994 (Boardwatch [1994]). Some firms were also offering small commercial accounts prior to that, employing technical refinements developed over many years at academic modem pools and commercial bulletin boards. In the early years it was possible to run a small ISP on a shoe-string in either an urban or a rural area. These firms were devoted primarily to dial-up. However, this changed as the industry grew at an explosive pace. Consequently, by the summer of 1998, the time of this study, there were dozens of well-known national networks and scores of less-known national providers 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 [1999] for detail). Over 92% of the US population had low cost access to a competitive market for commercial ISPs.

This explosion of entrants and the resulting geographic pervasiveness came about because 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 registration and other traffic functions, and a connection to the Internet.[2] 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 at least learn them quickly. As a result, a simple dial-up service was inexpensive to operate and a web page was quite easy to develop. Hence, many entrepreneurs took to the technology. So too did many personnel from incumbent firms in related markets, such as bulletin boards operators and personnel in computing services.

[1] For more on the commercialization of the Internet, see Greenstein [2000a].

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

III. DETERMINANTS OF BUSINESS MODELS IN TECHNOLOGY-INTENSIVE MARKETS

Different firms offer different arrays of services in their attempt to differentiate from common competitors and in order to create temporary rents. These choices respond to varying firm-specific assets or other competitive factors. Bresnahan *et al.* [1997] demonstrate similar processes in their study of the PC industry, where firms try to push technical frontiers, develop brand names or combine recent technical advances with less technical businesses in unique ways. A similar line of reasoning appears frequently in ISP trade publications, where analysts distinguish between two types of activities other than basic access: high speed access and complementary services.

High-bandwidth applications offer greater value to consumers, but present many technical issues 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. *Offering services that are complementary to basic access* helps retain or attract a customer base. Many ISPs instead tried to develop additional services, such as filtering, hosting, web-design services and network maintenance for businesses. Some of these were quite costly, as they had to be properly assembled, maintained, and marketed. At the time many of these services pushed the boundaries of existing telecommunications and computing market definitions.

Why do firms make different choices? *Differences* across firms arise when decision makers face different demand conditions, different quality of local infrastructure, different labor markets for talent, or when they inherit firm assets of differing quality. These create a variety of economic incentives for adapting Internet infrastructure to new uses and applications. I examine the relative contribution of firm specific and location specific factors.

A well-known line of research about firm behavior in evolving markets emphasizes the number of firm-specific factors shaping the incentives to bring new technology into use (See, e.g., Demsetz [1988] or Nelson and Winter [1977] for a summary). In this instance, ISPs came to the new opportunities with different skills, experiences and commercial focus. In the face of considerable firm-specific commercial uncertainty, ISPs purchased and installed their own capital equipment, publicized brand and service agreements, and made other long-lasting investments. Many of these investments could commit the ISP to a particular array of services, even before market demand was realized or new commercial opportunities were recognized. Many such investments also foster economies of scope across old and new services or between clusters of new services.

Another well-known line of economic research, dating at least to Griliches [1957], has emphasized the geographic dispersion of the determinants of incentives to adopt new technology. Geographic variation

arises for many reasons. For example, while basic dial-up access is widely available in all urban areas and many rural areas, there is great variance in market structure on a local level. Some areas have low densities, precluding data services which require a minimum scale. Dense urban areas contain more suppliers from a wide variety of backgrounds, while less dense areas contain few suppliers, fostering differences in competitive pressures. In addition, many ISPs deliberately customize frontier technology to the needs of enterprises doing business at a specific time in a specific place, trying to establish long-lasting relationships with a nearby customer base. The costs and benefits of this approach may vary by region. Infrastructure differs by regions, so too does demand, as sophisticated users are unevenly distributed across geographic regions.

IV. DATA

IV(i). *Generating the Sample*

With the help of research assistants, I examined the business lines of 3816 Internet service providers in the United States who advertise on *thelist*.[3] This site, maintained by Meckler Media, allows users to compare ISPs by displaying firms' answers to a quesionnaire. From this original sample, which Greenstein [2000b] examines, I dropped all firms which operated in more than twenty area codes or five counties, or could not be matched with a listing from 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, 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.[4] For the sake of accuracy, I also required that the ISP list the same domain name for the home page in both *thedirectory* and *thelist*. That left 2089 small and medium sized ISPs, for which it is possible to identify both firm and location specific determinants. The sample is comprised of small firms so I could identify local conditions for each firm.[5]

By construction every firm in the sample provides some amount of dial-up or direct access and basic functionality, such as email accounts,

[3] For details see the appendices at the *Journal*'s editorial web site, http://www.stern.nyu.edu/~jindec/.

[4] 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 [1999] for further detail.

[5] 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 [1999] data. However, verifying these matches was tedious and potentially subjective, rendering it almost infeasible. See Greenstein [2000b] for further details.

shell accounts, IP addresses, new links, FTP and Telnet capabilities. It contains many observations from ISPs in rural areas, but 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). In addition, this sample does not examine firms who offer non-basic services but who do not offer basic access. Nonetheless, the sample provides a fairly good representation of small ISPs. Comparisons of the 2089 ISPs in the analysis sample with the roughly 5400 small ISPs in Downes and Greenstein [1999] showed little difference in the features of the service territories. Differences between this sample and a sample of national firms are highlighted in Greenstein [2000b].[6]

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. This is illustrated on a map where a county is blackened if it contains at least one ISP from the sample.[7]

IV(ii). *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. Any classification system for an evolving industry will necessarily reflect the judgement of contemporary trade literature. As in Bresnahan *et al.* [1997], some points of differentiation, such as being on a frontier, are necessarily defined in a way that eventually becomes dated. This will also be true of some of the complementary services, particularly those related to electronic commerce, which are rapidly changing at the time. Hence, the situation presents a number of challenges for measurement. Precise definitions are necessarily fleeting, even those most relevant to contemporary firms and users.

Based on contemporary magazines, I grouped services into five broad categories: basic access, frontier access, networking, hosting, and web page design. These broad categories provide a feasible and consistent view of economic activity of ISPs, emphasizing which activities push out frontier access and which provide services complementary to access. Since only coarse information was available about the characteristics of demand, these categories generally reflect contemporary supplier's view of how activities should be grouped together. See Figure 1 for the complete description.

[6] For example, in the 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 data set and in the sample correlates at 0.94, as one would expect if the 2089 ISPs were nearly a random selection.

[7] The map may be viewed at the *Journal*'s editorial web site, http://www.stern.nyu.edu/~jindec/.

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

(320) Providing tailored hosting services (i.e., hosting a 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

Figure 1
Internet Access Industry Product Code

(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 software design
(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) Newspapers

Figure 1 *Continued*

- *Basic access* constitutes any service slower than and including a T-1 line, including fractional T-1. 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, that is, it also includes ISPs, who offer parts of their own 'backbone' as a resale to others.

- *Networking* involves activities associated with enabling Internet technology at a user's location. All ISPs do a minimal amount of this as part of their basic service in establishing connectivity. However, an extensive array of these services, such as regular maintenance, assessment of facilities, emergency repair, and so on, are often essential to 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 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 information provision, site-analysis tools, and some services related to the conduct of electronic commerce.
- *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 other groups: traditional computing services (e.g., PC sales and service), traditional telecommunications (e.g., cellular phone sales and service), and miscellaneous services (e.g., copying, cafes and photography). While in practice these last categories were less common, the non-access lines of business of ISPs are revealing. For the most part, if an ISP advertises this business service, this was this firm's primary business before the firm became an ISP.

Once again, accuracy took precedent over other considerations. I will only record a service line if the ISP clearly states it as such. In practice, 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 and frontier access. In general, these methods should *undercount* the offering of any particular service line since many phrases were uninformative.[8] In addition, the lines between different

[8] 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

TABLE I
PRODUCT LINES OF ISPS

Category definition	Most common phrases in category	Sample[a]
Providing and Servicing Access though Different Channels	28.8, 56k, isdn, web TV, wireless access, T1, T3, DSL, frame relay, e-mail, domain registration, news groups, real audio, ftp, quake server, IRC, chat, video conferencing, cybersitter TM	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	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	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	757 (36.2%) *Rural ISPs (23.3%)*
High Speed Access	T3, DSL, xDSL, OC3, OC12, Access rate > 1056k	514 (24.6%) *Rural ISPs (12.0%)*

[a] Top number is for all 2089 ISPs in analysis sample. *Italicized* percentage is for the 325 ISPs found primarily in rural areas. See Figure 1 for definitions: Basic Access = 100–115, Networking = 210–234, Hosting = 310–325, Web Development = 410–422, High Speed Access = 116–118.

services are often, but not always, sharp. This warrants a cautious interpretative approach, because ambiguities in definitions naturally arise.

Table I lists the most common phrases for each line of business.[9] By definition, every ISP has at least one useful phrase indicating activity in the access business. An ISP could be in no service other than basic access, one other service or more than one. On average, an ISP had 8.6 useful phrases (standard deviation of 4.6, maximum of 40).

phrases which only appeared once with one firm, defying general characterization. There were 1105 such phrases (and 6795 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'.

[9] The entire list of phrases and the correspondence table are available from the author on request.

TABLE II
PRODUCT LINES OF ISPS

		Network, Hosting, and Web Design		
		Offers	Does not	Total
High Speed Frontier Access	Offers	314 (15%)	200 (10%)	514
	Does not	736 (35%)	839 (40%)	1575
	Total	1050	1039	2089

IV(iii). *The Service Lines of ISPs*

Table I shows that, of the 2089 firms in the sample, 1260 (60%) have at least one line of business other than basic dial-up or direct Internet access, 514 provide high speed access, 440 networking, 460 web hosting, 757 web page design. For such a cautious method, this reveals quite a lot of non-access services by firms in the access business.[10]

Table II 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., Kalakota and Whinston [1996]), 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 rivals. Many of these services require 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 technical reason for it.

The fraction of firms in networking, hosting, and web design is higher among those with high speed access, but the relationship is not as strong as perhaps one might think. Of the 514 in high speed access, 314 (61%) provided networking, hosting or web design. By comparison, of the 1575 not providing high-speed access, 200 (12.6%) did so. Similarly, of the 1050 providing networking, hosting or web design services, 314 (30%) provided high speed access. Of the 1039 not providing networking, hosting and web design, 200 (19.2%) provided high speed access. Further comparisons of different lines of business are in Greenstein [2000b].

[10] 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.

Table I shows the contrast between urban and rural areas.[11] 1764 ISPs primarily serve urban areas. Of the 1764 ISPs, 26.9% offer frontier access, 22.9% offer networking services, 23.5% offer hosting services, and 38.6% offer web design services. 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 for rural ISPs are between 40% and 60% lower in each category. A test for difference of means between urban and rural ISPs rejects the hypothesis that the propensity is the same between the urban and rural samples of ISPs. This holds for every type of activity.

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.*

V. THE DETERMINANTS OF NON-BASIC SERVICES

The above tests are unconditional comparisons. To control for firm-specific and location-specific factors, I estimate a trivariate probit analysis of the propensities to provide networking, hosting,and web design, and a bivariate probit analysis of the propensities to provide at least one of these three complementary services, and the propensity to provide frontier access. After considerable exploration in early versions of this study, it was found that most of the importance of different determinants can be characterized with these two straightforward models.

The *firm specific factors*, which are represented as a set of dummy variables, measure attributes that generally tend to cluster together, partly due to economies of scope and partly due to a firm's focus on particular markets. EXPERIENCE indicates the ISP was listed in *thedirectory* in the spring of 1997, more than a year earlier than the survey in *thelist.* Since there were roughly two thousand new entrants in 1997 and 1998, it measures whether a firm was an early entrant into the ISP business. COMMUNICATIONS, COMPUTER and MISCBUSINESS indicate that the ISP lists another, non-TCP/IP based line of business, related to communications, computers (e.g., typically a retail outlet for purchases or service) or some other industry (e.g., retail outlet for photocopies or a cafe). HANDHOLDING counts the number of times an ISP advertises its ability to do simple tasks such as e-mail, filtering, downloading, name registration, and so measures the attempt to make basic access technology easy to use for non-technical customers. NODIALUP indicates that an

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

TABLE III
DESCRIPTIVE STATISTICS FOR THE ANALYSIS SAMPLE
2089 ISPs

	MEAN	STD DEV	MIN	MAX	SOURCE[a]
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*
MULTICOUNTY	0.206	0.405	0.000	1.00	*Thedirectory*
MULTIAREACODE	0.489	0.500	0.000	1.00	*Thelist*
DEDICATED	0.905	0.293	0.000	1.00	*Thelist*
NODIALUP	0.016	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

[a] *Thedirectory* is www.thedirectory.com. *Thelist* is www.thelist.com. Census is the US Census. D&G is Downes and Greenstein [1999]. See Figure 1 for definitions: Hand holding = 121–127, Telecommunications = 510, Computers = 610–632, Misc = 810–850.

ISP does not offer 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 and its presence indicates a better capital stock.[12] The geographic reach of an ISP is measured by MULTIAREACODE and MULTICOUNTY, which equal one if the ISP maintains service in more than one area code, as indicated in *thelist* and more than one county, as indicated in *thedirectory*, respectively.

The *location-specific factors* are URBAN, the percentage of urban counties in which the ISP offers local dial-up service or maintains a headquarters, and FRACPROF, the fraction of the population in white collar work (see Downes and Greenstein [1999]). URBAN, by itself, supports several interpretations, including local market competitiveness, density of available customers, and the quality of local infrastructure. Likewise, FRACPROF, although ostensibly measuring local differences in demand, might also be capturing other demographic elements, including income, and education. Early specifications included more detailed measurement of demographic features of areas, infrastructure, competitiveness and the presence of universities in the county in which the ISP provides service, but these were not statistically different from zero, mostly due to multi-

[12] Both NODIALUP 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.

collinearity. For brevity, they were dropped in favor of URBAN and FRACPROF. See the Appendix for detail.[13]

Since FRACPROF coincides only partially with the urban/rural categorization (it has a mean of 0.41 for ISPs in urban counties, and a value of 0.32 for those in rural counties), it can identify urban/rural differences which arise due to demand instead of other factors, such as competitiveness and density.

Table III includes summary statistics for all exogenous variables, as defined below.

VI. RESULTS

Table IV presents estimates for the models. The first, second and third columns are the trivariate model and the last two columns are the bivariate probit.

The absence of a dial-up capability reveals an ISP that 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 NODIALUP is dropped from the complimentary side of the bivariate probit and all the estimates in the trivariate probit.

Table V presents changes in the predicted probabilities which result from setting the variable of interest to its minimum, holding all other variables and coefficients at their estimate values.[14] The table provides the average over the difference across all 2089 observations in the sample.

VI(i). *Description of Findings*

NODIALUP is positive 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 sample has no dial-up capability, so it is a good predictor for only a small number of cases. The change in predicted probabilities in Table V reflects this fact. DEDICATED is positive and significant in the complementary activity

[13] See the appendices at the *Journal*'s editorial web site, http://www.stern.nyu.edu/~jindec/.

[14] For all the dummy variables, this is equivalent to measuring the change in probabilities from setting the coefficient to zero. The equivalent procedure for continuous variables is to set the variable at its minimum and compare the change in probabilities over the sample. For HANDHOLDING the min is zero; for FRACPROF the min is 0.17.

TABLE IV
ESTIMATES FOR TRIVARIATE AND BIVARIATE PROBIT MODELS
2089 ISPs
Standard Errors below Estimates in Italics

	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*
MULTICOUNTY	−0.21**	−0.10	−0.02	0.18**	−0.13*
	0.09	*0.08*	*0.08*	*0.08*	*0.08*
MULTIAREACODE	0.28**	0.08	0.22**	0.58**	0.21**
	0.07	*0.07*	*0.06*	*0.07*	*0.06*
NODIALUP				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*				

part of the bivariate, indicating that the investment in some dedicated capabilities predicts more new services. It also matters for networking and web design, but not hosting. Since almost 10% of the sample has no dedicated capability, Table V shows that it does not change the predicted probability much on average.

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.

TABLE V
AVERAGE CHANGES TO PREDICTED PROBABILITIES FROM EXCLUDING VARIABLE[a]
2089 ISPs

	Trivariate Probit			Bivariate Probit	
	Network	Hosting	Web	Frontier	Three Activities
EXPERIENCE	0.041	0.000	0.001	−0.010	0.027
COMMUNICATION	0.002	−0.000	−0.000	0.002	0.001
COMPUTER	0.013	0.005	0.011	0.002	0.013
MISCBUSINESS	0.002	0.001	0.002	0.000	0.001
MULTICOUNTY	−0.012	−0.005	−0.001	0.012	−0.009
MULTIAREACODE	0.037	0.011	0.038	0.088	0.037
NODIALUP	—	—	—	0.004	—
DEDICATED	0.098	−0.020	0.108	0.064	—
HANDHOLDING	0.044	0.076	0.067	0.011	0.119
URBAN	0.019	0.003	0.001	−0.002	0.010
FRACPROF	0.116	0.014	0.116	0.082	0.109
LOCAL-SPECIFIC	0.135	0.016	0.127	0.077	0.120
FIRM-SPECIFIC	0.209	0.068	0.229	0.083	0.257

[a] This table reports the mean across all observations of $\{P(Xb|x_i = \min x_i) - P(Xb)\}$, using estimated coefficients b, where $\min x_i$ is the minimum for the variable(s) of interest and all other X are held at their actual values. For dummies variables $\min x_i = 0$.

On average it changes the predicted probabilities more than any other firm-specific variable, reflecting the skewness and wide variance in HANDHOLDING and the large number of observations where HANDHOLDING exceeds zero. 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 consistent with the view 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 pattern of estimated coefficients on COMMUNICATIONS, COMPUTERS, and MISCBUSINESS in the bivariate probit indicate that experience in any other line of business is a good predictor of more new services in at least one type of complementary service, but, not surprisingly, only business in communications influences experimentation with high speed access. The trivariate probit reveals some interesting differences among the three complimentary services. All three predict networking services, COMPUTERS and MISCBUSINESS predict web design, but only COMPUTERS predicts hosting. Again, this is consistent with expectations: a firm selling or repairing PCs before the commercialization of the Internet is quite likely to expand its 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 caveat is that only a small percentage of the ISPs, have another (related) line of business, so most observations are not influenced by these estimates. The average change in predictive probabilities over the entire sample is small.

EXPERIENCE is insignificant in all estimates except for networking, where its effect is not very large on average. Taken together, the coefficients on MULTIAREACODE and MULTICOUNTY suggest that ISPs that operate over a small area are less likely to offer frontier service. However, the results are mixed or weak for complementary services.

The evidence for the importance of location-specific factors is mixed. URBAN is not significant except in the networking probit, but this estimate has a small effect on predicted probabilities. 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.

FRACPROF is almost always statistically significant and does influence predicted probabilities. However, these results needs a cautious interpretation. To be sure, several standard deviation swings in this variable influence predicted probabilities to an appreciable degree. Compared to an ISP located in an area with a low fraction of professionals (e.g., 0.17), one located in an area with a high fraction (e.g., 0.5), is more likely to offer frontier access, web design, and especially networking. However, the high average predicted probabilities partly arises because the counter-factual base is four standard deviations below the mean (i.e., min = 0.17 and mean = 0.39), a point of comparison which makes most of the observations look comparatively good.

VI(ii). *Overall Assessment*

The estimates strongly suggest that frontier access and other activities are not similar. The estimates lead to a sound rejection of equality of the coefficients on both sides of the bivariate probit, consistent with the modeling decisions to treat these two decisions as interrelated but separate. At only 0.14, the estimate for the correlation coefficient reinforces this conclusion.

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. Likewise, the correlations of pairwise errors in the trivariate probit are relatively high. Indeed, the correlation of 0.58 between networking and web design 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.

From this analysis several conclusions arise. First, there appears to be significant ISP-specific factors which cluster together with the choice to offer new 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. Third, while hosting is more similar to the other services than frontier access, it also has several differences, mostly importantly that it is influenced by few location-specific factors. 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 to become a national product, while, in contrast, networking and web design may retain a structure with both some national and some local suppliers.

In general, the location-specific variables have less importance than the firm-specific variables except in the frontier estimate, where both factors are important. Interestingly, some of the firm-specific variables—whose distribution does vary over geographic space—also helps explain some of the observed variance. This includes HANDHOLDING, COMPUTING, MISCBUSINESS and DEDICATED.[15]

These findings are consistent with the view that small ISPs choose strategies for differentiation based on firm-specific growth strategies, limited (possibly) by non-convexities arising at a local level. Basic service has some scale economies arising from capital equipment investment and other fixed costs on the back end, but these scale economies are not severe because small ISPs rely on existing telecommunications infrastructure. Frontier access is scale intensive, requiring higher volume of use and, therefore, is not profitable without large capital investments and a density of potential users, typically businesses comprised of professionals, a situation prevalent in urban areas and only a few rural areas. Networking and web design require a core mass of business customers to defray the costs of acquiring capital and maintaining sufficient technical expertise. These costs are also defrayed by some economies of scope among these services and between these and other lines of business.

These observations suggest the industry may obtain a bifurcated size structure in the long run. Many observers forecast consolidation around a few national providers who find economies of scale in a national service, perhaps consistent with the presence of endogenous sunk costs *à la* Sutton [1991]. However, small ISPs appear to be finding some economies of scope

[15] There is more hand-holding in urban ISPs (1.03 vs 0.64 on average), more experience with computing (0.01 versus 0.006), more experience with other business (0.012 versus 0.008), and differences in dedicated investments (0.90 versus 0.93)—albeit, these are not a large differences for the latter three.

between Internet access and another line of service, especially one with local elements such as high-speed access or networking service. These findings suggest that national service and local service may remain imperfect substitutes in the eyes of users. In that case, the industry could retain a mix of local and national firms.

VI(iii). *Differentiation, Density and the Growth in Evolving Markets*

The structure of the ISP business is shaped by the geographic diversity of local markets and the heterogeneity of firms who commercialize that technology. This dispersion shapes the customization of technology to new users and established businesses. This process is a source of great policy concern (Werbach [1997], Esbin [1998], Weinberg [1999]), as this relationship shapes the creation and targeting of subsidies associated with new services, such as the E-rate program, as proposed in the 1996 Telecommunications Act.[16]

While this data tends to support the view that there is a lower propensity for new services in low-density areas, any conclusion has to be carefully drawn. While the unconditional data document a difference in the propensity 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 new services because of two factors: (1) increased exposure to national ISPs, who expand their services more often;[17] and (2) the local firms in urban areas possess features that lead them to offer services with propensities similar to the national firms. That is, high density areas 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

[16] 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 not 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 inducing the offering of services which few want.

[17] The general features of the firm-specific variables for the local ISPs in urban areas resembles those for larger ISPs. Larger ISPs locate most of their points of presence in urban areas. In earlier experiments, no differences were found between the firm-specific variable means or variances for large ISPs or small ISPs in urban areas. See the appendices at the *Journal*'s editorial web site, http://www.stern.nyu.edu/~jindec/. 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.

areas benefit from repeated exposure to many ISPs who offer such services. More entrants will lead to more realized numbers of new services, raising the probability of finding one, two or three instances of new services in a specific location.

This is particularly evidence in the case when ISPs in urban areas have higher propensities to offer services, as in this data, because 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 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 offer services. 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 offer services in urban/rural settings results from these unobserved location-specific factors.[18] 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 of 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 fewer new services. 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 inclined to expand (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.

Hence, it is appropriate to be cautious about inferring causality. The tendency of firm-specific factors to cluster together can also result from

[18] 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.

the presence of an unobserved third variable, such as entrepreneurial ability, causing both the endogenous and exogenous variable to move together.

VII. CONCLUSION

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. Commercializing the Internet is difficult and adaptation is time-consuming. Many new services do not employ frontier technology at all. Indeed, much commercialization involves bending basic technology to the needs of unsophisticated 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 in the provision of services.

Commercializing Internet access gave rise to new business models, new cost structures and new applications. Like any other economic activity, not all firms were alike. Providing access involved a mix of the general technical capabilities and specific circumstances facing a particular firm in a particular place. ISPs customized Internet technologies to the unique needs of users and their organizations, solving problems as they arose, tailoring general solutions to idiosyncratic circumstances and their particular commercial strengths. Sometimes ISPs called this activity consulting, and charged for it separately, sometimes it was included as normal business practices. In either case, it involved the translation of general knowledge about Internet technologies into specific applications which yielded 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 provide empirical guidelines for understanding the variety of new services. Some services were shaped by previous ISP experience, while others were mildly responsive to local conditions. The factors which lead small ISPs to offer new services, such as large geographic scope, previous investments and strategic focus, are disproportionately found in urban areas.

This study raises questions about the nexus of industry evolution and organizational change. Will this industry retain its structure of small and large firms? How do the economies behind combinations of new services evolve as firms grow, add capital structures and alter their pricing strategies? Do hand-holding activities emerge from investments by firms and how does the local labor market for related activities, such as

computer services, foster its growth? These issues cannot be understood without further work on the fundamentals of demand and organizational change in Internet activities.

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