DEPARTMENT OF ECONOMICS

WORKING PAPER

2005

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Understanding Why Universal Service Obligations May Be Unnecessary: The Private Development of Local Internet Access Markets[1]

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July 2005

Abstract: This study analyzes the geographic spread of commercial Internet Service Providers (ISPs), the leading suppliers of Internet access. The geographic spread of ISPs is a key consideration in U.S. policy for universal access. We examine the Fall of 1998, a time of minimal government subsidy, when inexpensive access was synonymous with a local telephone call to an ISP. Population size and location in a metropolitan statistical area were the single most important determinants of entry, but their effects on national, regional and local firms differed, especially on the margin. The thresholds for entry were remarkably low for local firms. Universal service in less densely-populated areas was largely a function of investment decisions by ISPs with local focus. There was little trace of the early imprint of government subsidies for Internet access at major U.S. universities.

Keywords: Internet; Universal service; Geographic diffusion; Telecommunications

[1]This study was funded by the Institute for Government and Public Affairs at the University of Illinois and by a Mellon Small Grant in the Economics of Information at the Council on Library Resources. We appreciate comments from Amy Almeida, Tim Bresnahan, Linda Garcia, Zvi Griliches, Kristina McElheran, Scott Marcus, Padmanabhan Srinagesh, Pablo Spiller, Dan Spulber, Scott Stern, John Walsh, Wes Cohen, and many seminar participants. Howard Berkson, Heather Radach, Holly Gill, Helen Connolly, and Joshua Hyman provided excellent research assistance at various stages. We would especially like to thank Angelique Augereau for her extraordinary research assistance in the final stages. The authors take responsibility for all remaining errors.

I. Overview

Through a series of decisions in the 1980s and early 90s, policy makers in the Department of Defense and the National Science Foundation (NSF) decided to privatize investment for TPC/IP infrastructure, effectively commercializing the Internet. For most of the 1990s, the Internet developed through largely private, uncoordinated, and market-oriented investment.[1] Enough time has now passed to understand what transpired after privatization. In this paper we analyze an unintended outcome: commercial Internet access firms in the U.S. almost achieved a public policy ideal: universal geographic coverage.

This study analyzes the geographic spread of commercial Internet Service Providers (ISPs), the leading suppliers of Internet access. The geographic spread of ISPs was, and still is, a key consideration in U.S. policy for universal access. While all consumers had access to the Internet at some price, the key questions for public policy concerned the condition of small and medium adopters, who care about inexpensively acquiring access.[2] In this era inexpensive was synonymous with a local telephone call to an ISP. Hence, the number of commercial ISPs accessible via a local phone call determined whether a competitive, commercial Internet was readily available to a community.

We measure economic determinants of ISP availability. We construct and analyze a comprehensive measure of the number of suppliers for every county in the U.S. More specifically, we characterize the determinants of the location of over 60,000 dial-up access points (i.e., "points of presence" or POPs in industry parlance) offered by commercial ISPs in the Fall of 1998 in every county in the United States. We build an econometric model for predicting the

[1]These policies are well known. For summaries, see Webach (1997), Greenstein (2001), Cannon (2001), and Mowery and Simcoe (2002).
[2]This theme resonates throughout the literature. See e.g., Cherry and Wildman (1999), Compaine and Weinraub (1997), Compaine (2001), Drake (1995), Garcia (1996), Garcia and Gorenflo (1997), Kalil (1995), National Academy of Engineering (1995), National Research Council (1996), Strover (2001), Strover, Oden and Inagaki (2002), or Werbach (1997).

density of suppliers. Our model measures several factors: the importance of economies of scale, pre-existing demographic features of an area, pre-existing infrastructure for other communications technologies, and spillovers from universities.

Fall of 1998 was a good time for analyzing the determinants of the geographic coverage of ISPs. By this point, the industry's structure was no longer changing every month. Most of the leading firms had been in the ISP market for a few years, making it possible to document their strategies, behavior, and commercial achievement. More to the point, the geographic dispersion of access and conditions of supply were similar throughout most of 1998. This arose despite continued entry and exit, as well as some hints of -- but little movement towards -- consolidation of ownership of supply.

Fall of 1998 was also an interesting date in the economic history of the Internet access network. First, we believe we are viewing geographic coverage with only moderate concentration of supply and without significant inter-modal competition. During our snapshot of the industry, AOL's leadership was not yet solidified. The AOL-CompuServe merger occurred just prior to our snapshot, while the AOL-Time Warner merger came a couple years later. In addition, this date preceded any significant rollout of broadband access over cable or phone lines to U.S. homes.

Perhaps most important, we believe the period of our analysis provides the best set of conditions for learning what the market would do with minimal government subsidy. Our snapshot preceded the full implementation of Internet II and the E-Rate program. The NSF largely coordinated the former program, a private/public partnership to move academic and research infrastructure to the next generation of technology. The Federal Communications Commission (FCC) administered the latter, a two billion dollar federal program authorized in the 1996 Telecom Act. This program was held up by court challenges during our snapshot, but eventually subsidized delivery of Internet access to individuals living in low-density areas and in poor communities. In other words, government subsidies accelerated after the Fall of 1998.

In previous research (Downes and Greenstein, 2002), we showed that the US market can be analyzed as thousands of local markets. These markets consisted of small, geographically dispersed local providers for Internet access. In addition, a number of national firms provided access over extremely wide and geographically dispersed areas. In this paper we focus on understanding how variation in economic factors produced different competitive conditions. Our key findings are:

- Population size and location in a metropolitan statistical area were the single most important determinants of entry, but their effects on national, regional and local firms differed, especially on the margin. The thresholds for entry were remarkably low for local firms.
- Universal service in less densely-populated areas was largely a function of investment decisions by ISPs with local focus. National firms did not play a significant role in bringing access to the U.S. population in less densely-populated areas. If national and local firms differed in the quality of services provided, then marginal adopters experienced differentials in access.
- Other important attractors for ISPs included the demographic make-up of a residential and business population and the pre-existing infrastructure of the area. For national firms these factors were of substantially less importance than population and urban location. The location of local firms was much more sensitive to factors other than population and presence in an MSA.
- By 1998, there was still a small trace of the early imprint of the government subsidies for Internet access at major U.S. universities. However, the early growth of

ISPs largely diminished the importance of the presence of a research university. There was also a small effect from the presence of nearby infrastructure that lowered the costs of opening a small ISP, such as highways and rail lines, along which backbone was laid.

Throughout the paper, we are careful to distinguish between the factors that are quasi-permanent, such as the geographic patterns of density, and those that are idiosyncratic to this technology, such as the identities of suppliers. We try to determine if the quasi-permanent or idiosyncratic factors helped achieve near-universal geographic access with very little government involvement. This distinction continues to elicit interest. The targeting of subsidies, if any, depends critically on understanding when privately funded access services achieve near-universal geographic access and when they do not.

More recent research continues to find select patterns of demographic and geographic inertia in the deployment and use of Internet access technologies, even among recent access technologies such as broadband over cable modem service or DSL over telephone lines (Grubesic, 2005; Flamm, 2005; Hu and Prieger, 2005). The same people in the same places – for example, in the Appalachian region – continue to face problematic circumstances with regard to access. Dial-up ISP service was the first example of an Internet technology to manifest this type of pattern. Understanding this pattern provides a useful perspective on similar patterns today.

The remainder of this paper begins with some background about ISPs. In the section that follows, we state several open research questions. The fourth section of the paper provides a description of the econometric model; the data are described in the fifth and sixth sections. In the seventh section, we analyze the estimates, and we close the paper with a discussion of the implications of our results.

II. ISPs and Geographic Coverage

We focus on firms that provided dial-up service which enabled a user to employ an Internet browser. Browser development occurred at about the same time as the final implementation of policies by the NSF to commercialize the Internet and at the same time as the widespread adoption and development of WWW (World-Wide Web) technology. Furthermore, we make no distinction between firms that began as on-line information providers, computer companies, telecommunications carriers, or entrepreneurial ventures. As long as a firm provided commercial Internet access as a backbone or a downstream provider, this firm is an ISP in our study.

The presence of ISPs within a local call area determined a user's access to inexpensive Internet service. The cost of this phone call depended on state regulations defining the size of the local calling area, as well as both state and federal regulations defining the costs of long-distance calling (Nicholas, 2000). Non-toll local areas were typically between ten and twenty miles, depending on state-specific policies for urban and rural charges. Consequently, from a user’s perspective, the market structure for low-cost access was defined over a small geographic region. The number of ISPs in the geographic region in which non-toll calls could be made determined the density of supply of low-cost access to Internet services within any given small geographic region.

The geographic reach and coverage of an ISP is best understood as one of several important dimensions of firm strategy. Geographic coverage was determined in conjunction with choices for value-added services, scale, performance and price. More to the point, ISPs displayed much heterogeneity in their underlying capital and equipment structures, indicative of experimentation in these investments and organizations.[3] ISPs made strategic choices regarding the scale of service, the quality of the hardware and software associated with offering connections, the value-added services to offer in conjunction with access, the geographic scope of the enterprise, and the pricing of product lines. Not surprisingly, ISPs also made different choices about the sizes and features of areas to cover.

A local, independent ISP required a modem farm, one or more servers to handle registering and other traffic functions, and a connection to the Internet backbone.[4] Higher-quality components were optional, but were essential for serving most business customers. High-speed connections to the backbone were expensive, as were fast modems. Facilities needed to be monitored, either remotely or in person, by an employee or ISP owner/operator. Local telephone firms had some options to use their existing capital and configure their network architecture to receive and carry calls. Additional services, such as web-hosting and network maintenance for businesses, were also costly. All these decisions influenced the quality of the service the customers' experienced, ultimately influencing the revenues and profitability of the business (Maloff, 1997).

National ISPs also differed in their choices of target customer and target area for service. Some targeted only business users, providing them with value-added services such as web hosting. In this business model, dial-up access might have been a necessary complement to the other, more profitable services offered. Other national ISPs focused on residential customers and on a different set of value-added services, such as appropriate chat rooms or an array of easy-to-use bulletin boards. Still others seemed to do a bit of everything, targeting both business and residential use. Substantial price variation survived in this market, depending on the value-added

[3] This theme arises in many industry reports and analyses. See e.g., Maloff Group International, Inc. (1997), the Economist (1997), Greenstein (2000), or Augereau and Greenstein (2001).

[4] For example, see the description in Kalakota and Whinston (1996), Lieda (1997), and the accumulated discussion on http://www.amazing.com/isp/ .

services offered in conjunction with dial-up service and on other factors associated with degrees of differentiation.

These different strategies influenced the geographic focus of providers. ISPs who sought to provide national service tended to maintain points of presence (POPs) in all large and many moderately-sized cities in the U.S., covering a high fraction of the population and potential travel destinations. Some local ISPs targeted niche markets in urban areas that the national ISPs failed to address, seeking to attract those users requiring a "local" component or customized technical service. National firms potentially brought with them the same capabilities in all localities. Local firms were dependent on various local characteristics such as labor markets, the quality of existing infrastructure and educational institutions, and the initiative of stake-holders in the community. Local firms had the potential advantage, however, of being able to tailor their services to local demand. Thus, our expectation was that, while population and presence in an urban area would be the principal determinants of the location pattern of national ISPs, variation in local conditions would explain much more of the variation in the location of local ISPs.

III. Research Questions

We are hesitant to presume very much about the specific features of firm behavior and market equilibrium in a young market, particularly for purposes of estimating firm entry and exit. Rather, we borrow from the spirit of the economics literature on firm entry, as applied in many other markets for local services (e.g., Bresnahan and Reiss, 1991; Downes and Greenstein, 1996). While this literature does not provide very firm predictions about what factors influence the entry of access providers, it does emphasize several common themes for framing hypotheses about the economic determinants of the scope and nature of geographic coverage.

We focus on two of these themes. First, we analyze what conditions created highly-competitive areas or less-competitive ones. For reasons already noted, virtually all major urban areas attracted some combination of local and national firms (Downes and Greenstein, 2002). We are less certain about the nature of entry in areas outside of central urban centers. Thus, one of our research goals is to characterize the factors influencing entry in less dense circumstances. Second, we describe the factors that contribute to variations in the entry behavior of different types of providers. We do this because we expect these firms to be responsive to different economic incentives and to offer different services. We hypothesize that this will help clarify how these differences shaped the nature of entry in less-dense circumstances.

We consider several theories about determinants of supply:

Economics of scale and presence in an MSA: Network-access providers grew by adding POPs. A sufficient amount of revenue must justify expending the costs of maintaining the POP. Hence, we expect small populations to support fewer POPs. We expect higher population densities, which were prevalent in urban areas, to be easier to serve.

Pre-existing investment and demand: By 1998, personal computers could be found in 42.1% of U.S. households. In 26.2% of households, at least one member of the household used the Internet at home (Newburger, 2001). Households with computers tended to have higher incomes, to have heads who were better educated, and to be non-minority.[5] We expect such demographic features to have influenced the presence of Internet suppliers.

Local communication-intensive activities and infrastructure: Internet technology was complementary to existing local communications infrastructure, both in use and in supply. Internet access vendors often targeted business users, many of whom were already users of computing and communications infrastructure. A large and developed infrastructure and labor market had grown in many localities, tailored to the presence of communications-intensive or

[5]See e.g., Kridel et al. (1999), Goolsbee and Klenow (2002), National Telecommunications Information Administration (1999, 2000), and Fairlee (2004).

computing-intensive business users (Greenstein, Lizardo, and Spiller, 2003). Therefore, we develop and test several measures of the presence of related infrastructure for other communications activity, such as the presence of major telephone companies or other factors that promoted the presence of backbone lines.

The imprint of the origins of the Internet: The presence of a nearby university might have influenced the demand for Internet service, because universities acted as substitute suppliers for some potential users. In addition, universities were also an important source of potential supply of entrepreneurs to start businesses that supplied Internet access. In this study, we analyze whether these origins for the Internet continued to influence its geographic dispersion a few years into commercialization.

State regulation: States differed in their regulations for interconnection and local calling plans. Though the 1996 Telecommunications Act standardized some of these rules across localities, there were still significant differences as of 1998. While it is difficult to measure directly the influence of these regulatory factors, they may influence many of the locations in the same state. Thus, we utilize state-specific effects to control for variation in the effects of state regulation.

IV. Modeling Approach

We assume that the entrepreneurs who contemplated forming ISPs came from two groups, either the national firms who were developing national ISP brands or from a set of local individuals directly interested in providing Internet access to a local area. In each period the number of observed entrants (or successful entrepreneurs) was the sum of many decisions by potential entrants about whether to enter a particular region. In general, we presume little about this decision process. Our working hypothesis is that local economic factors shaped entry.

A precise measure of local competition requires detailed information about which connections between telephone switches are local calls, about the characteristics of the residences/businesses served by each switch, and about the locations of the POPs of every ISP. This type of data is difficult to assemble at a comprehensive level. Our strategy is to come close by constructing approximate measures of competition from a census about POPs and then matching it to US Census data about areas. This will lead to an approximate measure of how many ISPs provided service in certain sufficiently-small geographic areas. This approximation is adequate to allow us to infer which factors induced or discouraged entry.

We will infer firm presence from a census of every commercial POP in every county in the U.S. Let i stand for type of ISP (e.g., local, national) in county j. Let N_j^i be the number of ISPs of type i in county j.

Let X_j be the set of variables describing characteristics of county j that potentially influenced the location pattern of ISPs. These include measures of factors that encouraged supply, such as population levels and density, pre-existing features of demand and local infrastructure, the presence of universities, and state dummies.

Neighboring areas also contributed to potential supply. For example, consumers in county j could get low cost access from a supplier in an urban county next door that had many already-present suppliers. Assume there were H_j counties contiguous to county j and let X_h, h = 1,2,..., H_j, be the set of variables describing characteristics of contiguous county h. These factors should have induced supply in that county, to be sure, and also possibly influenced the behavior of potential suppliers for county j.

We assume the distribution for N_j^i is Poisson with mean λ_j^i, which takes the form

$$(1) \qquad \lambda_j^i = \exp[X_j\beta^i + \Sigma_{h \in Hj} \exp(-\alpha^{\iota} d_{jh})(X_h\gamma^i)] .$$

Here, $X_j\beta^i$ measures the influence of factors within county j, while $X_h\gamma^i$ measures the influence of factors within counties surrounding county j. We let d_{jh} be the distance between counties j and h. We weight by distance as a way of examining directly the geographic scope of the influence of the characteristics of neighboring counties factors. As in Bresnahan and Reiss (1991) and Downes and Greenstein (1996), we do not presume to know what neighboring factors were relevant to entrants. This specification permits us flexibly and parsimoniously to allow the characteristics of neighboring counties to have influenced the extent of entry in county j. The larger are the α^i (the coefficients on distance), the less important were the characteristics of neighboring counties.

If the numbers of ISPs of each type i in county j are independent Poisson random variables, then the log of the likelihood function is:

(2) $\ell = \sum_{i,j} P(N_j^i = n_j^i) = \sum_{i,j} [-\lambda_j^i + n_j^i \ln(\lambda_j^i) - \ln(n_j^i!)]$

Minimizing ℓ provides estimates of the parameters in (1).

If the distribution of the number of entrants has been correctly specified, minimizing (2) generates efficient parameter estimates. Cameron and Trivedi (1986) argue that economic data typically violate the restriction implicit in the Poisson that the mean and the variance are equal. If the data exhibit over-dispersion, estimates generated by minimizing (2) continue to be consistent as long as the mean number of ISPs is correctly specified (Gourieroux, Monfort, and Troghon, 1984). Appropriate corrections to the standard errors can be made using the formulas for robust standard errors given in Cameron and Trivedi (1986).[6]

This method has several strengths. First, the endogenous variables are skewed and non-negative but most of the observations concentrate at small countable numbers, appropriate for a

[6] An alternative approach is to use an explicit distribution in which the mean and variance are not equal. The most common distribution for this purpose is the negative binomial. If the assumptions underlying the negative binomial specification are valid, a simple test can be implemented to determine if it is appropriate to impose the equality of mean and variance restriction implicit in the Poisson specification. The risk, however, is inconsistent estimates if the negative binomial specification is invalid. Since we have no particular reason to believe the negative binomial specification is more appropriate than other possible distributional assumptions, we have chosen instead to estimate the basic Poisson model and correct the standard errors.

count data approach such as this. Second, we need a single method to summarize the determinants of observations with small counts (e.g., no or a small number of entrants in most rural counties of the U.S.) and large counts (e.g., major cities). This approach does this quite easily and without excessive sensitivity to the outlying observations. Third, the specification provides a flexible approach for examining the importance of neighboring geographic features, the key measurement issue whenever the geographic scope of the market is difficult to define precisely, *ex ante*.

In addition, this method allows us to explore the possibility that different types of ISPs had different objectives or that the competitive environment facing national and local firms might have differed. For example, Dinlersoz (2004) found that the location pattern of retail alcoholic beverage stores in California was consistent with a dominant firms-competitive fringe model. In the ISP context, such a model might be appropriate for urban markets, where the dominant firms were the national ISPs and the locals formed the competitive fringe. Dinlersoz showed that, in the dominant firms-competitive fringe model, there would be differences across firm type in the effects of the determinants of the location pattern.

We test for evidence of differences in the determinants of location patterns by testing the null hypothesis that the β^i, α^i, and γ^i are the same for all types. The test is only suggestive of differences driven by the supply-side of the market; differences in these parameters could result from differences in the effects of demand-side determinants of the location pattern.

V. Data

Data sources and construction: In the Fall of 1998, the authors surveyed every compilation of ISPs on the Internet. Only a few of these compilations were found to be comprehensive, systematic, and regularly updated in response to entry and exit. This study's data combine a count of the ISP dial-in list from August/September of 1998 in *thedirectory* and a count of the backbone dial-in list for October of *Boardwatch* magazine.[7] This choice was made because the *thedirectory* ISP list contained the most comprehensive cataloguing of the locations of POPs maintained by all ISPs except the national backbone providers, for which *Boardwatch* contained a superior survey of locations.

For many of the tables below, the key question will be the following: how many suppliers had POPs in a market? When the city of a dial-in phone number was listed by an ISP, we used that to infer the presence of a POP.[8] When it was in doubt, the area code and prefix of the dial-in POP were compared to lists of the locations of local switches with these area-codes and prefixes. Then we used the location of the local switch to infer location. If this failed to locate the POP, which happened for small ISPs that only provided information about their office and nothing about the size of their dial-up network, then the voice dial-in number for the ISP was used as an indicator of location.[9] Finally, to enhance a variety of marketing and performance goals, some ISPs maintained two or more POPs in the same location; in such cases, we counted this as one firm presence.

On final count, the merged set contained over 65,000 phone numbers which served as dial-in POPs. Applying the above procedures resulted in a total of 6,000 ISPs. Of 3,109 counties, over three-quarters were associated with just over four or more firms. Of the total number of ISPs, approximately half were ISPs for which we had only a single phone number.

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[7]Incomplete historical versions of these lists posted at http://www.archive.org/ provide a sense of the data utilized in this study. Our data set includes POPs found in the ISP section of *thedirectory* (http://www.thedirectory.org/)and excludes POPs found in bulletin boards. Our data set also includes POPs for ISPs listed in the *Boardwatch* backbone section.

[8]When a city is part of two counties and the phone number did not resolve the ambiguity, the phone number was counted as part of the county in which the city has the greatest share of its land.

[9]This last procedure mostly resulted in an increase in the number of firms we cover, not a substantial change in the geographic scope of the coverage of ISPs. It did, however, help identify entry of ISPs in a few small rural areas.

Strengths and Weaknesses. Our procedure for establishing the location of POPs will produce flawed information about entry only if it generates sampling error which correlates with geography. We have taken several steps to quantify and, if necessary, correct any biases that the procedure may have imparted. We checked our data against very detailed maps of the U.S. and standard name/places references.[10] We also checked our data against multiple sources. In addition, though we avoided all apparent measurement error, we adopted statistical procedures to correct for any measurement error we may have inadvertently induced. Overall, we found no evidence of any error in the coverage of small commercial ISPs.[11]

This approach has several potential weaknesses. It provides no information about the market shares of suppliers in specific locations, nor about their quality. For reasons noted above, the absence of information on market share is not problematic, given the timing of our data. Second, while we cannot measure quality, we are aware of related work that has found some differences in the quality of local, regional, and national firms.[12] By separately examining the location pattern of different types of providers, we can look indirectly at variation in quality.

Our procedure may create the impression that there had been less ISP entry than had actually occurred in new suburbs in counties that bordered on dense, urban counties. New suburbs frequently used the telephone exchange of existing cities. Unless the ISP specifically named this new suburb in the bordering county as a targeted area, our procedures will not count

[10] Sometimes an ISP would not provide clear indications about the extent of its coverage. However, in most cases we could infer coverage from other supplemental information. Our largest problems arose in the suburbs of recently growing cities. When these suburbs approached and crossed county boundaries, it became increasing difficult to attribute a supplier to a distinct area with full confidence. In such instances, we normally attributed the ISP to the area with the highest population. Also, some ISPs used common names to refer to their area of coverage, though the common name could literally refer to multiple different places in a region – such as a lake community, forest area, valley settlement or resort/vacation complex. With careful triangulation of several sources of data we could often attribute the ISP to the appropriate area. The default in a handful of instances was to attribute it to the most-populated areas.

[11] The Foundation for Rural Service publishes membership directories for hundreds of rural cooperative telephone companies. The 1998 directory portrayed fairly widespread support of Internet access by rural telephone firms. Our findings did not qualitatively change when we integrated this information into our database, suggesting that our first two sources were comprehensive.

[12] See, e.g., Nicholas (2000), Greenstein (2001), Strover (2001), or Strover, Oden and Nagoki (2002).

the ISP's presence in that new suburb.[13] Our best control for this potential bias is our definition of the market for an ISP as a county and its nearby neighbors.

Finally, our procedure offers only a snapshot of the industry. A snapshot could be problematic for a new industry if the industry's geographic coverage patterns changed frequently. Aware of this potential issue from the outset, we tracked the geographic developments in the industry every six months for two consecutive years (Downes and Greenstein, 2002). We observed big changes in the geographic patterns of coverage between 1996 and 1997, but comparatively little between Fall of 1997 and Spring of 1998. We found almost no change between Spring of 1998 and Fall of 1998, by which time new entry had slowed. We chose Fall of 1998 after noting its stability. Results for Spring 1998 do not differ qualitatively.

We reaffirmed this decision in retrospect as we took note of a few changes in the market.[14] The implementation of the E-rate program began on a large scale in 1999. This program, along with the AOL-Time Warner merger a year later, altered the expectations for the industry's growth. Hence, in retrospect, we view Spring and Fall 1998 as the closest the ISP industry ever got to a stable equilibrium that occurred with minimal government intervention.

Definitions: In all tables below, national ISPs are defined as firms that maintain POPs in more than 25 states. Local firms are present in three or fewer counties. We classify the remainder as regional ISPs.

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[13] A similar and related bias arises when a county's boundaries and a city's boundaries are roughly equivalent, even when the neighboring county contains part of the suburbs of the city. In this situation, many ISPs that serve the neighboring county will be located within the city's boundary.

[14] This time period also is coincident with comparative stability in firm strategy. By this time, virtually every firm had implemented flat-rate pricing as one of its options, and sometimes as its only option. In addition, AOL had since recovered from its mismanagement of the introduction of flat-rate pricing. As it turned out, the next major experiment in business models (largely in 1999) came from the introduction of so-called "free" ISPs. Their entry did not alter geographic coverage much because virtually all of these firms were national in scope and initially made contracts to use existing infrastructure operated by others.

We only examine commercial ISPs, excluding firms such as bulletin boards, the primary business of which was providing downloadable text or software without Internet access. Both *thedirectory* and *Boardwatch* tried to distinguish between bulletin boards and ISPs, where the former might have consisted of a server and modems while the latter provided WWW access, FTP, e-mail, and often much more.[15]

Both sources for data eschewed listing university enterprises that acted as ISPs for students and faculty. This is less worrisome than it seems, since commercial ISPs provided over 90 percent of household access in 1998 (Clement, 1998; NTIA, 1999). In addition, commercial ISPs gravitated towards the same locations as universities. This study's procedure, therefore, will likely pick up the presence of ISP access at remotely-situated educational institutions unless the amount of traffic outside the university was too small to have induced commercial entry. We also control for the presence of different types of universities, so if different types of universities substituted for commercial firms, our statistical procedures should capture this.

The tables below provide a broad description of county features. Population numbers come from 1998 U.S. Bureau of the Census estimates. We labeled a county as urban when the Census Bureau gave it an MSA designation, which is the broadest indicator of an urban settlement in the region and includes about a quarter of the counties in the United States. The data pertain to all states except Hawaii and Alaska.[16] These data also include the District of Columbia, which is treated as another county. Throughout this study, county definitions correspond to standard U.S. Census county definitions. This results in a total of 3,109 counties.

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[15] Extensive double-checking verified that *thedirectory* and *Boardwatch* were careful about the distinction between an ISP and a bulletin board. No bulletin boards were ISPs, and they were appropriately not classified as an ISP.

[16] Alaska and Hawaii are excluded because the geography and related statistics are so unusual. We have, however, estimated the specifications presented below including all usable observations from Alaska and Hawaii. None of the conclusions are changed when these observations are included.

VI The Geographic Scope of ISPs in Fall of 1998

The summary of the nature of ISP coverage can be found in Table 1. This table provides a summary of our endogenous variable.[17] Table 1 is organized by counties in the continental U.S. In calculating these summary statistics, we accounted for the presence of ISPs in nearby counties.[18] Specifically, we used as the unit of observation a county together with all other counties with a geographic center within 30 miles of the geographic center of the central county. We chose 30 miles to create this market definition because this was within the first mileage band for a long-distance call in most rural areas.[19] See Downes and Greenstein (2002) for more detailed discussion of these issues, where we considered a variety of procedures for a sample taken a year earlier and concluded that this procedure was superior.

Of the 3,109 counties, 229 did not contain a single POP supported by any ISP in its county or in any nearby county, 121 had only one, 203 had only two, and 126 had only three. These counties tended to contain a small part of the population. Just over three percent of the U.S. population lived in counties with three or fewer ISPs nearby. As evidence that low (high) entry was predominantly a rural (urban) phenomenon, almost ninety-seven percent (1,317 out of 1,360) of the counties with ten or fewer suppliers were rural.

In Table 1, we also indicate which markets were served by only local, regional or national suppliers. The most common occurrence (which was a rural country) was that a market was entirely supplied by local or regional ISPs. Rarely, if ever, were markets with few providers entirely supplied by national ISPs. In fact, of the 3,109 counties in our data set, 1,458 counties

[17] For more extensive discussion of the geographic scope of ISP coverage, see Downes and Greenstein (2002).
[18] To do this we use the U.S. Bureau of the Census's CONTIGUOUS COUNTY FILE, 1991: UNITED STATES.
[19] In Downes and Greenstein (2002), we experimented with a number of different definitions of the market. We began by using the counties themselves as the unit of observation. We found that this definition failed to account for the fact that counties with little entry frequently border on competitive markets. We also tried calculating the influence of all neighboring counties without distinguishing by their distance, but found that this was far too inclusive of neighboring counties, the populations of which could not be linked by local phone calls.

were not within 30 miles of a national provider, 473 were not within 30 miles of a regional provider, and 660 were not within 30 miles of a local ISP.[20]

Table 1 also gives information on the types of providers in markets with few entrants. Of the 121 with only one supplier in this county and nearby counties, 49 were served by a local ISP, 68 were served by a regional ISP, and 4 were served by a national ISP. Of the 203 with two suppliers in this county and nearby counties, 72 had only local suppliers, 99 had only regional, and 5 had only national. The predominance of local and regional suppliers in less competitive markets also held in markets with three or four total suppliers. Once the number of entrants got past about five or six in a county and nearby area, then residents likely had a choice from at least one national ISP, as well as additional local and regional suppliers.

The other columns of Table 1 show the population that lived in the counties with only one type of supplier. Just under 3.28 million people lived in counties with only local ISPs. Just over 5.03 million lived in counties with only regional suppliers. Just under 0.28 million lived in counties with only national providers. Further, about 10.19 percent of the population resided in counties in which no national ISP was present in the market. If national, regional and local firms provided different qualities of service, and if the national firms were better, then Table 1 is evidence that the presence of an ISP might not have been sufficient to infer similar access in both urban and rural areas.

To illustrate these points, we provide Figure 1, which shows all the counties with at least one national provider. Counties shaded in black have at least one national provider, and counties shaded in gray have only local or regional providers. The figure shows clearly that national firms were present primarily in the major urban areas. In the areas with the least entry, predominantly rural counties, no national firm had entered.

[20]These were not mutually exclusive. Many of the counties without a local ISP were the same counties without a regional or national ISP.

To characterize the sources of variation in entry across counties, we collected data about the local areas. Table 2 presents descriptive statistics for our econometric model.

Population: We included measures of the population at the county level, as noted above. This accounted for economies of scale. We also included a dummy variable for whether a county was designated as part of an urban area, capturing the notion that density alone lowered costs of provision.

Pre-existing demand: We included measures of the population that correlated with those found in measures of the demand for PCs, which might have induced entry of suppliers in order to meet potential demand or provided potential entrepreneurs for opening ISPs.[21] We included measures of the age and education distributions of the population. To control both for the level and the distribution of income in each county, we included median family income in 1999 as well as the percent of families with incomes under $25,000 and over $75,000.

Recent research, particularly Fairlee (2004), has documented racial/ethnic differences in access to the Internet. Fairlee noted that, even after accounting for differences in income, education, and occupation, large racial/ethnic differences in Internet access remain, conditional on computer ownership. Fairlee went on to argue that, while price differences probably do not explain remaining gaps, racial differences in access to the Internet could. To explore that possibility, we included as controls the percent of each county's population that is African-American, Native American, Hispanic, and Asian-American. In addition, given Fairlee's suggestion that occupation could influence demand for Internet access, we included as a control the percent of each county's population employed in occupations classified as professional.

Location communication infrastructure: We looked at features of the workforce from which ISPs drew their employees so as to examine factors that either raised costs to suppliers or

[21] We also attempted to utilize direct measures of the fraction of the population that adopted PCs. We found that available data (from the CPS supplement) only sufficiently sampled major urban areas, forcing us to exclude too many observations from our analysis.

induced entry to meet demand. As a result, we included the percent of the county's workforce employed in professional occupations and the wages for workers in the computer services sector and in the business services sector. Suppression due to privacy restrictions meant that observations on the percent of the workforce employed in professional occupations and on wages were missing for a number of smaller counties. As a result, we also present results that excluded the workforce composition and wage variables.[22]

Since there should be spillovers from the business computing community in the supply of technical talent, we also constructed a measure of the scale of the business computing community: the number of large-scale computing sites per capita. We also have dummy variables for whether the primary provider of local voice services was a descendant of the Bell companies or GTE, who were presumed to provide more advanced infrastructure than independent phone companies.

Finally, conversations with those in the industry suggested that the backbone needed for high-quality communications was more easily routed to communities near major highways and railroad lines, since the necessary cables could be laid along these highways or railroads. To determine if ISP presence was influenced by the pre-existing layout of transportation infrastructure, we used as controls dummy variables that indicate whether a limited access highway or major railroad lines passes through the county. We created these variables from the classification of transportation infrastructure present in the Tiger Line files produced by the U.S. Census Bureau.

The Imprint of the origins of the Internet: We also constructed measures of total enrollment and enrollment in technical disciplines at local post-secondary institutions. We

[22]If data on one of the wage variables was missing for a county, that county was excluded from the estimation of any model that included that wage variable. We needed, however, to make it possible for counties with missing data to be included in the set from which contiguous counties are selected. To do that, we assigned each county with missing wage data the state average for that wage. Similarly, we assigned each county with missing data on the county's workforce employed in professional occupations a value of zero for that percent.

divided post-secondary institutions into four types, based on their Carnegie classifications. Type 1 are institutions that grant PhDs. Type 2 are institutions that grant degrees above a Bachelors, but not PhDs. Type 3 are institutions that grant bachelor degrees. All other institutions fall into the remaining classification. These institutions might have served as a source of demand or local supply of entrepreneurs for potential ISPs.

VII. The determinants of geographic presence

Table 3 presents estimates of a model that uses the total number of ISPs as the dependent variable and includes no controls for contiguous county characteristics. The estimates in Table 4 are of parameters of a model that continues to use total ISP presence as the dependent variable but adds contiguous county characteristics. In addition to the controls described above, we also included state dummies as controls for variation in state regulatory influences and in other economic determinants that were common across the state.

To determine whether the estimates in Tables 3 or 4 are preferred, we tested the null hypothesis that the coefficients on the characteristics of the neighboring counties were jointly equal to zero. For the specification implied by Model 1, the F-statistic corresponding to this null is 121.42, allowing us to reject the hypothesis at the 1 percent level.[23] The coefficient on distance in Model 1 in Table 4 implies that the characteristics of a neighboring county with its center 30 miles from the center of the county of interest are given a weight equal to 78.33 percent of the county of interest.

In Tables 5A, 5B, 6A, and 6B, we present estimates of variants of the models in Tables 3 and 4 in which we allow for differences in the equilibrium location pattern of local and national

[23]We were also able to reject the null for the specifications implied by Models 2, 3, and 4.

ISPs.[24] Using these models, we tested for similarities of coefficients between national and local firms. We easily rejected the hypothesis that they had equal sensitivity to the exogenous variables.[25]

For each of the count models that we estimated, we performed a goodness of fit test. In every case, we were able to reject the null hypothesis that the parameters of the model were jointly equal to zero.[26] A comparison of actual and predicted numbers confirms that these models generally do a good job fitting the data. Figure 2 plots actual number of ISPs against predicted numbers for the Model 1 in Table 3. The dominance of observations at or near zero is apparent from the figure. The figure also reveals the fact that this model tends to over-predict for counties with few ISPs and under-predict for counties with moderate numbers of entrants. We improve on this fit by distinguishing between types of entrants. Figure 3 plots actual number of entrants against predicted numbers which sum across specifications that distinguish between national, regional and local ISPs but do not incorporate contiguous county information. Here we see the model tends to predict better in areas where there are few entrants.

Economics of scale and population density: All estimates show that entry was sensitive to population levels. The total number of ISPs increased as population increases. This is consistent with the presence of economies of scale at the point of presence. That said, the effect of population was relatively small, once we accounted for the other determinants of ISP location. For example, the estimates of Model 1 in Table 4 indicate that, all else equal, the elasticity of the

[24]The effects of the determinants of the location pattern of regional providers differed significantly from the impact of the location pattern of both local and national providers. Since, however, the qualitative effects of the determinants were, for the most part, very similar to their effects on the location pattern of local providers, we did not include estimates for the regional providers. These estimates are available from the authors.

[25]For example, when no controls for contiguous county information were included, the Wald test statistic that corresponds to the null of equality of the coefficients on all variables except for the state dummies in Model 1 in Tables 5A and 5B took on the value of 187.64. Since there were 25 degrees of freedom, we could easily reject the null hypothesis at the 1 percent level.

[26]For example, for Model 1 in Table 3, the value of the test statistic was 39,464.29. Since the statistic has a chi-squared distribution with 3,036 degrees of freedom, we could reject the null at the one-percent level.

mean number of ISPs with respect to population was 0.014 for a county with the mean population.[27] We interpret this as an estimate of size alone. That said, we have clearly found ISPs in areas with small populations, so this motivates further investigation of the result.

There are interesting differences between different types of firms in the elasticity of the mean number of ISPs with respect to population. This elasticity was more than twice as large for local firms in comparison to national or regional firms. This is consistent with Table 1, where local firms entered at lower population levels than did national firms.

While the total number of ISPs in a county was unrelated to the population of contiguous counties, more local ISPs were located in those counties for which the populations of contiguous counties were larger. Even for local ISPs, however, the contribution of population in a contiguous county was small. For example, for local ISPs, the elasticity of the mean number of ISPs with respect to population in a contiguous county with 100,000 residents was 0.0069, while the elasticity of the mean number of local ISPs with respect to own population was 0.029 if the county had 100,000 residents.

Population levels largely accounted for the greater presence of local firms in low- density areas. In addition, local firms displayed lower profitability thresholds. To be sure, the differences between the local and national providers in the coefficients on population have multiple interpretations. For example, these differences are consistent with lower costs for local providers or, because of differences in preferences, local ISPs' willingness to suffer lower profits in order to provide local service.[28]

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[27]Let X_k^j be the kth element of X^j. Then the elasticity of the mean number of ISPs of type i in county j (λ_i^j) with respect to X_k^j is $\beta_{ik}X_k^j$. For contiguous-district characteristics, the elasticity of the mean number of ISPs with respect to the kth element of X_k^h for contiguous county h is $e^{-\alpha_i d^{jh}}(X^h_k\gamma_{ik})$.

[28]This is also in keeping with the norms of rural telephony, where local firms deliberately provide new services with public goods features or local regulators cross-subsidize their delivery.

Related differences arose in the coefficients on the dummy variable indicating location in an MSA. The results of Model 1 in Table 6A imply that, all else equal, counties classified as urban attracted over 886.5 percent more national firms than non-urban counties. While this result is consistent with lower costs of provision in areas of higher density, such an explanation for this estimated effect would be consistent with similar responsiveness from local and regional firms, which we did not find. Urban counties only saw 53.3 percent more local firms. Hence, we think that this finding arose due to difference in objectives or due to the type of dominant firm-competitive fringe dynamics discussed in Dinlersoz (2004). For example, many national firms provided national service to traveling business customers, so they provided POPs in the urban centers that were the most common travel destinations. Local firms had no motive to open their own facilities.[29]

Since population and density are highly correlated in cross-sectional data, it is often difficult to infer which one is responsible for inducing entry. These results suggest that density, not population, was the more important of the two factors. If population were of independent importance, then the elasticity of the mean number of ISPs with respect to population would be substantially larger. But these estimates imply that extremely large changes in population were needed to induce differences in the number of vendors. On the other hand, presence in an MSA, independent of population, induced substantive entry, particularly of national providers.[30]

[29] By this point in the evolution of business practices among ISPs, it was possible for a local firm to arrange to "rent" phone numbers in major cities from other national backbone firms, such as Sprint. With such renting a local ISP could provide its business customers with options when they left their local area (Boardwatch, 1998).

[30] The estimated coefficients on the MSA dummy variables are likely to provide an imperfect picture of the role of density, since there was significant variation across metropolitan areas in density. Some of that variation would be absorbed by the demographic and infrastructure factors and by the state dummy variables, if there was variation across states in the density of MSAs. Some variation in density would, however, go unexplained. The most likely outcome is that the coefficient on density understates the full impact of density on ISP location. For example, in areas like New York County (Manhattan), certain neighborhoods would have density in excess of the density of the county. If the ISPs in New York County located nearest to these neighborhoods, the role of density could never be estimated using county-level data.

Pre-existing investment and demand: While population and location in an MSA can explain a portion of the variability across counties in the presence of ISPs, our estimates imply that there clearly was more to the diffusion of Internet infrastructure than population or density. Since there was substantial variation in ISP presence in the Fall of 1998, differences in the demographics of counties and in the infrastructure that was related to ISP presence must explain the large variation in supply conditions across localities.

The entry of ISPs was especially responsive to the presence of white collar workers. For a county with the mean percent of the population in professional employment, the elasticity of the mean number of ISPs with respect to this measure was 2.01. This type of sensitivity was strong across all the types of ISPs, though it was especially high for the national firms. The coincidence of this variable with the presence of college graduates in the population might explain the surprising result that ISP presence was not significantly related to percentage of college graduates but was higher in those counties with higher percents who finished high school but not college. Education mattered, but not as much as the composition of employment in a county.

The strong correlation of median family income with the percent of the population in professional employment might also help explain the negative and significant relationship between median family income and the number of ISPs present in a county. The coefficient gives the impact of a $10,000 increase in median family income, holding constant the percent of families in the county who had incomes in the upper and lower tails of the income distribution. In other words, if one county had a higher median family income and had a larger percentage of families with incomes over $75,000 than did a comparison county, the higher-income county would typically have more ISPs. That conclusion is attributable to the facts that more ISPs were located in counties with higher percentages of families with income above $75,000 and that the coefficient on the percent of families with incomes over $75,000 is relatively larger than the coefficient on median family income. The elasticity of the mean number of ISPs with respect to family income was -3.13, while the elasticity with respect to the percent of families with incomes over $75,000 was 1.78.

The impact of an increase in the percent of families with incomes below $25,000 was generally insignificant. Only for local providers was there ever a significant relationship between the number of ISPs and the percent of families with incomes below $25,000. For these providers, an increase in the percent of families in the lower end of the income distribution had an effect in the opposite direction of the effect of an increase in the percent of families in the upper tail.

Generally, the relationship between ISP presence and a county's age composition makes intuitive sense. Increases in the percent of the population 22 to 29 – and concomitant reductions in the population under 18 – increased the presence of ISPs. This result is unsurprising, since individuals 22 and 29 were heavy Internet users. Increases in the relative size of two groups who made less use of the Internet, those 30 to 39 years and those 40 to 64 years, reduced ISP presence. Again, these results seem plausible. What seems implausible, however, is our finding that relative growth of the percent over 64 years was associated with more ISP presence. Explaining this result is difficult, particularly since every survey shows that Internet use was lower for the oldest population in the U.S. But what every survey also shows was that growth of Internet use was most rapid in the over 64 group. Possibly ISPs were responding to this reality and to the fact that those over 64 acquired Internet access for themselves and not for someone else in their family.

Our results indicate that the digital divide between race and ethnic groups could not be explained by less presence of ISPs in counties with larger minority populations. In fact, we find that there were significantly more ISPs in counties with larger percents African-American and Hispanic, holding all else constant.

Local communication-intensive activities and infrastructure: The presence of local infrastructure had a consequence for the development of the commercial access industry. While individually, the economic importance of each of the infrastructure elements was comparatively small, in most counties the cumulative impact of infrastructure was larger than the impact of population and presence in an MSA.

The estimates on the regional Bell and GTE dummies are positive in all cases, with the GTE dummy being the smaller of the two. While digital switches were largely diffused everywhere by this time, there were still some rural areas not served by a regional Bell or GTE where no such upgrade had been made (Greenstein, Lizardo and Spiller, 2002; Shampine, 2001). Thus, it is not surprising that the presence of the technical sophistication of the major providers seemed to induce entry.

This effect, however, was probably not attributable to infrastructure alone. In addition, any asymmetric treatment of local phone companies by state regulators would be picked up by these two dummy variables as long as the asymmetry was common across states. For example, ISPs' difficulties interconnecting with regional Bell companies, which were are usually the largest incumbent local exchange carriers in a state, might have received more scrutiny than interconnection with GTE. In turn, GTE's actions might have received more scrutiny than other independent firms.[31]

[31] For example, Mini (2001) carefully documents that Competitive Local Exchange Companies had very different experiences depending on whether they were interconnecting with Regional Bell Operating Companies, GTE, or independent telecommunications firms. RBOCs often developed interconnection agreements and policies as part of the quid-pro-quo with the FCC, who sought to disallow entry into long-distance markets until the RBOCs complied with a series of tests for opening up their local markets (Shiman and Rosenwercel, 2002). In contrast, the non-RBOC incumbents simply made interconnection agreements, if they made any at all, under the guidance of the state regulatory commissions.

The coefficient on the number of large-scale computer sites per capita indicates that the presence of a technically sophisticated business computing population encouraged entry. In all cases, however, these influences were comparatively small. The coefficient on the regional Bell dummy in Model 1 in Table 4 indicates that those counties that had been served by a regional Bell company had 80.4 percent more ISPs than did counties not served by a regional Bell company. Similarly, the elasticity of the mean number of ISPs with respect to the number of mainframe sites per 100,000 people was 0.0994. The implication is that infrastructure variation would only generate substantive differences in counties where the supply was already low for other reasons. In other words, the presence of a relatively-sophisticated plant in a low-density location did induce a bit of entry, particularly when it was supported by one of the major telephone companies.

The presence of highways and rail lines also played an interesting role in fostering entry. The estimates of Model 1 in Table 4 imply that, all else equal, counties in which at least one limited access highway was present had 25.47 percent more ISPs than did counties with no limited access highways. The difference between national and local firms is especially interesting. While the coefficients on the limited access highway and major rail line indicator variables are consistently positive in Table 6A, they are never statistically significant. Thus, the presence of these transportation features had no impact on the geographical dispersion of national ISPs. The results in Table 6B imply, however, that significantly more local ISPs were located in counties with limited access highways and with major rail lines. For example, the estimates of Model 1 in that table imply that counties in which at least one limited access highway was present had 35.1 percent more local ISPs than did counties with no limited access highways and that counties in which at least major rail line was present had 43.41 percent more ISPs than did counties with no major rail lines. Since these transportation features were ubiquitous in high-density areas, where the national firms predominated, it is not that surprising that the geographic dispersion of the national firms was unrelated to the presence of these features. What is notable is boost these transportation features provided in low-density areas where local firms accounted for most of the entry.

The influence of local wages for technically-sophisticated employees differed across the different types of ISPs. More local firms were located in counties with higher wages for business services or computer services workers, though the magnitude of the relationship was small. For example, the estimates of Model 4 in Table 5B imply the elasticity of the mean number of ISPs with respect to the mean weekly wage in computer services was 0.0034. In addition, the entry of national ISPs was unrelated to either of the wage measures. For none of the providers do we see the expected relationship, fewer ISPs present in those counties where the cost of labor was likely to be higher. This counterintuitive result is probably attributable in part to the fact that labor costs were a small portion of the total costs of setting up and operating an access point. In addition, all else equal, wages of workers in computer services and other related fields would tend to be higher in those markets where there is more demand for all computer services, including Internet access. Thus, the wage variation we observe may proxy for unmeasured differences in demand.

The imprint of the origins of the Internet: Did federal subsidies for the Internet influence the presence of commercial firms in the Fall of 1998? We find some evidence of this imprint, but the effects were small.

In counties with a Carnegie 1 presence, the number of ISPs declined as per-capita enrollment at a Carnegie 1 institution increases. The estimates in Tables 5A and 5B and in Tables 6A and 6B reveal that the effect of Carnegie 1 enrollment was concentrated among the national ISPs. Further, even for the national ISPs, only when Carnegie 1 enrollment was quite large was the impact of economic importance.

The limited impact of the presence of Carnegie 1 institutions and the absence of any impact of the presence of Carnegie 2 and 3 institutions run counter to the popular wisdom that diffusion of Internet access was influenced by the presence of access that had been built with federal subsidies. Nonetheless, we do not want to suggest that this popular wisdom is an urban myth. Rather, we infer that commercial firms had largely diffused around the country by 1998, overwhelming the imprint of university subsidies on cross-sectional supply and entry.[32] Further, the negative relationship between a county's Carnegie 1 enrollment and the presence of national ISPs in that county is consistent with the view that the national firms viewed the large research universities that had been primary beneficiaries of federal subsidies as competitors.

State regulation: While states differed in the regulations for interconnection and local calling plans, no measures of these differences in regulation exist. Since we expected regulatory differences to matter, we included state dummies in our specification. We could not, however, disentangle the effects of regulatory differences from other unmeasured factors that were correlated within a state. Hence, the coefficients on our state dummies do not provide much useful information on the causes of these systematic interstate differences.

Here we give a brief summary of the estimated coefficients on the state dummies associated with Model 1 in Table 3. The baseline was Wyoming, a state with relatively low ISP presence per county. This made most of the coefficients for the state dummies positive. All else equal, counties in California, Connecticut, Delaware, Maine, Massachusetts, Nevada, New Hampshire, New Jersey, Ohio, Oregon, Pennsylvania, Vermont, Washington, and West Virginia had significantly more ISPs than did counties in Wyoming. Counties in Georgia, South Dakota,

[32] It is our impression that this finding is partly a result of the timing of our survey. The industry is full of examples of suppliers located next to major universities just as commercialization ensued. It appears that commercial entry was so swift and so large that any such effect was largely eliminated by the Fall of 1998.

and Virginia had significantly fewer. In both Nevada and Vermont, the number of ISPs in the state's counties was over 200 percent higher than the number in the counties in Wyoming, all else equal. In South Dakota, the total number of ISPs in the state's counties was over 200 percent lower than the number in the counties in Wyoming, all else equal.

VIII Discussion

Precursor episodes of communications network development offer a useful contrast to the diffusion of low-cost Internet access. During the first two decades of telephony in the U.S., the technology and commercial business co-evolved, largely under the single coordinating hand of the Bell companies (Weiman, 2000; Mueller, 1997). The new voice network was a radical technical and organizational departure from the existing telegraph network, eventually competing with it. Geographic dispersion occurred gradually and over many decades, both under Bell direction and, also, after the emergence of competition after the expiration of the Bell patents.

In contrast, Internet technology incubated under government supervision for over two decades prior to commercialization. This incubation, arguably, made it ripe for immediate use by many vendors (Greenstein, 2000; Mowery and Simcoe, 2002). During the first few years the Internet was a complement to existing communications technology and generated greater use of the existing voice network. Overall, the most common access mode, dial-up Internet services, was a retrofit on top of telephones and required incremental investment by users of personal computers. The most common provider was not an incumbent local telephone firm at first, but eventually these firms also became involved in supply, resulting in large mix of different types of providers by 1998.

Such technical maturity and complementarity did not guarantee widespread diffusion, but this propitious combination of features did enable low-cost private investment and development. Furthermore, at the time of commercialization, the technology was such that there were limited economies of scale for an ISP that operated few POPs. Hence, the presence of access in comparatively small towns, which initially were ignored by national firms, became feasible for local and independent ISPs, who were the dominant providers in such areas. Only a few years after commercialization, only a small fraction of the country did not have a local provider (Downes and Greenstein, 2002).

Yet, even with these circumstances there were some places that did not attract much entry. The places that lacked access had features that drove up cost, such as low density, lack of major highway or railway for carrying backbone, and the absence of investments in other IT infrastructure that supported a labor market for technical talent. In addition, extremely unfavorable demographics contributed to lack of demand, which naturally led to less entry. In this sense we conclude that, in this era, the supply of Internet access was largely a function of local economic factors that tend not to change rapidly.

We think this experience is informative about policies for network development in the absence of government subsidy. Targeted subsidies should not go to areas where private suppliers would amply and competitively supply access services. Our findings would emphasize lack of encouraging demographics (e.g., age, education or income), discouraging infrastructure conditions (e.g., lack of major roads or pre-existing labor markets), and other cost related issues associated with providing Internet access in low density areas. Interestingly, we found that nearby presence of a higher educational institution was not relevant. We also emphasize that the presence of a few (but not all) favorable factors was sufficient to induce some entry in this era. *Lack of entry* required the majority of these factors to be unfavorable.

Two factors in the dial-up era seem unique. Our findings depended on the low economies of scale in dial-up access. Broadband access technologies do not exhibit such low economies of scale. In addition, our findings emphasize the distinctly different roles played by local and national firms. Local ISPs are less prevalent in the diffusion of broadband technologies. Both of these factors raise troubling questions today.

The provision of universal service in the dial-up era was a decentralized and uncoordinated affair. In the less densely-populated areas of the country, national firms were less likely to supply access than were their local or regional counterparts, who, according to our estimates, were far less sensitive to the population, density, and infrastructure of a prospective market. In addition, our estimates indicate that, in choosing locations, national firms placed more weight than did local firms on the age structure, adult education level, and employment composition of a county's population. National firms appeared to conclude that less-populated areas were not sufficiently profitable, while local firms appeared to conclude something quite different. Hence, hard-to-serve areas only got access if one or more of thousands of local entrepreneurs and business decision makers in different localities decided to open an ISP.

This comparison between local and national ISPs also raises questions about the quality of provision in less-dense areas. If local firms did not provide similar products as national firms, then users in low-density areas may have experienced lower quality than that found in urban areas. To be sure, some local ISPs in small towns offered high-quality service, more attention, and product tailored to local needs. But there is mounting evidence that some local suppliers upgraded their equipment more slowly (Augereau and Greenstein, 2001), provided narrower arrays of frontier services (Greenstein, 2000), and limited their services to only business users (Nicholas, 2002; Strover, 2001). Such behavior would have consequences for local economic growth, as well as for the achievement of educational and social objectives of public policies for widening access to underserved populations.

The comparative success of local firms in this instance places great weight on the ease with which a wide set of decision makers in a wide set of environments embedded TCP/IP technology in their investments. This emphasis is particularly striking in comparison to the low sensitivity of entry to the presence of a university. Universities did not play a large role with localized geographic spillovers, as was seen in other new technologies. More to the point, if universities did do so, the local effects were overwhelmed by commercial entry within a few years.

In retrospect, the most significant role for the university was its place as a laboratory for developing, refining, and expanding use of TCP/IP applications, as well as teaching a generation of students in the 1990s how to use basic technologies, such as email and browsing (Goldfarb, 2005). Because it suited their low budgets, student-staffed environment and minimal needs, university IT administrators eventually developed a technology with low-economies of scale and strong complementarities with the existing infrastructure. These features helped produce a highly mobile technology, one that was *not* limited much by geographically local information flows, labor markets, supply conditions or other local conditions.

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Figure 1

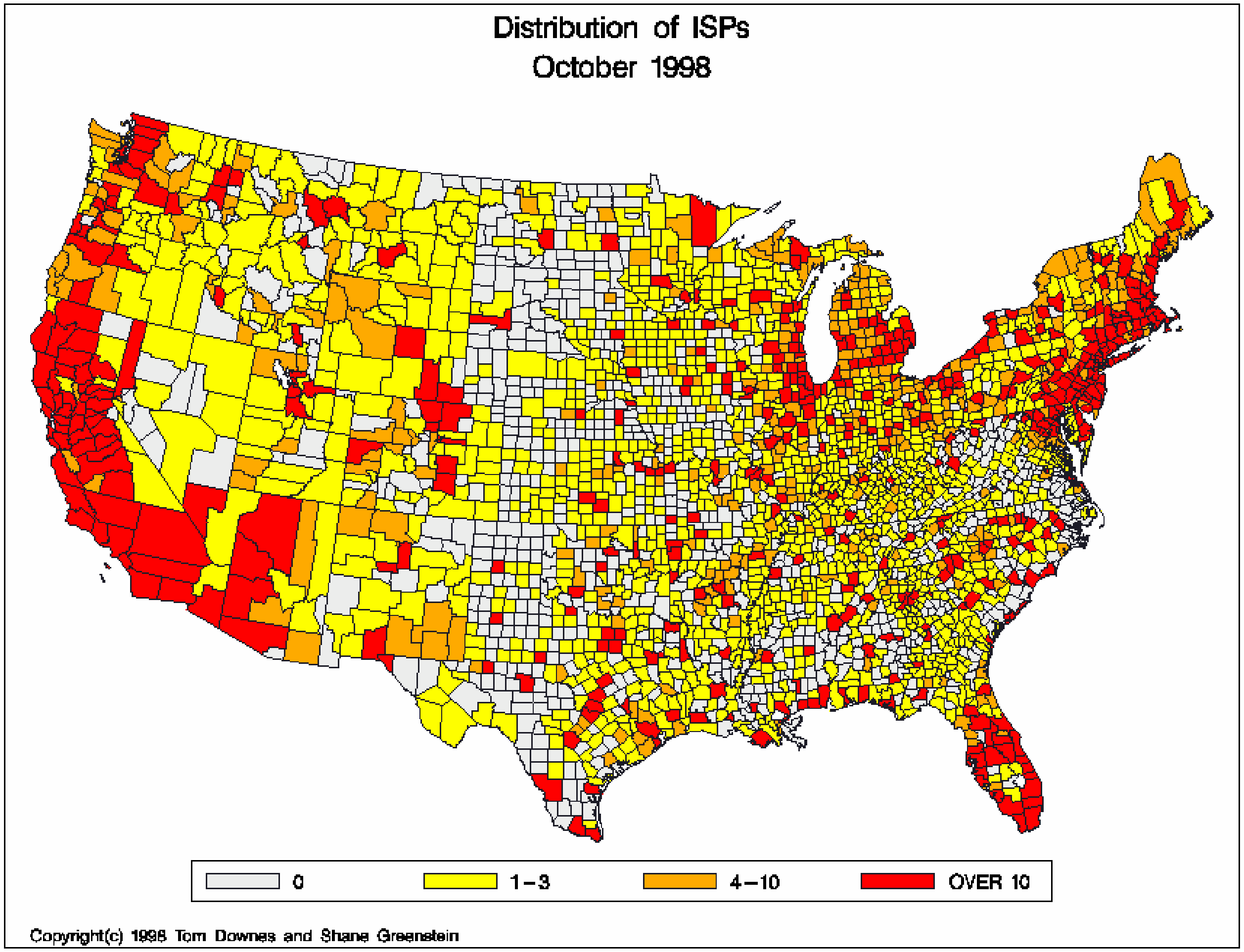

Distribution of ISPs
October 1998
0
1-3
4-10
OVER 10
Copyright(c) 1998 Tom Downes and Shane Greenstein

Figure 2
Comparison of fitted and actual counts

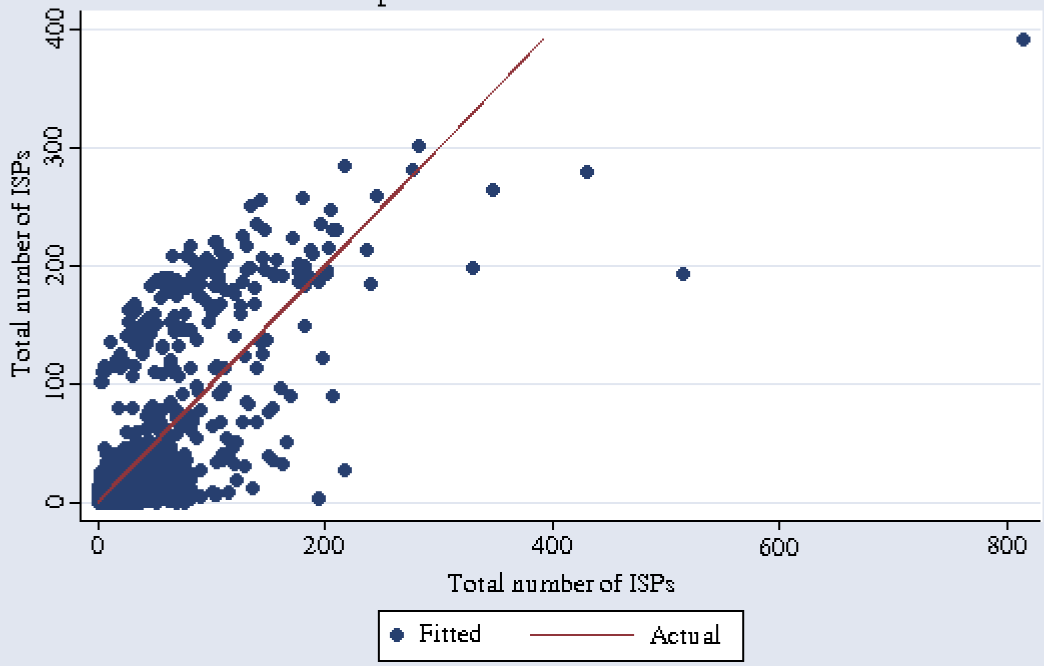
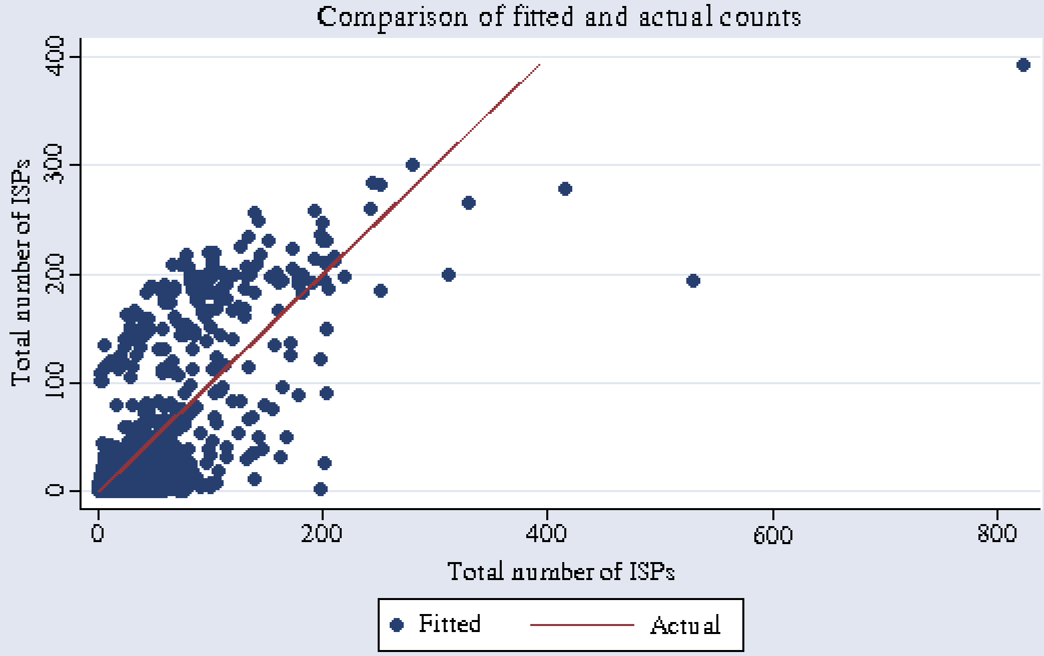


Figure 3
Comparison of fitted and actual counts



Note: Models for national, regional, and local ISPs estimated separately

Table 1
Summary Statistics - Number of ISPs in County by Type

Variable	Number of Counties	Mean	Standard Deviation	Minimum	Maximum
Number of Local ISPs	3109	1.8559	5.8211	0.0000	162.0000
Number of Regional ISPs	3109	2.1866	5.3043	0.0000	59.0000
Number of National ISPs	3109	10.7414	35.1913	0.0000	171.0000
Total Number of ISPs	3109	14.7838	42.5318	0.0000	392.0000

Number of ISPs in the Market by Type of ISP

Market Definition: County of Residence and All Counties Within 30 Miles							
Number of ISPs in Market	**Number of Counties**	**Number of Counties Local Only**	**Popula-tion Local Only[1]**	**Number of Counties Regional Only**	**Popula-tion Regional Only[1]**	**Number of Counties National Only**	**Popula-tion National Only[1]**
0	229	.	.	.	.	.	.
1	121	49	467,248	68	755,512	4	23,782
2	203	72	1,116,307	99	1,302,040	5	116,972
3	126	22	385,180	39	492,560	0	0
4	173	22	677,831	51	732,401	1	27,006
5	92	8	164,268	15	182,876	0	0
6	124	7	218,754	19	231,534	1	110,089
7	67	2	86,446	11	211,640	0	0
8	89	2	59,964	17	359,895	0	0
9	72	2	103,237	13	152,367	0	0
10	64	0	0	5	52,955	0	0
11-15	281	0	0	17	336,735	0	0
16-20	168	0	0	6	120,365	0	0
21 or more	1,300	0	0	4	102,412	0	0
Total	3,109	186	3,279,235	364	5,033,292	11	277,849

Note: 1) For the calculations in these columns, the county of residence is treated as the unit of observation.

Table 2
Summary Statistics for 3109 Counties in Continental U.S.

Variables	Observa-tions	Mean	Standard Deviation	Minimum	Maximum
Population	3109	89927.1300	293514.8000	67.0000	9519338.0000
Located in an MSA	3109	0.2740	0.4461	0.0000	1.0000
Median family income	3109	42034.6900	9817.5780	14167.0000	97225.0000
Pct. of families with incomes below $25,000	3109	26.3406	9.2764	3.9552	67.9426
Pct. of families with incomes above $75,000	3109	17.4084	8.9284	1.9139	63.8412
Pct. Native American	3109	1.4991	6.1550	0.0000	92.7483
Pct. African-American	3109	8.7150	14.5035	0.0000	86.0780
Pct. Asian-American	3109	0.7976	1.5800	0.0000	31.1530
Pct. Hispanic	3109	6.1562	12.1162	0.0000	98.1044
Pct. 18-21 years	3109	5.4186	2.5412	1.4045	36.9562
Pct. 22-29 years	3109	9.2410	2.2676	0.0000	24.1677
Pct. 30-39 years	3109	13.8672	1.9206	2.9851	23.3141
Pct. 40-64 years	3109	31.1815	3.0863	9.6761	58.2090
Pct. 65 years and over	3109	14.8234	4.1167	1.7740	34.7123
Pct. in prof. employ.	3109	35.2084	6.6123	16.0185	67.4399
Pct. HS grad.	3109	60.8279	7.0137	37.5892	81.0811
Pct. college grad.	3109	16.5062	7.7994	4.9205	63.7460
Limited access hwy. dummy	3109	0.5082	0.5000	0.0000	1.0000
Major railroad dummy	3109	0.9225	0.2675	0.0000	1.0000
Mainframe computer sites per 100,000 pop.	3109	2.2641	4.1023	0.0000	89.0869
Regional Bell dummy	3109	0.2625	0.4400	0.0000	1.0000
GTE dummy	3109	0.0746	0.2628	0.0000	1.0000
Per cap. enroll. in Carn. 1	3109	0.0074	0.0653	0.0000	2.6154
Per cap. enroll. in Carn. 2	3109	0.0085	0.0386	0.0000	0.5485
Per cap. enroll. in Carn. 3	3109	0.0046	0.0199	0.0000	0.4714
Frac. work. in prof. employ.	2607	0.5247	0.0841	0.2334	0.8789
Mean weekly wage in business services	2414	371.2400	160.6060	59.0000	1733.0000
Mean weekly wage in comput. services	1219	803.5500	388.6340	149.0000	5075.0000

Table 3
Specifications of Mean Number of ISPs (No contiguous county information)
(Asymptotic Standard Errors in Parentheses)

Variables	Model 1	Model 2	Model 3	Model 4
Population (in millions)	0.1899*** (0.0548)	0.1864*** (0.0553)	0.1857*** (0.0549)	0.1767*** (0.0525)
Located in an MSA	1.4637*** (0.1158)	1.3815*** (0.1181)	1.3274*** (0.1158)	1.1988*** (0.1300)
Median family income (in $10,000s)	-0.7482*** (0.2409)	-0.7925*** (0.2668)	-0.7625*** (0.2721)	-0.5863** (0.2767)
Pct. of families with incomes below $25,000	-0.0219 (0.0180)	-0.0248 (0.0193)	-0.0250 (0.0200)	-0.0216 (0.0221)
Pct. of families with incomes above $75,000	0.0853*** (0.0237)	0.0874*** (0.0289)	0.0831*** (0.0266)	0.0678** (0.0284)
Pct. Native American	-0.0070 (0.0084)	-0.0128 (0.0101)	-0.0149 (0.0116)	0.0034 (0.0126)
Pct. African-American	0.0204*** (0.0048)	0.0180*** (0.0054)	0.0184*** (0.0055)	0.0186*** (0.0060)
Pct. Asian-American	-0.0005 (0.0128)	0.0014 (0.0138)	0.0025 (0.0140)	0.0053 (0.0143)
Pct. Hispanic	0.0144** (0.0061)	0.0152** (0.0064)	0.0157** (0.0064)	0.0161** (0.0066)
Pct. 18-21 years	-0.0159 (0.0408)	0.0024 (0.0465)	0.0022 (0.0470)	0.0161 (0.0483)
Pct. 22-29 years	0.1247*** (0.0392)	0.0974** (0.0420)	0.0935** (0.0428)	0.0760 (0.0476)
Pct. 30-39 years	-0.1011** (0.0475)	-0.0774 (0.0499)	-0.0744 (0.0518)	-0.0714 (0.0566)
Pct. 40-64 years	-0.1005*** (0.0298)	-0.1169*** (0.0334)	-0.1189*** (0.0343)	-0.1309*** (0.0381)
Pct. 65 years and over	0.0485** (0.0206)	0.0501** (0.0216)	0.0548** (0.0224)	0.0646*** (0.0239)
Pct. of pop. in prof. employ.	0.0600*** (0.0158)	0.0612*** (0.0189)	0.0729*** (0.0200)	0.0718*** (0.0244)

Variables	Model 1	Model 2	Model 3	Model 4
Pct. HS grad.	0.0495*** (0.0139)	0.0543*** (0.0146)	0.0526*** (0.0152)	0.0442*** (0.0169)
Pct. college grad.	0.0146 (0.0183)	0.0146 (0.0192)	0.0065 (0.0200)	-0.0019 (0.0231)
Limited access hwy. dummy	0.4014*** (0.1253)	0.4337*** (0.1268)	0.3839*** (0.1287)	0.2899* (0.1639)
Major railroad dummy	0.2813 (0.2699)	0.2695 (0.3389)	0.2682 (0.3707)	0.5729 (0.5420)
Mainframe computer sites per 100,000 pop.	0.0461*** (0.0069)	0.0532*** (0.0090)	0.0525*** (0.0093)	0.0541*** (0.0104)
Regional Bell dummy	0.7076*** (0.1085)	0.6586*** (0.1109)	0.6290*** (0.1101)	0.5612*** (0.1207)
GTE dummy	0.4185*** (0.1343)	0.3686*** (0.1382)	0.3429** (0.1377)	0.2725* (0.1472)
Enrollment in Carnegie 1 per capita	-2.8431* (1.5018)	-3.4035* (1.7747)	-3.2290* (1.7592)	-3.8488** (1.6778)
Enrollment in Carnegie 2 per capita	-0.2247 (1.4113)	-0.8494 (1.6052)	-0.8695 (1.5873)	-1.0239 (1.6289)
Enrollment in Carnegie 3 per capita	-2.4846 (2.3314)	-3.4351 (2.4547)	-3.9075 (2.5576)	-5.7717** (2.9152)
Fraction of workers in prof. employment		0.5026 (0.7411)	0.6291 (0.7494)	0.7627 (0.8160)
Mean weekly wage in business services (in $10000s)			-0.1565 (2.6084)	
Mean weekly wage in comput. services (in $10000s)				1.0638 (1.0261)
Value of pseudo-likelihood	-23407.1600	-21865.0240	-21094.7060	-17706.5580
Observations	3109	2607	2171	1143

Notes: * Significant at 10 percent level.
** Significant at 5 percent level.
*** Significant at 1 percent level.

Table 4
Specifications of Mean Number of ISPs (Contiguous county information)
(Asymptotic Standard Errors in Parentheses)

Variables	Model 1	Model 2	Model 3	Model 4
Coefficients on Home County Characteristics				
Population (in millions)	0.1512*** (0.0485)	0.1520*** (0.0518)	0.1466*** (0.0513)	0.1329*** (0.0502)
Located in an MSA	1.4194*** (0.1180)	1.2990*** (0.1187)	1.2472*** (0.1168)	1.1122*** (0.1255)
Median family income (in $10,000s)	-0.7435*** (0.2170)	-0.7955*** (0.2362)	-0.8031*** (0.2423)	-0.6751*** (0.2589)
Pct. of families with incomes below $25,000	0.0110 (0.0193)	0.0207 (0.0202)	0.0240 (0.0207)	0.0245 (0.0235)
Pct. of families with incomes above $75,000	0.1023*** (0.0232)	0.1081*** (0.0252)	0.1095*** (0.0262)	0.1080*** (0.0297)
Pct. Native American	-0.0192* (0.0112)	-0.0147 (0.0118)	-0.0197 (0.0148)	0.0107 (0.0130)
Pct. African-American	0.0307*** (0.0054)	0.0265*** (0.0058)	0.0264*** (0.0058)	0.0259*** (0.0063)
Pct. Asian-American	0.0077 (0.0147)	0.0101 (0.0158)	0.0138 (0.0172)	0.0288 (0.0176)
Pct. Hispanic	0.0282*** (0.0069)	0.0260*** (0.0072)	0.0262*** (0.0071)	0.0232*** (0.0074)
Pct. 18-21 years	0.0053 (0.0411)	0.0016 (0.0470)	0.0005 (0.0468)	0.0073 (0.0488)
Pct. 22-29 years	0.1642*** (0.0372)	0.1472*** (0.0409)	0.1412*** (0.0419)	0.1406*** (0.0479)
Pct. 30-39 years	-0.0509 (0.0493)	-0.0512 (0.0495)	-0.0549 (0.0507)	-0.0739 (0.0560)
Pct. 40-64 years	-0.0490 (0.0319)	-0.0709** (0.0340)	-0.0735** (0.0350)	-0.0861** (0.0383)
Pct. 65 years and over	0.0806*** (0.0220)	0.0692*** (0.0226)	0.0718*** (0.0232)	0.0743*** (0.0249)
Pct. of pop. in prof. employ.	0.0571*** (0.0169)	0.0579*** (0.0206)	0.0691*** (0.0219)	0.0638** (0.0263)

Variables	Model 1	Model 2	Model 3	Model 4
Pct. HS grad.	0.0690*** (0.0157)	0.0826*** (0.0171)	0.0834*** (0.0179)	0.0692*** (0.0198)
Pct. college grad.	0.0345* (0.0209)	0.0428* (0.0232)	0.0349 (0.0244)	0.0180 (0.0272)
Limited access hwy. dummy	0.2269* (0.1180)	0.2985*** (0.1150)	0.2451** (0.1139)	0.1710 (0.1368)
Major railroad dummy	0.4080 (0.2554)	0.3399 (0.2721)	0.3341 (0.2818)	0.5937 (0.4084)
Mainframe computer sites per 100,000 pop.	0.0439*** (0.0068)	0.0532*** (0.0089)	0.0534*** (0.0092)	0.0567*** (0.0104)
Regional Bell dummy	0.5900*** (0.1021)	0.5406*** (0.1070)	0.5111*** (0.1073)	0.4529*** (0.1188)
GTE dummy	0.4356*** (0.1219)	0.4240*** (0.1299)	0.4050*** (0.1311)	0.3422** (0.1451)
Enrollment in Carnegie 1 per capita	-3.3933** (1.5180)	-3.5547* (1.8182)	-3.3990* (1.7784)	-4.0745** (1.6735)
Enrollment in Carnegie 2 per capita	-0.2223 (1.3960)	-0.6042 (1.6496)	-0.6603 (1.6061)	-1.5723 (1.6971)
Enrollment in Carnegie 3 per capita	-2.5539 (2.4279)	-2.9257 (2.5905)	-3.4630 (2.7380)	-5.9812* (3.1535)
Fraction of workers in prof. employment		0.0233 (0.7137)	0.1560 (0.7208)	0.5456 (0.7826)
Mean weekly wage in business services (in $10000s)			0.0755 (0.2217)	
Mean weekly wage in comput. services (in $10000s)				-0.0265 (0.0915)
Distance (in 100 miles)	0.8139*** (0.2932)	2.2502*** (0.4603)	2.4605*** (0.4633)	4.1520*** (0.7128)
Coefficients on Contiguous County Characteristics				
Population (in millions)	-0.0173 (0.0337)	-0.0369 (0.0676)	-0.0526 (0.0739)	-0.2319 (0.1446)

Variables	Model 1	Model 2	Model 3	Model 4
Located in an MSA	0.0162 (0.0535)	0.0953 (0.0841)	0.1053 (0.0899)	0.2660* (0.1438)
Median family income(in $10,000s)	-0.0530 (0.1164)	-0.1214 (0.1652)	-0.1130 (0.1777)	-0.1304 (0.2540)
Pct. of families with incomes below $25,000	-0.0171** (0.0071)	-0.0259** (0.0109)	-0.0260** (0.0116)	-0.0332* (0.0186)
Pct. of families with incomes above $75,000	0.0016 (0.0103)	0.0056 (0.0151)	0.0042 (0.0163)	-0.0026 (0.0263)
Pct. Native American	0.0125** (0.0059)	0.0188* (0.0100)	0.0231** (0.0114)	0.0577** (0.0272)
Pct. African-American	-0.0049*** (0.0017)	-0.0064** (0.0026)	-0.0069** (0.0028)	-0.0074 (0.0046)
Pct. Asian-American	-0.0110 (0.0079)	-0.0078 (0.0109)	-0.0061 (0.0116)	0.0107 (0.0183)
Pct. Hispanic	-0.0046* (0.0024)	-0.0051 (0.0037)	-0.0051 (0.0039)	-0.0016 (0.0064)
Pct. 18-21 years	-0.0002 (0.0184)	-0.0013 (0.0276)	-0.0054 (0.0290)	-0.0185 (0.0475)
Pct. 22-29 years	-0.0383** (0.0195)	-0.0628** (0.0289)	-0.0716** (0.0311)	-0.1098** (0.0487)
Pct. 30-39 years	0.0179 (0.0217)	0.0419 (0.0346)	0.0502 (0.0368)	0.0879 (0.0586)
Pct. 40-64 years	-0.0146 (0.0120)	-0.0261 (0.0200)	-0.0322 (0.0217)	-0.0571 (0.0368)
Pct. 65 years and over	-0.0087 (0.0096)	-0.0098 (0.0156)	-0.0112 (0.0167)	-0.0158 (0.0275)
Pct. of pop. in prof. employ.	-0.0046 (0.0064)	-0.0093 (0.0104)	-0.0088 (0.0115)	-0.0061 (0.0200)
Pct. HS grad.	-0.0132** (0.0067)	-0.0216** (0.0105)	-0.0222** (0.0112)	-0.0298 (0.0186)
Pct. college grad.	-0.0121 (0.0075)	-0.0176 (0.0117)	-0.0177 (0.0126)	-0.0235 (0.0211)

Variables	Model 1	Model 2	Model 3	Model 4
Limited access hwy. dummy	-0.0188 (0.0458)	-0.0243 (0.0714)	-0.0304 (0.0776)	-0.1031 (0.1293)
Major railroad dummy	-0.0105 (0.1005)	-0.1260 (0.1670)	-0.1415 (0.1821)	-0.2165 (0.3582)
Mainframe computer sites per 100,000 pop.	-0.0105 (0.0086)	-0.0104 (0.0138)	-0.0095 (0.0144)	-0.0085 (0.0232)
Regional Bell dummy	-0.0367 (0.0515)	-0.0539 (0.0754)	-0.0587 (0.0802)	-0.1220 (0.1215)
GTE dummy	-0.0370 (0.0693)	-0.0958 (0.1046)	-0.1131 (0.1138)	-0.2008 (0.1793)
Enrollment in Carnegie 1 per capita	-0.5622 (0.4901)	-0.8223 (0.6550)	-0.8002 (0.5973)	-1.2917 (1.3022)
Enrollment in Carnegie 2 per capita	0.7558 (0.6626)	1.1374 (0.9527)	-1.3936 (0.9796)	-1.5544 (1.8025)
Enrollment in Carnegie 3 per capita	2.7836** (1.2663)	4.5314** (1.8939)	5.3497*** (2.0538)	9.5765** (3.9831)
Fraction of workers in prof. employment		-0.1777 (0.1547)	-0.2130 (0.1671)	-0.3120 (0.2857)
Mean weekly wage in business services (in $10000s)			-0.0619 (0.2920)	
Mean weekly wage in comput. services (in $10000s)				-0.2428* (0.1425)
Value of pseudo-likelihood	-19626.3001	-18191.7352	-17351.9018	-14009.2264
Observations	3109	2607	2171	1143

Notes: * Significant at 10 percent level.
** Significant at 5 percent level.
*** Significant at 1 percent level.

Table 5A
Specifications of Mean Number of National ISPs (No contiguous county information)
(Asymptotic Standard Errors in Parentheses)

Variables	Model 1	Model 2	Model 3	Model 4
Population (in millions)	0.1727*** (0.0658)	0.1679** (0.0664)	0.1681** (0.0663)	0.1591** (0.0651)
Located in an MSA	2.3745*** (0.2441)	2.1922*** (0.2354)	2.0880*** (0.2253)	1.7524*** (0.2227)
Median family income (in $10,000s)	-0.8721*** (0.3289)	-0.8844** (0.3520)	-0.8574** (0.3542)	-0.6642* (0.3488)
Pct. of families with incomes below $25,000	-0.0313 (0.0263)	-0.0350 (0.0274)	-0.0358 (0.0279)	-0.0348 (0.0284)
Pct. of families with incomes above $75,000	0.0890*** (0.0330)	0.0883** (0.0348)	0.0841** (0.0351)	0.0618* (0.0356)
Pct. Native American	-0.0217 (0.0174)	-0.0292 (0.0193)	-0.0328 (0.0218)	-0.0039 (0.0195)
Pct. African-American	0.0216*** (0.0066)	0.0171** (0.0073)	0.0176** (0.0074)	0.0174** (0.0076)
Pct. Asian-American	0.0114 (0.0177)	0.0132 (0.0189)	0.0143 (0.0191)	0.0141 (0.0187)
Pct. Hispanic	0.0164** (0.0078)	0.0173** (0.0078)	0.0170** (0.0078)	0.0157** (0.0079)
Pct. 18-21 years	-0.0062 (0.0562)	0.0179 (0.0623)	0.0165 (0.0618)	0.0167 (0.0610)
Pct. 22-29 years	0.1094** (0.0549)	0.0776 (0.0580)	0.0760 (0.0582)	0.0582 (0.0601)
Pct. 30-39 years	-0.1505** (0.0702)	-0.1225* (0.0727)	-0.1194 (0.0747)	-0.1103 (0.0738)
Pct. 40-64 years	-0.1464*** (0.0430)	-0.1723*** (0.0470)	-0.1714*** (0.0477)	-0.1755*** (0.0494)
Pct. 65 years and over	0.0501* (0.0282)	0.0511* (0.0288)	0.0545* (0.0296)	0.0624** (0.0298)
Pct. of pop. in prof. employ.	0.0862*** (0.0240)	0.0826*** (0.0274)	0.0920*** (0.0282)	0.0875*** (0.0311)

Variables	Model 1	Model 2	Model 3	Model 4
Pct. HS grad.	0.0564*** (0.0198)	0.0622*** (0.0204)	0.0591*** (0.0207)	0.0450** (0.0212)
Pct. college grad.	0.0082 (0.0266)	0.0098 (0.0272)	0.0026 (0.0277)	-0.0052 (0.0293)
Limited access hwy. dummy	0.5444*** (0.2401)	0.6030** (0.2437)	0.5378** (0.2387)	0.3824 (0.2486)
Major railroad dummy	0.6093 (0.5791)	0.7340 (0.7642)	0.7382 (0.7958)	0.7752 (0.8768)
Mainframe computer sites per 100,000 pop.	0.0571*** (0.0087)	0.0660*** (0.0125)	0.0649*** (0.0129)	0.0625*** (0.0135)
Regional Bell dummy	0.8380*** (0.1626)	0.7679*** (0.1602)	0.7397*** (0.1581)	0.6109*** (0.1563)
GTE dummy	0.5396*** (0.1928)	0.4655** (0.1935)	0.4405** (0.1914)	0.2956 (0.1884)
Enrollment in Carnegie 1 per capita	-3.8363** (1.9321)	-4.8914** (2.2714)	-4.7068** (2.2194)	-4.6320** (2.1277)
Enrollment in Carnegie 2 per capita	-0.2955 (1.9545)	-1.3534 (2.1760)	-1.3890 (2.1258)	-1.1714 (2.0960)
Enrollment in Carnegie 3 per capita	-3.1011 (3.3654)	-4.6740 (3.5603)	-5.0273 (3.5612)	-6.0338 (3.6764)
Fraction of workers in prof. employment		0.9999 (1.0131)	1.0952 (1.0101)	1.1589 (1.0240)
Mean weekly wage in business services (in $10000s)			-0.5518 (3.5514)	
Mean weekly wage in comput. services (in $10000s)				1.1248 (1.3064)
Value of pseudo-likelihood	-22223.9714	-21139.6770	-20850.0510	-18641.5990
Observations	3109	2607	2171	1143

Notes: * Significant at 10 percent level.
** Significant at 5 percent level.
*** Significant at 1 percent level.

Table 5B
Specifications of Mean Number of Local ISPs (No contiguous county information)
(Asymptotic Standard Errors in Parentheses)

Variables	Model 1	Model 2	Model 3	Model 4
Population (in millions)	0.3280*** (0.0400)	0.3234*** (0.0395)	0.3228*** (0.0387)	0.3162*** (0.0366)
Located in an MSA	0.5206*** (0.0653)	0.4837*** (0.0677)	0.4465*** (0.0667)	0.3349*** (0.0769)
Median family income (in $10,000s)	-0.4918*** (0.1521)	-0.5308*** (0.1611)	-0.4840*** (0.1636)	-0.3468* (0.1788)
Pct. of families with incomes below $25,000	-0.0314*** (0.0118)	-0.0306** (0.0125)	-0.0289** (0.0130)	-0.0216 (0.0156)
Pct. of families with incomes above $75,000	0.0688*** (0.0152)	0.0695*** (0.0163)	0.0621*** (0.0166)	0.0547*** (0.0189)
Pct. Native American	-0.0006 (0.0073)	-0.0009 (0.0090)	-0.0008 (0.0096)	0.0173** (0.0074)
Pct. African-American	0.0155*** (0.0032)	0.0172*** (0.0034)	0.0171*** (0.0034)	0.0208*** (0.0038)
Pct. Asian-American	0.0131 (0.0106)	0.0129 (0.0108)	0.0110 (0.0107)	0.0118 (0.0106)
Pct. Hispanic	0.0161*** (0.0056)	0.0193*** (0.0057)	0.0203*** (0.0056)	0.0234*** (0.0057)
Pct. 18-21 years	-0.0714** (0.0288)	-0.0615** (0.0275)	-0.0630** (0.0274)	-0.0337 (0.0323)
Pct. 22-29 years	0.1394*** (0.0258)	0.1369*** (0.0277)	0.1358*** (0.0280)	0.1588*** (0.0339)
Pct. 30-39 years	-0.0362 (0.0324)	-0.0179 (0.0350)	-0.0236 (0.0365)	-0.0221 (0.0410)
Pct. 40-64 years	-0.0452** (0.0199)	-0.0330 (0.0225)	-0.0379 (0.0234)	-0.0208 (0.0266)
Pct. 65 years and over	0.0374*** (0.0145)	0.0415*** (0.0159)	0.0444*** (0.0163)	0.0653*** (0.0180)
Pct. of pop. in prof. employ.	0.0226** (0.0111)	0.0369*** (0.0133)	0.0526*** (0.0147)	0.0702*** (0.0192)

Variables	Model 1	Model 2	Model 3	Model 4
Pct. HS grad.	0.0374*** (0.0095)	0.0420*** (0.0099)	0.0429*** (0.0103)	0.0416*** (0.0125)
Pct. college grad.	0.0175 (0.0131)	0.0129 (0.0141)	0.0013 (0.0153)	-0.0131 (0.0190)
Limited access hwy. dummy	0.3556*** (0.0602)	0.3288*** (0.0624)	0.2765*** (0.0626)	0.1956** (0.0775)
Major railroad dummy	0.2731** (0.1310)	0.2265 (0.1440)	0.1534 (0.1493)	0.4068** (0.1857)
Mainframe computer sites per 100,000 pop.	0.0350*** (0.0055)	0.0412*** (0.0054)	0.0399*** (0.0055)	0.0421*** (0.0063)
Regional Bell dummy	0.5274*** (0.0640)	0.4969*** (0.0645)	0.4519*** (0.0633)	0.4232*** (0.0734)
GTE dummy	0.4136*** (0.0916)	0.3837*** (0.0932)	0.3517*** (0.0929)	0.3304*** (0.1033)
Enrollment in Carnegie 1 per capita	0.2794 (0.9262)	0.5008 (0.5970)	0.5638 (0.4472)	-0.7889 (0.9984)
Enrollment in Carnegie 2 per capita	0.8186 (0.9347)	0.8106 (0.7404)	0.6343 (0.6620)	-0.7687 (1.0964)
Enrollment in Carnegie 3 per capita	-0.4038 (1.6135)	-1.1174 (1.5325)	-1.4506 (1.5189)	-5.6190*** (2.0007)
Fraction of workers in prof. employment		-0.6469 (0.4778)	-0.3567 (0.4830)	-0.5028 (0.5769)
Mean weekly wage in business services (in $10000s)			3.0975** (1.3281)	
Mean weekly wage in comput. services (in $10000s)				1.1635** (0.5651)
Value of pseudo-likelihood	-4195.3432	-3808.7965	-3557.2054	-2514.5276
Observations	3109	2607	2171	1143

Notes: * Significant at 10 percent level.
** Significant at 5 percent level.
*** Significant at 1 percent level.

Table 6A
Specifications of Mean Number of National ISPs (Contiguous county information)
(Asymptotic Standard Errors in Parentheses)

Variables	Model 1	Model 2	Model 3	Model 4
Coefficients on Home County Characteristics				
Population (in millions)	0.1357** (0.0670)	0.1391** (0.0672)	0.1354** (0.0665)	0.1226* (0.0648)
Located in an MSA	2.2890*** (0.2448)	2.1067*** (0.2366)	2.0136*** (0.2256)	1.6604*** (0.2109)
Median family income (in $10,000s)	-1.0525*** (0.3092)	-1.0084*** (0.3267)	-1.0101*** (0.3272)	-0.8085** (0.3309)
Pct. of families with incomes below $25,000	0.0147 (0.0290)	0.0206 (0.0296)	0.0216 (0.0297)	0.0174 (0.0310)
Pct. of families with incomes above $75,000	0.1436*** (0.0339)	0.1386*** (0.0358)	0.1354*** (0.0361)	0.1229*** (0.0379)
Pct. Native American	-0.0389** (0.0196)	-0.0437* (0.0246)	-0.0552 (0.0355)	0.0041 (0.0264)
Pct. African-American	0.0327*** (0.0074)	0.0279*** (0.0078)	0.0272*** (0.0079)	0.0273*** (0.0081)
Pct. Asian-American	0.0250 (0.0220)	0.0186 (0.0228)	0.0183 (0.0242)	0.0286 (0.0233)
Pct. Hispanic	0.0237*** (0.0092)	0.0239** (0.0099)	0.0237** (0.0100)	0.0207** (0.0101)
Pct. 18-21 years	-0.0206 (0.0607)	0.0003 (0.0701)	-0.0636 (0.0679)	0.0086 (0.0662)
Pct. 22-29 years	0.1723*** (0.0578)	0.1563** (0.0612)	0.1470** (0.0617)	0.1424** (0.0627)
Pct. 30-39 years	-0.1286* (0.0721)	-0.1047 (0.0751)	-0.1137 (0.0757)	-0.1138 (0.0775)
Pct. 40-64 years	-0.1266*** (0.0457)	-0.1365*** (0.0508)	-0.1427*** (0.0525)	-0.1442*** (0.0527)
Pct. 65 years and over	0.0656** (0.0313)	0.0675** (0.0323)	0.0662** (0.0333)	0.0738** (0.0331)
Pct. of pop. in prof. employ.	0.0821*** (0.0276)	0.0797** (0.0314)	0.0897*** (0.0321)	0.0854** (0.0353)

Variables	Model 1	Model 2	Model 3	Model 4
Pct. HS grad.	0.0824*** (0.0238)	0.0918*** (0.0254)	0.0920*** (0.0260)	0.0658** (0.0265)
Pct. college grad.	0.0282 (0.0334)	0.0328 (0.0347)	0.0258 (0.0355)	0.0031 (0.0363)
Limited access hwy. dummy	0.3214 (0.2032)	0.3956* (0.2062)	0.3228 (0.1987)	0.1999 (0.2028)
Major railroad dummy	0.6524 (0.5267)	0.6174 (0.5853)	0.6410 (0.5899)	0.7088 (0.6511)
Mainframe computer sites per 100,000 pop.	0.0568*** (0.0098)	0.0656*** (0.0130)	0.0651*** (0.0130)	0.0654*** (0.0137)
Regional Bell dummy	0.7189*** (0.1589)	0.6432*** (0.1606)	0.6057*** (0.1600)	0.4666*** (0.1568)
GTE dummy	0.6543*** (0.1910)	0.5886*** (0.1933)	0.5617*** (0.1932)	0.4060** (0.1916)
Enrollment in Carnegie 1 per capita	-4.7148** (2.1464)	-5.1191** (2.5553)	-4.8050** (2.4161)	-5.4144** (2.2344)
Enrollment in Carnegie 2 per capita	-0.8700 (2.1390)	-1.3845 (2.3911)	-1.2595 (2.2567)	-2.2055 (2.2465)
Enrollment in Carnegie 3 per capita	-4.2488 (4.2499)	-4.8668 (4.3227)	-4.8631 (4.2739)	-7.6275* (4.3402)
Fraction of workers in prof. employment		0.3857 (1.0155)	0.5933 (1.0157)	0.8181 (1.0233)
Mean weekly wage in business services (in $10000s)			0.2663 (0.3266)	
Mean weekly wage in comput. services (in $10000s)				0.0078 (0.1240)
Distance (in 100 miles)	3.0342*** (0.4237)	2.8704*** (0.3772)	2.8725*** (0.3643)	3.1477*** (0.3855)
Coefficients on Contiguous County Characteristics				
Population (in millions)	-0.2855* (0.1566)	-0.2295 (0.1428)	-0.2258 (0.1434)	-0.2752* (0.1544)

Variables	Model 1	Model 2	Model 3	Model 4
Located in an MSA	0.1755 (0.1332)	0.2086 (0.1342)	0.2066 (0.1332)	0.2209 (0.1378)
Median family income(in $10,000s)	-0.0252 (0.2619)	-0.0288 (0.2611)	-0.0050 (0.2673)	0.0273 (0.2808)
Pct. of families with incomes below $25,000	-0.0362** (0.0174)	-0.0344** (0.0172)	-0.0334** (0.0170)	-0.0286 (0.0185)
Pct. of families with incomes above $75,000	-0.0135 (0.0252)	-0.0105 (0.0246)	-0.0133 (0.0249)	-0.0174 (0.0271)
Pct. Native American	0.0401** (0.0159)	0.0408*** (0.0158)	0.0425** (0.0175)	0.0502** (0.0206)
Pct. African-American	-0.0046 (0.0041)	-0.0047 (0.0041)	-0.0050 (0.0041)	-0.0047 (0.0043)
Pct. Asian-American	0.0026 (0.0187)	0.0028 (0.0178)	0.0025 (0.0180)	0.0142 (0.0190)
Pct. Hispanic	-0.0017 (0.0060)	-0.0011 (0.0060)	-0.0011 (0.0060)	0.0008 (0.0065)
Pct. 18-21 years	0.0217 (0.0555)	0.0342 (0.0552)	0.0256 (0.0543)	0.0279 (0.0601)
Pct. 22-29 years	-0.0674 (0.0491)	-0.0900* (0.0473)	-0.0944** (0.0476)	-0.1086** (0.0505)
Pct. 30-39 years	0.0542 (0.0551)	0.0886 (0.0546)	0.0877 (0.0539)	0.1107* (0.0590)
Pct. 40-64 years	-0.0385 (0.0325)	-0.0342 (0.0340)	-0.0369 (0.0337)	-0.0396 (0.0372)
Pct. 65 years and over	-0.0026 (0.0257)	0.0051 (0.0259)	0.0108 (0.0260)	0.0072 (0.0280)
Pct. of pop. in prof. employ.	-0.0060 (0.0182)	-0.0084 (0.0175)	-0.0080 (0.0180)	-0.0005 (0.0197)
Pct. HS grad.	-0.0277 (0.0172)	-0.0277 (0.0168)	-0.0274 (0.0168)	-0.0250 (0.0182)
Pct. college grad.	-0.0215 (0.0199)	-0.0234 (0.0196)	-0.0237 (0.0196)	-0.0252 (0.0214)

Variables	Model 1	Model 2	Model 3	Model 4
Limited access hwy. dummy	-0.0222 (0.1185)	-0.0482 (0.1153)	-0.0455 (0.1176)	-0.0728 (0.1302)
Major railroad dummy	-0.2424 (0.3070)	-0.1447 (0.3141)	-0.1340 (0.3093)	-0.0738 (0.3434)
Mainframe computer sites per 100,000 pop.	-0.0152 (0.0216)	-0.0079 (0.0205)	-0.0072 (0.0203)	-0.0080 (0.0224)
Regional Bell dummy	-0.1623 (0.1247)	-0.1227 (0.1199)	-0.1156 (0.1206)	-0.1120 (0.1257)
GTE dummy	-0.2024 (0.1696)	-0.1980 (0.1669)	-0.1955 (0.1685)	-0.1763 (0.1740)
Enrollment in Carnegie 1 per capita	-3.1624 (2.3996)	-2.5033 (2.2379)	-2.1211 (2.1188)	-2.3026 (2.4278)
Enrollment in Carnegie 2 per capita	0.1081 (2.2618)	-0.5132 (2.1344)	1.0437 (2.0704)	1.2444 (2.3058)
Enrollment in Carnegie 3 per capita	8.4871** (3.5586)	7.6732** (3.4930)	8.2020** (3.5196)	9.2399** (4.1378)
Fraction of workers in prof. employment		-0.2113 (0.2458)	-0.2278 (0.2446)	-0.2514 (0.2630)
Mean weekly wage in business services (in $10000s)			0.0637 (0.4136)	
Mean weekly wage in comput. services (in $10000s)				-0.2317* (0.1359)
Value of pseudo-likelihood	-17754.0768	-16840.5412	-16502.7077	-14424.1332
Observations	3109	2607	2171	1143

Notes: * Significant at 10 percent level.
** Significant at 5 percent level.
*** Significant at 1 percent level.

Table 6B
Specifications of Mean Number of Local ISPs (Contiguous county information)
(Asymptotic Standard Errors in Parentheses)

Variables	Model 1	Model 2	Model 3	Model 4
Coefficients on Home County Characteristics				
Population (in millions)	0.2900*** (0.0298)	0.2803*** (0.0292)	0.2756*** (0.0281)	0.2779*** (0.0262)
Located in an MSA	0.4272*** (0.0659)	0.3810*** (0.0688)	0.3486*** (0.0681)	0.2540*** (0.0771)
Median family income (in $10,000s)	-0.2696* (0.1399)	-0.2967** (0.1484)	-0.2499* (0.1497)	-0.1660 (0.1608)
Pct. of families with incomes below $25,000	-0.0186 (0.0122)	-0.0125 (0.0128)	-0.0081 (0.0131)	0.0050 (0.0152)
Pct. of families with incomes above $75,000	0.0391*** (0.0148)	0.0376** (0.0158)	0.0324** (0.0162)	0.0312* (0.0188)
Pct. Native American	-0.0029 (0.0082)	0.0003 (0.0094)	-0.0032 (0.0106)	0.0047 (0.0104)
Pct. African-American	0.0179*** (0.0033)	0.0180*** (0.0036)	0.0175*** (0.0036)	0.0183*** (0.0040)
Pct. Asian-American	0.0245** (0.0096)	0.0241** (0.0100)	0.0255*** (0.0098)	0.0260** (0.0102)
Pct. Hispanic	0.0239*** (0.0052)	0.0276*** (0.0053)	0.0290*** (0.0051)	0.0290*** (0.0055)
Pct. 18-21 years	-0.0619* (0.0351)	-0.0502* (0.0268)	-0.0478** (0.0235)	0.0010 (0.0323)
Pct. 22-29 years	0.1546*** (0.0248)	0.1522*** (0.0261)	0.1477*** (0.0259)	0.1677*** (0.0309)
Pct. 30-39 years	-0.0345 (0.0294)	-0.0106 (0.0309)	-0.0106 (0.0325)	-0.0031 (0.0352)
Pct. 40-64 years	-0.0237 (0.0186)	-0.0071 (0.0198)	-0.0077 (0.0206)	0.0248 (0.0241)
Pct. 65 years and over	0.0548*** (0.0147)	0.0584 (0.0158)	0.0623*** (0.0162)	0.0800*** (0.0174)
Pct. of pop. in prof. employ.	0.0221** (0.0112)	0.0371*** (0.0129)	0.0505*** (0.0136)	0.0567*** (0.0168)

Variables	Model 1	Model 2	Model 3	Model 4
Pct. HS grad.	0.0457*** (0.0103)	0.0543*** (0.0108)	0.0560*** (0.0110)	0.0584*** (0.0129)
Pct. college grad.	0.0358*** (0.0128)	0.0340** (0.0137)	0.0231 (0.0142)	0.0176 (0.0168)
Limited access hwy. dummy	0.3008*** (0.0633)	0.2882*** (0.0658)	0.2552*** (0.0652)	0.1721** (0.0775)
Major railroad dummy	0.3605*** (0.1270)	0.3041** (0.1392)	0.2008 (0.1409)	0.5258*** (0.1739)
Mainframe computer sites per 100,000 pop.	0.0359*** (0.0051)	0.0432*** (0.0046)	0.0429*** (0.0046)	0.0485*** (0.0052)
Regional Bell dummy	0.4465*** (0.0607)	0.4332*** (0.0624)	0.3962*** (0.0608)	0.3939*** (0.0690)
GTE dummy	0.3688*** (0.0855)	0.3548*** (0.0864)	0.3372*** (0.0865)	0.3758*** (0.0943)
Enrollment in Carnegie 1 per capita	0.0775 (1.5349)	0.4124 (0.9089)	0.5616 (0.5518)	-1.2809 (1.2926)
Enrollment in Carnegie 2 per capita	0.7411 (1.3463)	0.7914 (0.9104)	0.6202 (0.6967)	-1.1764 (1.1939)
Enrollment in Carnegie 3 per capita	0.1052 (1.7670)	-0.4002 (1.4206)	-0.7066 (1.3695)	-5.8614*** (1.9931)
Fraction of workers in prof. employment		-0.6901 (0.4433)	-0.5008 (0.4495)	0.5391 (0.5394)
Mean weekly wage in business services (in $10000s)			0.2645* (0.1488)	
Mean weekly wage in comput. services (in $10000s)				0.0424 (0.0618)
Distance (in 100 miles)	0.2991 (0.2169)	0.3549 (0.2245)	0.3792 (0.2339)	0.5776** (0.2462)
Coefficients on Contiguous County Characteristics				
Population (in millions)	0.0751*** (0.0221)	0.0685*** (0.0214)	0.0675*** (0.0208)	0.0767*** (0.0219)

Variables	Model 1	Model 2	Model 3	Model 4
Located in an MSA	0.0741** (0.0317)	0.0733** (0.0324)	0.0760** (0.0332)	0.0895** (0.0382)
Median family income(in $10,000s)	-0.1901*** (0.0656)	-0.2028*** (0.0685)	-0.1671** (0.0702)	-0.1881** (0.0802)
Pct. of families with incomes below $25,000	-0.0034 (0.0038)	-0.0047 (0.0040)	-0.0026 (0.0041)	-0.0010 (0.0047)
Pct. of families with incomes above $75,000	0.0177*** (0.0064)	0.0194*** (0.0068)	0.0166** (0.0069)	0.0194** (0.0083)
Pct. Native American	-0.0018 (0.0251)	-0.0023 (0.0027)	-0.0014 (0.0028)	-0.0008 (0.0036)
Pct. African-American	-0.0053*** (0.0010)	-0.0052*** (0.0011)	-0.0050*** (0.0011)	-0.0040*** (0.0012)
Pct. Asian-American	-0.0017 (0.0042)	-0.0017 (0.0042)	0.0005 (0.0044)	-0.0009 (0.0048)
Pct. Hispanic	-0.0053*** (0.0015)	-0.0054*** (0.0015)	-0.0052*** (0.0014)	-0.0052*** (0.0017)
Pct. 18-21 years	-0.0126 (0.0114)	-0.0161 (0.0119)	-0.0189 (0.0121)	-0.0092 (0.0145)
Pct. 22-29 years	-0.0310*** (0.0114)	-0.0349*** (0.0116)	-0.0376*** (0.0116)	-0.0536*** (0.0139)
Pct. 30-39 years	0.0012 (0.0112)	-0.0039 (0.0119)	-0.0032 (0.0120)	0.0104 (0.0146)
Pct. 40-64 years	-0.0128* (0.0067)	-0.0179** (0.0073)	-0.0201*** (0.0076)	-0.0296*** (0.0092)
Pct. 65 years and over	-0.0180*** (0.0054)	-0.0206*** (0.0059)	-0.0216*** (0.0059)	-0.0201*** (0.0072)
Pct. of pop. in prof. employ.	-0.0088** (0.0039)	-0.0085** (0.0041)	-0.0058 (0.0040)	-0.0050 (0.0048)
Pct. HS grad.	-0.0019 (0.0034)	-0.0025 (0.0037)	-0.0019 (0.0036)	0.0001 (0.0045)
Pct. college grad.	0.0006 (0.0047)	-0.0001 (0.0049)	0.0002 (0.0049)	0.0002 (0.0057)

Variables	Model 1	Model 2	Model 3	Model 4
Limited access hwy. dummy	-0.0108 (0.0266)	-0.0208 (0.0277)	-0.0324 (0.0277)	-0.0651** (0.0330)
Major railroad dummy	-0.0175 (0.0536)	-0.0218 (0.0591)	-0.0198 (0.0593)	0.0360 (0.0749)
Mainframe computer sites per 100,000 pop.	-0.0030 (0.0045)	-0.0024 (0.0045)	-0.0016 (0.0043)	0.0018 (0.0047)
Regional Bell dummy	0.0442 (0.0281)	0.0433 (0.0289)	0.0405 (0.0284)	0.0306 (0.0322)
GTE dummy	0.0236 (0.0400)	0.0087 (0.0411)	-0.0064 (0.0429)	-0.0500 (0.0488)
Enrollment in Carnegie 1 per capita	0.0602 (0.3226)	0.1130 (0.3023)	0.1742 (0.2798)	-0.3249 (0.4116)
Enrollment in Carnegie 2 per capita	0.1204 (0.4635)	0.1538 (0.4694)	0.0326 (0.4812)	-0.3432 (0.5888)
Enrollment in Carnegie 3 per capita	-0.6846 (0.7511)	-0.7958 (0.7675)	-0.6973 (0.7693)	-0.8838 (0.9253)
Fraction of workers in prof. employment		0.0171 (0.0632)	-0.0284 (0.0645)	-0.0275 (0.0727)
Mean weekly wage in business services (in $10000s)			-0.1527* (0.0881)	
Mean weekly wage in comput. services (in $10000s)				-0.0718 (0.0454)
Value of pseudo-likelihood	-3954.7979	-3580.2231	-3332.3023	-2301.0526
Observations	3109	2607	2171	1143

Notes: * Significant at 10 percent level.
** Significant at 5 percent level.
*** Significant at 1 percent level.

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