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The Geographic Dispersion of Commercial Internet Use

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1. Introduction

Advances in frontier technology are only the first step in the creation of economic progress. The next step involves use by economic agents. Adoption by users typically needs time, invention, and resources before economic welfare gains are realized. This principle applies with particular saliency to the Internet, a malleable technology whose form is not fixed across locations. To create value, the Internet must be embedded in investments at firms and households that employ a suite of communication technologies, TCP/IP protocols and standards for networking between computers. Often organizational processes also must change.

The dispersion of Internet use to commercial users is a central concern for economic policy. As a *general purpose technology* (GPT) (Bresnahan and Trajtenberg 1995), the Internet will have a greater impact if and when it diffuses widely to commercial firms. This is particularly so because commercial firms do the vast majority of the investment in Internet infrastructure, and at a scale of investment reaching tens of billions of dollars. Concerns about dispersion are difficult to address, however. Measuring dispersion requires a census of commercial Internet use, which, in turn, requires extensive data and an appropriate framework. This has not been done by any prior research. This study fills this gap.

We construct a census of adoption, the most common yardstick for measuring a new technology's use (Rogers 1995). We use this census to answer questions on the regional distribution of commercial Internet use.[1] How widely dispersed is Internet technology across locations and industries? Which regions adopt often and which do not? How does this measurement of dispersion compare with other ways of measuring the spread of the Internet?

Three themes shape our approach to answering these questions. First, our approach is consistent with standard ruminations about the strategic advantages affiliated with adoption of Internet technology. For example, some investments in Internet technology are regarded as "table stakes"—they are required for companies to be a player in a market—whereas other investments are regarded as the basis of competitive advantage (Porter 2001). Second, our framework extends principles of "universal service" to Internet technology (Compaine 2001, Noll et al. 2001). Third, since there is no preset pattern for the adoption of GPTs, we seek to document differences in adoption between locations.

We propose to analyze the dispersion of use of the Internet in two distinct layers. In one layer—hereafter termed *participation*—investment in and adoption of Internet technology enables participation in the Internet network. Participation is affiliated with basic communications, such as email use, browsing and passive document sharing. It also represents our measure of "tables stakes," namely, the basic Internet investment required to do business. In the second layer—hereafter termed *enhancement*—investment in and adoption of Internet technology enhances business processes. Enhancement uses Internet technologies to change existing internal operations or to implement new services. It represents our measure of investment aimed at competitive advantage.

Our analysis covers all medium and large commercial users, approximately two-thirds of the workforce. We use a private survey of 86,879 establishments with over 100 employees. The survey is updated to the end of 2000. Harte Hanks Market Intelligence, a commercial market research firm that tracks use of Internet technology in business, undertook the survey. We use the County Business Patterns data from the Census and routine statistical methods to generalize our results to the entire population of medium to large establishments in the United States.

We develop three major conclusions: First, we conclude participation and enhancement display contrasting patterns of adoption and dispersion. Overall, we find an average rate of adoption in excess of 88 percent; participation is near saturation in a majority of geographic locations. By any historical measure, such extensive adoption is remarkable for such a young technology. In contrast, though enhancement is widespread across industries and locations, the rate is much lower than that found for participation. Such investment occurs at approximately 12.6 percent of establishments.

Second, we show that Internet technologies displayed geographic usage patterns common to other communication technologies; however we argue different reasons from other authors. Specifically, there is evidence consistent with a mild geographic digital divide in both participation and enhancement. Although participation is high, the average establishment in a small metropolitan statistical area (MSA) or rural area is about 10 percent to 15 percent less likely to participate than one in the largest MSAs. Also, establishments in MSAs with over one million people are one and a half times as likely to use the Internet for enhancement than are establishments in MSAs with less than 250,000 people.

Why do some regions lead and others lag? We offer an explanation that differs sharply with the literature on digital divide. We conclude that the (preexisting) distribution of industries across geographic locations explains much of the differences in rates in enhancement. This is not the entire explanation, but it is certainly important. Hence, we question the prevailing opinion that the dispersion of the Internet sharply benefited a small number of regions. We argue that regional growth policies, in addition to focusing on correcting lack of participation in a few locations, should also focus on understanding how regional growth policies can broaden the foothold that enhancement has across the majority of regions.

Third, existing studies fail to document the dispersion of use by commercial establishments. We establish this by comparing our data with other measures. We find that the geographic dispersion of commercial Internet use is positively related to the dispersion in household and farm use, as documented in previous research, but the relationship is not strong. Hence, we conclude that previous studies provide a misleading picture of dispersion.[2]

2. Background

Our framework builds on microstudies of Internet investment in commercial establishments and organizations.[3] It is motivated by the user-oriented emphasis in the literature on GPTs.[4]

2.1 General Purpose Technologies and the Commercialization of the Internet

The diffusion of the Internet can be viewed in the context of observations about technological convergence (Ames and Rosenberg 1984), which is the increasing use of a small number of technological functions for many different purposes. Bresnahan and Trajtenberg (1995) develop this further in their discussion of GPTs, which they define as capabilities whose adaptation raises the marginal returns to inventive activity in a wide variety of circumstances. GPTs involve high fixed costs in invention and low marginal costs in reproduction. A GPT is adapted for any new use, and this adaptation takes time, additional expense and further invention. Following the literature, we label these as *co-invention expenses*. Studies have found that co-invention influences computing and Internet technology investments by business users (Bresnahan and Greenstein 1997, Forman 2002).

Almost by definition, GPTs have a big impact if and when they diffuse widely, that is, if they raise the marginal productivity of a disparate set of activities in the economy. As a practical matter, "disparate" means a great number of applications and industries, performed in a great number of locations. What stands in the way of achieving wide and disparate diffusion? Barriers arise as a result of users facing different economic circumstances, such as differences in local output market conditions, quality of local infrastructure, labor market talent levels, quality of firm assets or competitive conditions in output markets. Simply put, these barriers are different co-invention expenses.

There is no preset pattern for the dispersion of GPTs. They can diffuse in layers or waves (e.g., Lipsey, Becker, and Carlaw 1998). Below we argue that analysis of the dispersion of the Internet to commercial business requires analysis of distinct layers. We hypothesize that the co-invention costs of certain types of Internet investment were low, whereas other bottlenecks persistently produced high coinvention costs. For low co-invention activities, adoption became a requirement to be in business. When the costs were higher and the benefits variable for other aspects, firms were more hesitant, investing only when it provided competitive advantage.

Consequently, we ignore differences across applications and intensities of use within an establishment. We focus on two layers that vary across location and industry. We label these layers as *participation* and *enhancement.*

The first layer, participation, is a key policy variable. As noted, it represents the basic requirements for being at the table for medium and large businesses. By 2000, participation was regarded as a routine matter. Its emphasis also arises in many studies of ubiquitous communications networks. A ubiquitous network is one in which every potential participant is, in fact, an actual participant. Concerns about ubiquity emerge in policy debates about applying principles of "universal service" to new technologies (Cherry, Wildman, and Hammond 1999, Compaine 2001, Noll et al. 2001). For our purposes, we recognize that many different policies for ubiquity target geographic variance in adoption (e.g., reducing urban/rural differences).

The second layer, enhancement, is also important for policy because its use is linked to the productive advance of firms and the economic growth of the regions in which these firms reside. It usually arrives as part of other intermediate goods, such as software, computing or networking equipment. Implementation of enhancement was anything but routine. Enhancement included technical challenges beyond the Internet's core technologies, such as security, privacy, and dynamic communication between browsers and servers. Organizational procedures usually also changed. Benefits accrue to the business organization employing enhancement through the addition of competitive advantage, but the co-invention costs and delays vary widely.

Participation represents a measure of "table stakes," while enhancement represents a measure of investment for competitive advantage.[5] Both layers of activity are important for economic advance, but each has distinct effects on regional and industrial growth. We do not necessarily presume that the two are closely related, but intend to measure the correlation between them.

3. Data and Method

The data we use for this study come from the Harte Hanks Market Intelligence CI Technology database (hereafter CI database).[6] The CI database contains establishment-level data on (1) establishment characteristics, such as number of employees, industry and location; (2) use of technology hardware and software, such as computers, networking equipment, printers and other office equipment; and (3) use of Internet applications and other networking services. Harte Hanks Market Intelligence (hereafter HH) collects this information to resell as a tool for the marketing divisions at technology companies. Interview teams survey establishments throughout the calendar year; our sample contains the most current information as of December 2000.

HH tracks over 300,000 establishments in the United States. Since we focus on commercial Internet use, we exclude government establishments, military establishments and nonprofit establishments, mostly in higher education. Our sample contains all commercial establishments from the CI database that contain over 100 employees, 115,671 establishments in all;[7] and HH provides one observation per establishment. We will use 86,879 of the observations with complete data generated between June 1998 and December 2000. We adopt a strategy of utilizing as many observations as possible, because we need many observations for thinly populated areas.[8] This necessitates routine adjustments of the data for the timing and type of the survey given by HH.

3.1. Data Description and Sample Construction

To obtain a representative sample, we compared the number of firms in our database to the number of firms in the Census. We calculated the total number of firms with more than 50 employees in the Census Bureau's 1999 County Business Patterns data and the number of firms in our database for each two-digit NAICS code in each location. We then calculated the total number in each location. This provides the basis for our weighting. The weight for a given NAICS in a given location is

$$\frac{\textit{Total \# of census establishments in location — NAICS}}{\textit{Total \# of census establishments in location}} \cdot \frac{\textit{Total \# of establishments in our data in location}}{\textit{Total \# of establishments in our data in location — NAICS}}$$

Therefore, each location-NAICS is given its weighting from its actual frequency in the census. In other words, if our data under-samples a given two-digit NAICS at a location relative to the census then each observation in that NAICS-location is given more importance.

Using two survey forms, HH surveyed establishments at different times. To adjust for differences in survey time and type, we econometri-

Table 5.1
National Internet Adoption Rates (in percentages)

	Weighted average	Unweighted average	Northeast	Midwest	South	West
Participation	88.6%	80.7%	88.0%	88.7%	89.0%	85.7%
Enhancement	12.6%	11.2%	12.7%	12.7%	12.4%	12.5%
Enhancement & experimenting with enhancement	23.2%	18.1%	24.0%	23.1%	22.7%	23.3%

cally estimate the relationship between an establishment's decision to participate or enhance as a function of its industry, location, timing of survey and form of survey. We then calculate predicted probabilities of adoption for each establishment *as if it were surveyed in the second half of 2000 and were given the long survey*. Once we weight by the true frequency of establishments in the population, we have information about establishments related to two-thirds of the U.S. workforce. The more observations we have for a given region or industry the more statistical confidence we have in the estimate.

3.2. Definitions of behavior

Identifying participation was simple compared to identifying enhancement. We identify participation as behavior in which an establishment has basic Internet access or has made any type of frontier investment. In contrast, for enhancement, an establishment must have made the type of investment commonly described in books on electronic commerce. We identify enhancement from substantial investments in electronic commerce or "e-business" applications. We look for commitment to two or more of the following projects: Internet-based enterprise resource planning or TCP/IP-based applications in customer service, education, extranet, publications, purchasing or technical support.

In table 5.1 we show the results of these definitions. Participation by establishments within the sample is at 80.7 percent (see Unweighted Average in table 5.1). The sample under-represents adopters. Our estimate of the economy-wide distribution, using the true distribution of establishments from the Census, is 88.6 percent (see Weighted Average in table

5.1). Enhancement has been undertaken by 11.2 percent of our sample and 12.6 percent of the true distribution. We also can estimate the rate of adoption by "experimenters," that is, those establishments with some indication of use, but not much. As one would expect for a technology still in the midst of diffusion, the proportion for experimenters (combined with enhancement) is considerably higher than for enhancement alone, reaching 18.1 percent for the unweighted average and 23.2 percent for the weighted average. We have explored this latter definition and found that it tracks the enhancement definition we use below, so it provides no additional insight about the dispersion of use. We do not analyze it further.

4. Distribution Across Metropolitan Areas

In this section we estimate the dispersion of Internet technology to urban businesses. We identify features of urban leaders and laggards. We also show how the (preexisting) geographic distribution of industries is responsible for Internet technology's geographic distribution.

Tables 5.2a and 5.2b cover the largest economic areas in the United States. In them we list the estimates for both participation and enhancement, organized by MSAs with over one million people and listed by areas in the order of highest to lowest adoption rates.[9]

In tables 5.3a, 5.3b, and 5.3c we summarize results for all MSAs by population and average establishment size. Finally, in tables 5.4a, b, and c we show the estimates for the top ten areas for enhancement by population group as defined above. We also list the standard errors[10] and number of observations to show where we have statistical confidence in the estimates.

4.1. Participation

Table 5.2a shows that participation is high in major urban locations. Virtually all establishments in the major urban areas are participating; they have paid the "table stakes." We estimate that thirty-five of the forty-nine major metropolitan areas (MSAs) are above 90 percent.[11] All but five are within a 95 percent confidence interval of 90 percent. Big differences among metropolitan areas are apparent only at the extreme. The bottom ten areas range from 89.1 percent in Pittsburgh to 84.6 percent in Nashville. Although these are the lower adopting areas, they are not very low in absolute value.

From table 5.3a we see that large MSAs are highest with their average participation of 90.4 percent. Participation in medium MSAs averages 84.9 percent. In small MSAs the participation rates are even lower, 75.5 percent on average.

We examined participation across 320 MSAs in the country (unweighted by population size).[12] The median MSA in the United States has participation at 84.3 percent. The lower quartile is 76.4 percent. Of the 80 MSAs in the lowest quartile, 69 have a population of under one-quarter million. In other words, very low participation in urban settings, when it arises, exists primarily in small MSAs.

4.2. Enhancement

In table 5.2b we examine the use of enhancement at establishments in MSAs with over one million people. We estimate that thirty-eight of the forty-nine areas are above 12.5 percent. All but one are within a 95 percent confidence interval of 12.5 percent. The top ten include a set of areas that partially overlaps with the list in table 5.2a. It begins with the greater Denver area (with 18.3 percent) at number one and the greater Portland area at number ten (with 15.1 percent). In between are the greater San Francisco Bay Area, the greater Salt Lake City area, Minneapolis/St Paul, the greater Houston area, Atlanta, Oklahoma City, Dallas/Fort Worth, and San Antonio. Again, big differences with these leaders are only apparent at the extremes. The bottom ten areas range from 12.4 percent in Phoenix to 9.0 percent in Las Vegas. Even so, these low adopting areas are, once again, not very low relative to the average.

Overall, establishments in urban settings are more likely to adopt enhancement than those located outside major metropolitan areas. Table 5.3a shows the adoption of enhancement in MSAs of different population size, highlighting again that large MSAs are somewhat exceptional. Establishments in large MSAs have adoption rates of 14.7 percent. In medium MSAs, it averages 11.2 percent. In small MSAs the rates are even lower, 9.9 percent on average. The second and third columns of table 5.3b strongly hint at the explanation for these differences. The upper quartile of two-digit NAICS industries with the highest enhancement adoption rates includes management of companies and enterprises (55), media, telecommunications and data processing (51), utilities (22), finance and insurance (52), professional, scientific and technical services (54) and

Table 5.2a
Participation Among Metropolitan Areas with Over One Million People

Rank	City	Rate	Std error	Obs	Population
1	San Francisco–Oakland–San Jose, CA	96.4%	0.4%	2135	7,039,362
2	Denver–Boulder–Greeley, CO	95.9%	0.7%	940	2,581,506
3	Cleveland–Akron, OH	94.8%	0.6%	1099	2,945,831
4	Seattle–Tacoma–Bremerton, WA	93.9%	0.5%	1012	3,554,760
5	Salt Lake City–Ogden, UT	93.5%	0.8%	535	1,333,914
6	San Antonio, TX	93.3%	0.8%	395	1,592,383
7	Providence–Fall River–Warwick, RI–MA	93.0%	1.2%	290	1,188,613
8	Grand Rapids–Muskegon–Holland, MI	93.0%	0.7%	503	1,088,514
9	Minneapolis–St. Paul, MN–WI	92.7%	0.5%	1411	2,968,806
10	Los Angeles–Riverside–Orange County, CA	92.5%	0.4%	4099	16,373,645
11	Kansas City, MO–KS	92.2%	0.6%	753	1,776,062
12	Austin–San Marcos, TX	92.1%	0.7%	344	1,249,763
13	Dallas–Fort Worth, TX	92.1%	0.5%	1720	5,221,801
14	Portland–Salem, OR–WA	92.1%	0.6%	776	2,265,223
15	Houston–Galveston–Brazoria, TX	91.7%	0.6%	1413	4,669,571
16	Phoenix–Mesa, AZ	91.6%	0.7%	988	3,251,876
17	Raleigh–Durham–Chapel Hill, NC	91.6%	0.9%	398	1,187,941
18	Columbus, OH	91.5%	0.9%	574	1,540,157
19	Milwaukee–Racine, WI	91.5%	0.7%	855	1,689,572
20	San Diego, CA	91.5%	0.7%	738	2,813,833
21	Detroit–Ann Arbor–Flint, MI	91.4%	0.6%	1621	5,456,428
22	Indianapolis, IN	91.3%	0.8%	646	1,607,486
23	Greensboro–Winston-Salem–High Point, NC	91.1%	0.9%	570	1,251,509
24	Atlanta, GA	90.9%	0.6%	1426	4,112,198
25	Miami–Fort Lauderdale, FL	90.9%	0.7%	1010	3,876,380
26	Charlotte–Gastonia–Rock Hill, NC–SC	90.7%	0.9%	618	1,499,293
27	Boston–Worcester–Lawrence, MA–NH–ME–CT	90.6%	0.5%	2231	5,819,100

Table 5.2a
(Continued)

Rank	City	Rate	Std error	Obs	Population
28	Chicago–Gary–Kenosha, IL–IN–WI	90.5%	0.4%	3431	9,157,540
29	New York–Northern New Jersey–Long Island, NY–NJ–CT–PA	90.5%	0.4%	4775	21,199,865
30	Washington–Baltimore, DC–MD–VA–WV	90.4%	0.5%	2222	7,608,070
31	Philadelphia–Wilmington–Atlantic City, PA–NJ–DE–MD	90.3%	0.5%	1745	6,188,463
32	Rochester, NY	90.3%	1.0%	373	1,098,201
33	Hartford, CT	90.2%	0.9%	500	1,183,110
34	Oklahoma City, OK	90.2%	1.1%	339	1,083,346
35	Memphis, TN–AR–MS	90.0%	1.0%	437	1,135,614
36	Louisville, KY–IN	89.9%	1.0%	448	1,025,598
37	Cincinnati–Hamilton, OH–KY–IN	89.7%	0.8%	772	1,979,202
38	St. Louis, MO–IL	89.7%	0.7%	936	2,603,607
39	Pittsburgh, PA	89.1%	0.8%	727	2,358,695
40	Buffalo–Niagara Falls, NY	88.5%	1.1%	393	1,170,111
41	Tampa–St. Petersburg–Clearwater, FL	88.4%	0.9%	812	2,395,997
42	Jacksonville, FL	87.6%	1.3%	373	1,100,491
43	Las Vegas, NV–AZ	87.2%	1.2%	417	1,563,282
44	Sacramento–Yolo, CA	87.0%	1.2%	427	1,796,857
45	Norfolk–Virginia Beach–Newport News, VA–NC	86.9%	1.2%	374	1,569,541
46	New Orleans, LA	86.0%	1.1%	386	1,337,726
47	West Palm Beach–Boca Raton, FL	85.9%	1.2%	299	1,131,184
48	Orlando, FL	85.5%	1.0%	622	1,644,561
49	Nashville, TN	84.6%	1.1%	466	1,231,311

Table 5.2b
Enhancement among Metropolitan Areas with Over One Million People

Rank	City	Rate	Std error	Obs	Population
1	Denver–Boulder–Greeley, CO	18.3%	1.3%	940	2,581,506
2	San Francisco–Oakland–San Jose, CA	17.0%	0.9%	2135	7,039,362
3	Salt Lake City–Ogden, UT	16.7%	1.7%	535	1,333,914
4	Minneapolis–St. Paul, MN–WI	15.9%	1.0%	1411	2,968,806
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(Continued)

Rank	City	Rate	Std error	Obs	Population
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30	West Palm Beach–Boca Raton, FL	13.6%	2.0%	299	1,131,184
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Table 5.3a
Average Adoption by Size of MSA

Population	Average participation by MSA population	Standard error	Average enhancement	Standard error	Number of areas
> 1 million	90.4%	0.1%	14.7%	0.2%	57
250,000–1 million	84.9%	0.2%	11.2%	0.3%	116
<250,000	75.5%	0.2%	9.9%	0.3%	143

Table 5.3b
Percentage of Establishments in Top Quartile Industry for Enhancement, by Size of MSA

Population in top quartile	Percentage of establishments	# of areas
> 1 million	27.5%	57
250,000–1 million	19.5%	116
< 250,000	19.0%	143

wholesale trade (42).[13] The fraction of the number of these establishments over the total number of establishments in an MSA is highest in large MSAs (27.5 percent). That accounts for much of the difference between larger and smaller MSAs.

Table 5.3c provides a test of this proposition. It shows the results from a simple regression that predicts enhancement for an MSA, illustrating the effect of industry presence controlling for area size and establishment size. The coefficient shows that a ten percent drop in the percent of firms from leading industries (from e.g., 0.3 to 0.2) would lead to the 2 percent drop in the enhancement rate within an MSA. The importance of industry continues to come through even with the addition of MSA size effects, interaction terms, average establishment size, and other measures of laggard industries.[14] In sum, an area is advanced because its establishments happen to come from a leading industry. To be fair, the presence of leading industries is not the only factor, but it is an important one. It alone explains 20 percent of the variance in enhancement. In the last column we also show a similar result for participation. This demonstrates that the presence of leading industries strongly shapes participation as well.

Table 5.3c
Importance of Industry and Population on Enhancement and Participation (standard errors in parentheses)

	(1) enhancement	(2) enhancement	(3) enhancement	(4) enhancement	(5) enhancement	(6) enhancement	(7) participation
(a) Percent firms in top quartile	0.259*** (0.0291)	0.214*** (0.0388)	0.212*** (0.0612)	0.223*** (0.0606)	0.192*** (0.0613)	0.177*** (0.0616)	0.565*** (0.108)
(b) MSA population greater than 1 million	0.0127* (0.00719)	0.0189 (0.0221)	0.0241 (0.0219)	0.0227 (0.0218)	0.0187 (0.0219)	0.177*** (0.0384)	
(c) MSA population between 250,000 & 1 million	0.00331 (0.00479)	0.000163 (0.0132)	0.00335 (0.0131)	0.00462 (0.0130)	0.00248 (0.0131)	0.102*** (0.0230)	
(a)*(b)			-0.0250 (0.105)	-0.0563 (0.104)	-0.0554 (0.103)	-0.0317 (0.104)	-0.458** (0.182)
(a)*(c)			0.0199 (0.0876)	-0.00690 (0.0870)	0.0118 (0.0863)	0.00792 (0.0867)	0.226 (0.152)
% retailing					-0.158*** (0.0630)	-0.186*** (0.0624)	-0.267** (0.111)
% of firms with over 50 employees that have over 500 (census)				0.385*** (0.131)	0.321*** (0.132)		0.419* (0.233)
% of firms with over 50 employees that have over 1000 (census)						0.0823 (0.229)	
Constant	0.0706*** (0.00496)	0.0739*** (0.00538)	0.0742*** (0.00768)	0.0559*** (0.00981)	0.0906 (0.0169)	0.110 (0.0154)	0.719*** (0.0298)
Rsq	0.1995	0.2074	0.2079	0.2292	0.2445	0.2306	0.5338

***significant at 99% confidence level **significant at 95% confidence level *significant at 90% confidence level

Table 5.4a
Leading Adopters of Enhancement among MSAs with Over One Million in Population

MSA	Adoption rate	Standard error	Number of observations	% Establishments in top quartile
San Jose, CA	20.0%	1.6%	638	33.2%
Denver, CO	17.1%	1.4%	778	31.1%
Salt Lake City–Ogden, UT	16.7%	1.7%	535	26.1%
San Francisco, CA	16.5%	1.5%	608	39.4%
Houston, TX	16.2%	1.1%	1320	26.5%
Seattle–Bellevue–Everett, WA	16.0%	1.3%	799	29.1%
Minneapolis–St. Paul, MN–WI	15.9%	1.0%	1411	28.2%
Portland–Vancouver, OR–WA	15.6%	1.4%	683	27.5%
Oklahoma City, OK	15.4%	2.0%	339	19.7%
Atlanta, GA	15.4%	1.0%	1426	32.0%
Average of Top Ten Large MSAs	16.5%			26.6%
Average of Bottom Ten Large MSAs	10.7%			21.7%

In tables 5.4a, 5.4b, and 5.4c we further examine differences in enhancement rates across small, medium and large MSAs, listing the ten leading MSAs for enhancement according to MSA size. In addition we look at the percentage of leading enhancement industries within each MSA. This breakdown of information highlights the differences between large, medium, and small MSAs. These figures reinforce the results in table 5.3, showing that MSAs with leading enhancement rates are not only the larger ones, but also the ones with the highest percentage of leading establishments. Moreover, they show that the difference in enhancement rates between MSA sizes are driven by differences in industry composition at the lower tail of the distribution. Table 5.4a shows the enhancement rates for the top ten and bottom ten large MSAs. The average of the fraction of leading establishments in the top ten large MSAs (26.6 percent) ex-

Table 5.4b
Leading Adopters of Enhancement among MSAs with 250,000 to One Million in Population

MSA	Adoption rate	Standard error	Number of observations	% Establishments in top quartile
Huntsville, AL	19.5%	3.3%	136	27.7%
Appleton–Oshkosh –Neenah, WI	19.4%	3.2%	150	14.4%
El Paso, TX	18.8%	2.8%	185	15.0%
Boulder–Longmont, CO	18.4%	3.4%	121	33.8%
Des Moines, IA	18.0%	2.6%	234	33.7%
Biloxi–Gulfport–Pascagoula, MS	17.8%	4.4%	74	19.6%
Omaha, NE–IA	17.3%	2.1%	343	31.6%
Pensacola, FL	17.1%	4.0%	86	17.1%
Peoria–Pekin, IL	16.2%	3.2%	136	20.3%
Kalamazoo–Battle Creek, MI	16.2%	2.9%	172	15.6%
Average of Top Ten Medium MSAs	17.9%			24.4%
Average of Bottom Ten Medium MSAs	4.4%			16.3%

ceeds the fraction (21.7 percent) in the bottom ten large MSAs (note that the laggards are not shown in this table).

In table 5.4b and 5.4c we can see that the levels of adoption among the leaders of medium MSAs are very similar to those shown in table 5.4a, but the standard errors are much larger owing to smaller sample size. These standard errors make us cautious to emphasize any details about particular locations in these rankings, but we are able to make broad statements. As before, among medium and small MSAs the average fraction of leading industries in the ten leading MSA's (24.4 percent and 16.4 percent respectively for medium and small) exceeds the average fraction of leading industries in the ten laggard MSAs (16.3 percent and 11.1 percent respectively). While leading medium and small MSAs are just as likely to be as advanced as leading large MSAs, however, there are many

Table 5.4c
Leading Adopters of Enhancement among MSAs with 250,000 to Less Than 250,000 in Population

MSA	Adoption rate	Standard error	Number of observations	% Establishments in top quartile
Rapid City, SD	25.6%	6.2%	41	13.5%
Missoula, MT	19.1%	6.1%	32	17.6%
Charlottesville, VA	18.2%	5.5%	47	25.2%
Decatur, IL	17.3%	5.9%	37	16.5%
Cheyenne, WY	17.1%	7.1%	19	14.3%
Dover, DE	17.0%	5.3%	29	20.3%
Jackson, TN	16.9%	4.9%	55	3.7%
Sioux Falls, SD	16.8%	3.9%	86	24.6%
Jackson, MI	16.1%	4.9%	50	8.9%
Casper, WY	16.0%	6.9%	23	14.3%
Average of Top Ten Small MSAs	18%%			16.4%
Average of Bottom Ten Small MSAs	2.1%			11.1%

medium and small MSAs with fewer establishments in the top quartile of enhancement adoption. In other words, the difference in distributions arises entirely at the lower tail.

4.3. Comparison with other findings.

We compared our findings against the National Telecommunications Information Administration (NTIA) studies of Internet technology use in households for the same year. This study is one among many from NTIA about the digital divide. We aggregated data that appeared in summary form in the NTIA report to the MSA level. We were able to compute household adoption rates for PCs and the Internet for 231 MSAs, a sample weighted toward large to medium MSAs.[15] The correlations between these MSA averages for households and our estimates for commercial establishments in the same location are positive but weak. They range between 0.13 and 0.17. The rank Spearman correlations are mildly higher, between 0.17 and 0.22.

We conclude that the household use of the Internet or computers is mildly informative about the use of the Internet at commercial establishments, as one would expect if the education of the local labor force influences both. However, we also conclude that the correlation is weak within most medium to large MSAs. This is consistent with the view that commercial establishments in urban areas train their workers or simply find mobile technically adept employees. Our findings also support the view that the factors necessary to foster participation and enhancement of Internet business processes did not depend much on local household behavior.

Unlike much previous literature,[16] we find no evidence that this technology is being dominated by a small set of users concentrated in a small region, whether it is in Silicon Valley, along Route 128 outside of Boston, or in any other major urban center. Participation was widespread by the end of 2000, though it tends to mildly favor establishments in heavily populated areas. The use of enhancement to gain competitive advantage spread widely but favored medium and large urban areas with a heavy mix of industries that were high adopter industries. Large MSAs have fewer laggards than medium and small MSAs. We conjecture that the laggard small and medium MSAs may suffer from an inability to achieve scale economies in secondary markets for programmer, technical and other complementary services.

We will say more about the urban/rural divides below, but we speculate at this point that the difference in findings between our study and previous studies arises for four reasons: (1) We are observing medium to large commercial adopters, who have the highest propensity to invest in Internet technology; (2) We are observing their behavior late enough in the diffusion cycle to overwhelm geographic biases associated with very early experimentation (i.e., early experimentation tends to favor areas with a high proportion of technical and scientific users); (3) We are observing business use, which has quite distinct determinants compared with household and farm adoption of computing and internet technology; (4) We are observing use of technology, not production or design of new products, and the latter tends to receive much more attention in public discussion, but leaves a false impression about use.

4.4. Urban dispersion in broader perspective

We close the discussion of MSA adoption by noting that the geographic distribution of establishments largely existed prior to the commercialization and diffusion of the Internet. This leads to three striking observations. First, the preexisting distribution of industries shaped the diffusion of Internet technology.

Second, this technology was adopted across many industries—not all of which share similar geographic distributions. Hence, there are straightforward economic reasons why the use of this technology had a large dispersion over geographic space. It would have taken an implausibly fast and massive relocation of existing establishments and labor markets to concentrate this technology in a small number of places.

Third, concerns about the concentration of use (as emphasized in studies of the digital divide and early development of Internet infrastructure) are out of proportion with the technology's actual pattern of diffusion in business. To be sure, there are leader and laggard regions, but we hardly find it alarming, nor surprising, for an expensive business technology just past its early stages of development.

In this sense, we agree strongly with analysts who argue that geography plays a role in shaping the diffusion and impact of virtual communities.[17] At the same time these findings make us skeptical that this technology's diffusion is headed toward geographically concentrated use. Too many regions have numerous establishments using the Internet for enhancement.

5. Urban/rural divides across states

Tables 5.5a and 5.5b present adoption rates for participation and enhancement for rural and nonrural establishments across all the states in the United States except New Jersey and the District of Columbia.[18] This is also a useful perspective for policy, since many policies for encouraging universal service within rural communities are determined by state regulators and legislatures.

5.1. Participation and enhancement

The estimates for participation in table 5.5a are high in most rural establishments, as expected. One striking feature of the table is its spread.

There are only five states where the rate of participation in rural areas is lower than 80 percent, and eighteen below 87 percent; however, this is still worse than in urban areas. There are two states with urban areas below 80 percent adoption (Vermont and Montana) and only six below 87 percent.

The estimate for rural enhancement adoption in table 5.5b has a distinct distribution. The enhancement rates in the leading states are comparable with the leading metropolitan areas. The lead state is Minnesota with a rate of 15.5 percent. This is followed by Rhode Island, South Carolina, Louisiana, New York, Ohio, West Virginia, Wyoming, Utah and Alaska. In the leading rural states the rates in the urban and rural areas are comparable. However, the differences in the lower tail are large. Twenty-four states have rural enhancement rates below 10 percent, while only three states have urban rates under 10 percent.

We compare the rank ordering of tables 5.5a and 5.5b. Five states are in the top ten of both tables. Generally, however, the ranking in both tables are only weakly correlated. The Spearman rank correlation coefficient is 0.296, positive but not large. This is further evidence that participation and enhancement are distinct.

5.2. Comparison with other findings

We compared our estimates with a previous survey of rural Internet technology development—the United States Department of Agriculture (USDA) estimates for computer and Internet use by U.S. farmers, summarized at the state level.[19] The correlation between participation at rural commercial establishments and farm computer use is 0.41. For enhancement, it is 0.18. While these correlations are positive, only the first one is large. Not surprisingly, we conclude that the USDA survey is an incomplete assessment of nearby commercial Internet use. Our survey and theirs should be positively related, because the level of sophistication of the general population influences adoption at farm and nonfarm establishments. However, the economic costs and benefits from adoption differ between farming and nonfarming establishments. These results warn against inferring much about rural conditions from farm data alone.

As another important lesson in the economic geography of the Internet policies, tables 5.6a and b include adoption rates for states. As indicated by many previous tables, this level of aggregation hides much variance at

Table 5.5a
Participation in Rural Areas by State

Rank	State	Rural rate	Std error	Observations	Urban rate	Std error	Observations
1	IN	92.9%	0.8%	653	88.9%	0.6%	1745
2	MN	92.9%	0.7%	566	91.0%	0.5%	1628
3	WI	91.9%	0.7%	672	90.9%	0.5%	1728
4	WY	91.6%	1.7%	96	82.1%	2.8%	42
5	NY	91.5%	0.8%	365	89.4%	0.4%	4193
6	NE	91.3%	1.0%	250	91.5%	0.8%	460
7	MI	91.1%	0.9%	532	91.2%	0.5%	2623
8	OH	90.9%	0.8%	735	89.5%	0.4%	3465
9	UT	90.7%	1.3%	124	92.3%	0.7%	627
10	KS	90.6%	1.0%	327	92.8%	0.6%	623
11	SD	90.5%	1.6%	140	88.4%	2.0%	127
12	AR	90.2%	1.1%	371	88.8%	1.0%	481
13	ID	89.9%	1.2%	188	88.0%	1.3%	160
14	IA	89.7%	0.8%	555	88.0%	0.9%	644
15	LA	89.7%	1.3%	228	91.4%	0.7%	992
16	MO	89.4%	1.0%	438	90.1%	0.5%	1505
17	WV	89.3%	1.2%	223	89.3%	1.3%	242
18	IL	89.1%	1.0%	585	89.2%	0.4%	3977
19	AL	89.0%	0.9%	384	90.1%	0.7%	1138
20	VT	89.0%	1.2%	107	78.9%	2.0%	71
21	KY	88.7%	0.8%	574	89.4%	0.7%	798
22	WA	88.7%	1.2%	215	92.1%	0.5%	1408
23	TX	88.5%	0.9%	492	90.1%	0.4%	5073
24	AK	88.4%	1.6%	97	90.1%	2.1%	91
25	NC	88.1%	0.8%	895	89.9%	0.5%	2122
26	SC	87.9%	1.3%	331	87.4%	0.8%	921
27	OK	87.8%	1.5%	238	92.1%	0.7%	683
28	VA	87.4%	1.1%	411	89.2%	0.5%	1603
29	MD	87.2%	2.2%	114	87.8%	0.8%	1352
30	GA	87.1%	0.8%	749	88.1%	0.6%	1859
31	TN	87.1%	1.2%	545	90.3%	0.6%	1463
32	NV	86.6%	2.4%	72	86.0%	1.1%	537
33	NH	86.5%	1.1%	163	88.9%	1.3%	297
34	OR	86.4%	1.4%	224	91.7%	0.6%	855
35	MS	85.7%	1.0%	564	89.6%	1.2%	302
36	CO	84.6%	1.1%	153	90.0%	0.6%	1246
37	PA	84.6%	1.0%	502	89.6%	0.4%	3489
38	ND	83.8%	1.1%	112	89.0%	1.4%	152
39	NM	83.1%	1.9%	131	84.5%	1.2%	261
40	CA	82.0%	1.8%	183	91.4%	0.3%	8379
41	FL	81.9%	1.8%	206	87.9%	0.5%	4289

Table 5.5a
(continued)

Rank	State	Rural rate	Std error	Observations	Urban rate	Std error	Observations
42	MT	81.9%	2.1%	114	72.2%	2.2%	90
43	ME	81.8%	1.2%	202	92.1%	1.5%	217
44	HI	81.2%	1.8%	100	92.4%	1.1%	231
45	AZ	79.1%	2.4%	89	90.0%	0.6%	1300
46	CT	78.9%	1.2%	89	89.7%	0.6%	1136
47	MA	74.0%	3.5%	33	92.6%	0.5%	2221
8	DE	71.5%	4.6%	31	85.5%	1.4%	208
49	RI	67.9%	2.6%	21	92.4%	1.1%	290

the MSA and rural levels. The open question is "How badly do you do if state data is the only thing available?" First, we look at participation. This distribution lacks much variance. The highest state (Massachusetts at 92.4 percent) is hardly higher than the median state (Arkansas at 89.4 percent). Only six states are below 87 percent. Next, we examine enhancement across states. Again, there is not much of a spread. The highest state (Colorado at 16.7 percent) is not much higher than the median (Nebraska at 12.8 percent), and the difference in point estimates are not statistically significant at a 95 percent confidence level. Only three states are less than 10 percent in their point estimates, and none are below 10 percent at traditional significance levels. In general, because urban and rural are not highly correlated, these state-level statistics mask the information in more detailed data. At the same time the rates for participation and enhancement are positively correlated (at 0.40).

5.3. Urban/rural divides in broader perspective

We conclude that enhancement needs to be understood at a fine geographic level, preferably with data relating adoption to MSA and establishments. When this is done, it is apparent that in terms of both participation and enhancement, there are distinct differences between the establishments found in the most populous urban centers and the least dense, even within the same state. We further conclude that concerns about digital divide in commercial establishments are justified, but only if properly qualified. Since participation was not costly, it is surprising and disturbing to find any establishment in any area with low participation.

Table 5.5b
Enhancement in Rural areas by State

Rank	State	Rural rate	Std error	Observations	Urban rate	Std error	Observations
1	MN	15.5%	1.6%	566	15.5%	0.9%	1628
2	RI	14.9%	6.4%	21	15.5%	2.2%	290
3	SC	14.9%	1.7%	331	10.7%	1.1%	921
4	LA	13.4%	2.3%	228	12.0%	1.2%	992
5	NY	13.0%	1.8%	365	12.7%	0.6%	4193
6	OH	12.5%	1.2%	735	12.4%	0.6%	3465
7	WV	12.5%	2.0%	223	8.6%	1.5%	242
8	WY	12.5%	3.4%	96	18.5%	5.7%	42
9	UT	12.4%	3.0%	124	16.2%	1.6%	627
10	AK	12.2%	3.2%	97	15.2%	3.8%	91
11	DE	12.2%	5.1%	31	14.2%	2.2%	208
12	NV	12.1%	3.8%	72	9.4%	1.3%	537
13	ND	11.8%	3.0%	112	8.7%	2.2%	152
14	CT	11.7%	2.3%	89	14.6%	1.1%	1136
15	WA	11.6%	2.2%	215	13.5%	1.0%	1408
16	WI	11.6%	1.4%	672	13.4%	0.9%	1728
17	IA	11.4%	1.4%	555	15.5%	1.4%	644
18	ID	11.4%	2.4%	188	10.2%	2.5%	160
19	IL	11.4%	1.2%	585	14.3%	0.6%	3977
20	IN	11.4%	1.3%	653	12.2%	0.8%	1745
21	AL	10.9%	1.6%	384	11.9%	1.0%	1138
22	GA	10.8%	1.2%	749	14.0%	0.9%	1859
23	VA	10.3%	1.6%	411	13.8%	0.8%	1603
24	VT	10.2%	2.9%	107	11.3%	3.7%	71
25	OR	10.1%	2.0%	224	14.6%	1.2%	855
26	AR	9.9%	1.6%	371	13.8%	1.6%	481
27	HI	9.6%	3.0%	100	10.1%	2.1%	231
28	KY	9.6%	1.3%	574	13.0%	1.1%	798
29	MO	9.6%	1.5%	438	13.6%	0.8%	1505
30	MS	9.6%	1.3%	564	13.4%	2.0%	302
31	MT	9.4%	2.7%	114	15.3%	3.5%	90
32	TN	9.3%	1.3%	545	12.2%	0.9%	1463
33	TX	9.3%	1.4%	492	14.6%	0.6%	5073
34	OK	9.2%	1.9%	238	15.0%	1.4%	683
35	AZ	9.1%	2.9%	89	11.5%	0.9%	1300
36	CA	9.1%	1.8%	183	13.8%	0.5%	8379
37	CO	9.1%	3.0%	153	16.9%	1.1%	1246
38	NC	8.9%	1.0%	895	12.3%	0.8%	2122
39	KS	8.2%	1.5%	327	13.1%	1.2%	623
40	PA	8.2%	1.3%	502	12.9%	0.6%	3489
41	NE	7.7%	1.7%	250	15.2%	1.7%	460

Table 5.5b
(continued)

Rank	State	Rural rate	Std error	Observations	Urban rate	Std error	Observations
42	NH	7.7%	2.3%	163	11.0%	1.9%	297
43	SD	6.9%	2.3%	140	20.9%	3.6%	127
44	FL	6.8%	1.9%	206	12.8%	0.6%	4289
45	NM	6.4%	2.2%	131	13.4%	2.1%	261
46	MA	5.6%	3.6%	33	14.4%	0.9%	2221
47	MD	5.6%	3.0%	114	15.5%	1.0%	1352
48	ME	5.6%	1.9%	202	11.0%	2.3%	217
49	MI	5.6%	1.4%	532	13.7%	0.8%	2623

To be sure, if these disparities persist, then it is worrisome for business prospects in those locations since every other establishment in the United States takes this technology for granted. Nevertheless, the scope of the problem is limited: Laggard areas do not have large populations.

The dispersion of enhancement provides a different set of insights. This distribution is much more skewed. Yet, such skew is not strong evidence of a digital divide. It is more understandable as an economic matter. First, skew could arise alone from thin technical labor markets in smaller MSAs and rural areas. This would drive up costs of operating facilities employing Internet technology.

Second, this reasoning also suggests that preexisting single-establishment organizations would hesitate to open their own complex Internet facilities until the costs are lower. Either case would lead to more use of enhancement in major urban areas.

6. Conclusions

The diffusion of Internet technology has important consequences for comparative regional economic growth. However, there has been remarkably little statistical evidence documenting the uses and benefits of Internet adoption among commercial organizations. This lack of data has engendered some long-standing misperceptions about Internet use that could potentially cloud decision-making of policymakers. In this chapter, we have developed a framework for understanding commercial Internet

Table 5.6a
Participation in Rural Areas by State

Rank	State	Adoption rate	Standard error	Number of observations
1	MA	92.4%	0.4%	2254
2	KS	92.0%	0.5%	950
3	WA	91.9%	0.5%	1624
4	UT	91.8%	0.6%	751
5	CA	91.4%	0.3%	8581
6	MN	91.3%	0.4%	2194
7	OK	91.3%	0.7%	921
8	NE	91.3%	0.7%	710
9	MI	91.2%	0.4%	3159
10	LA	91.2%	0.6%	1220
11	WI	91.0%	0.4%	2400
12	OR	90.6%	0.5%	1079
13	IN	90.6%	0.5%	2398
14	WY	90.6%	1.5%	138
15	SD	90.5%	1.3%	267
16	RI	90.5%	1.0%	311
17	TX	90.0%	0.3%	5572
18	MO	89.8%	0.5%	1943
19	NJ	89.8%	0.5%	2020
20	TN	89.8%	0.6%	2008
21	AL	89.8%	0.6%	1522
22	OH	89.7%	0.4%	4203
23	CO	89.6%	0.6%	1403
24	NY	89.5%	0.3%	4558
25	NC	89.4%	0.4%	3021
26	AK	89.4%	1.4%	188
27	AZ	89.4%	0.6%	1389
28	WV	89.3%	0.9%	465
29	HI	89.3%	0.9%	331
30	PA	89.2%	0.4%	4000
31	IL	89.1%	0.4%	4563
32	AR	89.1%	0.7%	853
33	ID	89.1%	0.9%	348
34	CT	89.0%	0.6%	1199
35	VA	89.0%	0.5%	2015
36	KY	88.9%	0.6%	1372
37	ND	88.8%	0.9%	268
38	IA	88.6%	0.6%	1200
39	NH	88.3%	1.0%	460
40	MD	88.2%	0.5%	1466
41	FL	87.7%	0.5%	4501

Table 5.6a
(continued)

Rank	State	Adoption rate	Standard error	Number of observations
42	GA	87.7%	0.5%	2610
43	SC	87.7%	0.7%	1252
44	ME	87.5%	0.9%	419
45	MS	87.3%	0.8%	866
46	VT	86.6%	1.0%	178
47	NV	86.5%	1.0%	609
48	DC	85.9%	0.5%	285
49	NM	84.1%	1.0%	392
50	DE	84.0%	1.3%	239
51	MT	81.3%	1.5%	204

use and employed a unique data set to clarify the reality of commercial Internet usage.

We demonstrated the importance of distinguishing between different layers of Internet technology. Rapid diffusion in participation did not necessarily imply rapid diffusion in enhancement. This distinction is crucial to understanding the evolution of this technology. The widespread belief that Internet technology diffused rapidly and became table stakes for business was true for participation but not enhancement. Recent concerns that innovation in Internet technology has subsided are misplaced. We speculate that diffusion of enhancement will follow a more traditional path than participation, taking time, innovation, and resources before economic welfare gains are realized. There is still a large possibility that economic gains will manifest themselves in the future.

We showed that Internet use is widely dispersed across geographic regions. It is factually incorrect to characterize regional rivalry in use of the Internet as if use were concentrated. We conclude that research focused on concentration or digital divides—heretofore a central concern of the literature on Internet geography—is a misleading basis for formulating regional economic policy about Internet use in business. To be sure, the concerns about low growth are real for the areas in which adoption lags, but economic policy for laggards has little to do with the majority of areas, which do not lag. Policies for regional development in most places should devote attention to the factors that are possibly comple-

Table 5.6b
Enhancement among States

Rank	State	Adoption rate	Standard error	Number of observations
1	CO	16.7%	1.0%	1403
2	UT	15.6%	1.4%	751
3	MN	15.5%	0.8%	2194
4	RI	15.3%	2.1%	311
5	WY	15.1%	3.0%	138
6	CT	14.5%	1.1%	1199
7	MA	14.3%	0.9%	2254
8	SD	14.2%	2.1%	267
9	TX	14.2%	0.5%	5572
10	DE	14.2%	2.1%	239
11	DC	13.8%	0.9%	285
12	AK	13.8%	2.5%	188
13	OR	13.8%	1.1%	1079
14	IA	13.8%	1.0%	1200
15	NJ	13.8%	0.8%	2020
16	OK	13.7%	1.2%	921
17	IL	13.7%	0.6%	4563
18	CA	13.7%	0.5%	8581
19	WA	13.3%	0.9%	1624
20	VA	13.3%	0.7%	2015
21	MI	13.3%	0.7%	3159
22	GA	13.3%	0.7%	2610
23	WI	13.3%	0.7%	2400
24	MD	13.0%	0.8%	1466
25	MT	12.9%	2.3%	204
26	NE	12.8%	1.3%	710
27	MO	12.8%	0.7%	1943
28	NY	12.7%	0.6%	4558
29	OH	12.5%	0.6%	4203
30	FL	12.5%	0.6%	4501
31	PA	12.4%	0.6%	4000
32	LA	12.2%	1.0%	1220
33	IN	12.1%	0.7%	2398
34	AR	12.0%	1.2%	853
35	KY	11.7%	0.8%	1372
36	AL	11.7%	0.9%	1522
37	KS	11.6%	1.0%	950
38	TN	11.6%	0.8%	2008
39	NM	11.6%	1.7%	392
40	NC	11.5%	0.6%	3021
41	AZ	11.3%	0.9%	1389

Table 5.6b
(continued)

Rank	State	Adoption rate	Standard error	Number of observations
42	MS	11.2%	1.1%	866
43	VT	11.0%	2.3%	178
44	ID	10.9%	1.7%	348
45	NH	10.6%	1.5%	460
46	SC	10.5%	0.9%	1252
47	ND	10.3%	1.8%	268
48	HI	10.0%	1.7%	331
49	ME	9.9%	1.5%	419
50	NV	9.8%	1.2%	609
51	WV	8.8%	1.3%	465

mentary to the use of the Internet for competitive advantage (e.g., such as immobile skilled labor, see Feldman 2002, Kolko 2002). Bottlenecks in complementary factors will determine regional rivalry in the future.

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Notes

1. For discussion on how Internet use varies across industries, see Forman, Goldfarb, and Greenstein (2001).

2. Nevertheless, there has been much progress. For information about PC use, see, e.g., National Telecommunications Information Administration (2001), Census (2002), and Goolsbee and Klenow (1999); and for the beginnings in measuring electronic commerce see, e.g., Atrostic, Gates, and Jarmin (2000), Landefeld and Fraumeni (2001), Mesenbourg (2001), or Whinston et al. (2001). We discuss this further below. Several studies have also examined commercial Internet use, but are too small to study dispersion. E.g., Varian et al. (2001), Whinston et al. (2001), Forman (2002), and Kraemer, Dedrick, and Dunkle (2002).

3. See, e.g., Forman (2002), Gertner and Stillman (2001), Carlton and Chevalier (2001).

4. See, e.g., Bresnahan and Trajtenberg (1995), Bresnahan and Greenstein (2001), Helpman (1998).

5. Careful readers will notice that this varies from the definitions employed by Porter (2001). This is due to a difference in research goals. Throughout his article, Porter discusses the determinants of, and shifting boundaries between, investments that provided table stakes and those that complement a firm's strategy and enhance competitive advantage. He argues that these levels vary by industry and firm. This is the proper variance to emphasize when advising managers about their firm's strategic investment. However, when *measuring* this variance for purposes of formulating policy advice it is useful to shift focus. Our measurement goals require both a standardized definition (of something of interest for policy, but consistent with the spirit of strategy research) and a consistent application across industries and locations.

6. This section provides an overview of our methodology. For a more detailed discussion, see Forman, Goldfarb, and Greenstein (2002).

7. Previous studies (Charles, Ives, and Leduc 2002; Census 2002) have shown that Internet participation varies with business size, and that very small establishments rarely make Internet investments for enhancement. Thus, our sampling methodology enables us to track the relevant margin in investments for enhancement, while our participation estimates may overstate participation relative to the population of all business establishments.

8. If we were only interested in the features of the most populated regions of the country, then we could easily rely solely on the most recent data from the latter half of 2000, about 40 percent of the data. However, using only this data would result in very small number of observations for most regions with under one million in population.

9. When two or more MSAs are part of the same urban environment, the census combines them into CMSAs. For example the Dallas-Fort Worth CMSA contains both Dallas and Forth Worth. In figure 5.5 we present the CMSA results rather than the individual MSA results when an MSA is part of a CMSA. However, because we will be comparing data between metropolitan areas of different sizes, the only standard of measure we can use is the MSA, as opposed to the CMSA, which applies only to large areas. Thus, in our figures 5.6 and 5.7 we will be discussing rates of adoption in MSAs. This causes for a slight shift in the hierarchy of leaders and laggards. (See, for example, the minor changes in the top ten leaders of enhancement between figures 5.5b and 5.7a.)

10. These are computed using the delta method.

11. For metropolitan areas consisting of more than one PMSA, we use the CMSA rather than PMSA metropolitan area definition.

12. Since these results are simple, we discuss them only in the text. They are not reported in any figure.

13. For more details on inter-industry differences in adoption rates, see Forman, Goldfarb and Greenstein (2002).

14. In Forman, Goldfarb, and Greenstein (2002), we show that retailing is a lag-

gard industry. We tried a number of variations on the same type of regression, with similar qualitative results. Hence, we show the simplest result here.

15. Disclosure rules prevent the cell size from becoming too small. Hence, this sample undersamples small MSAs. The smallest cell size for any MSA in this data is six observations, for the next smallest it is eight, for the next it is ten.

16. See, e.g., Kolko (2002), Moss and Townsend (1997), Zooks (2000a, 2000b), Saxenian (1994), Castells (2002).

17. In addition to those already cited, see research on the geography of cyberspace. See, e.g., Cairncross (1997), Kitchin and Dodge (2001), Kotkin (2000), Kolko (2002), Castells (2002) chapter 8, Zooks (2000a, 2000b).

18. New Jersey has only one rural establishment in our data and D.C. has none.

19. The USDA groups several states together, so we only can compare 30 states. We use the data released 30, July 2001, available at http://usda.mannlib.cornell.edu/reports/nassr/other/computer/.

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