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Digital dispersion: An industrial and geographic census of commercial internet use

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THE CENTER FOR THE STUDY OF INDUSTRIAL ORGANIZATION

AT NORTHWESTERN UNIVERSITY

Working Paper #0031

Digital Dispersion: An Industrial and Geographic Census of Commercial Internet Use

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Abstract

Our study provides the first census of the dispersion of Internet technology to commercial establishments in the United States. We distinguish between *participation*, that is, use of the Internet because it is necessary for all business (e.g., email and browsing) and *enhancement*, that is, adoption of Internet technology to enhance computing processes for competitive advantage (e.g., electronic commerce).

We focus on answering questions about economy-wide outcomes: Which industries had the highest and lowest rates of participation and enhancement? Which cities, states and industries had a typical experience and which did not? How does this measurement of dispersion compare with other ways of measuring the spread of Internet technology?

Employing the Harte Hanks Market Intelligence Survey, we examine adoption of the Internet at 86,879 commercial establishments with 100 or more employees at the end of 2000. Using routine statistical methods, we project results to two-thirds of the US labor force.

We arrive at three conclusions. First, participation and enhancement display contrasting patterns of dispersion. In a majority of industries participation has approached saturation levels, while enhancement occurs at lower rates and with dispersion reflecting long standing industrial differences in use of computing. Second, the creation and use of the Internet does not eliminate the importance of geography. Leading areas are widespread, whereas laggards are more common in smaller urban areas and some rural areas. However, the distribution of industries across geographic regions explains much of the difference in rates of adoption of the Internet in different areas. Third, commercial Internet use is quite dispersed, more so than previous studies show.

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 location. 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 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 on adoption, the most common yardstick for measuring a new technology's use (Rogers, 1995). How widely dispersed is Internet technology across locations and industries? Which regions and industries 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 2000). 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 understand document differences in adoption between industries and 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%; participation is near saturation in a majority of industries. By any historical measure, such extensive adoption is quite 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% of establishments. By the long-standing norms for different industries, this pattern of investment is not surprising.

The finding for participation suggests that Internet adoption costs are low and the benefits are high. The finding for enhancement suggests that Internet adoption costs are high and benefits more variable. We argue that both perceptions are correct, even though they appear to contradict each other on the surface. Each perception reflects the distinct economic costs and benefits from investment activities affiliated either participation or enhancement. More to the point, the productivity associated with investments in participation and enhancement are distinct, meriting separate analyses.

Second, we show that Internet technologies displayed geographic usage patterns common to other communication technology, 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% to 15% 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 (pre-existing) distribution of industries across geographic locations explains much of the differences in rates in enhancement. This is not the entire explanation, but it is the most self-evident one. Moreover, because leadership in enhancement is quite dispersed across industries, it is also quite dispersed across locations. Hence, we question the prevailing opinion that the dispersion of the Internet sharply benefited a small number of regions. Consequently, we argue that regional growth policies have focused on correcting lack of participation or concentration of technologies in a few locations, but should additionally 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.¹

More broadly, we also conclude that existing surveys of commercial firms provide an incomplete picture of adoption and its dispersion. For example, the US Census has undertaken a large one-time survey of manufacturing plants.² Yet, manufacturing only comprises a third of US commercial establishments. Our study discusses the sense in which manufacturing does and does not represent the experience in other industries. In addition, several private surveys have analyzed the productivity benefits of Internet technologies at commercial firms, analyzing factors other than dispersion.³ In contrast, our approach aims for unprecedented geographic or industrial breadth, but doing so requires focusing on only for a few narrowly defined questions.

2. Background

Our framework builds on microstudies of Internet investment in commercial establishments and organizations.⁴ It is motivated by the user-oriented emphasis in the literature on GPTs.⁵

¹ To be sure, there has been much progress. For information about PC use, see e.g., National Telecommunications Information Administration (2001), Census (2001), and Goolsbee and Klenow (1999); and for the beginnings in measuring electronic commerce see, e.g., Fraumeni (2001), Landefeld and Fraumeni (2001), Mesenbourg (2001), or Whinston et al. (2001). We discuss this further below.

² See Atrostic, Gates, and Jarmin (2000), Mesenbourg (2001), and Atrostic and Gates (2001), as well as the Census (2002).

³ Also, the samples are often too small to study dispersion. See Varian et al. (2001), Whinston et al. (2001), Forman (2002), and Kraemer, Dedrick and Dunkle (2002).

⁴ See e.g., Forman (2002), Jones, Kato and Pliskin (2002), Gertner and Stillman (2001), Carlton and Chevalier (2001), Tan and Teo (1998).

⁵ See e.g., Bresnahan and Trajtenberg (1995), Bresnahan and Greenstein (2001), Helpman (1998).

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 co-invention costs. When costs for some activities were low, adoption of these aspects of Internet technology became required to be in business. When the costs were higher and the benefits

variable for other aspects, firms were more circumspect, 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.⁶ 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, Hammond and Wildman 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 another key policy variable 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.⁷ Benefits accrue to the business organization employing enhancement through the addition of competitive advantage, but the co-invention costs and delays vary widely.

⁶ Examples of participation include browsing and posting text-based web pages, advertising on the World Wide Web (WWW), WWW browsing, and a basic intranet.

2.2 A framework for measuring regional and industrial dispersion

Participation represents a measure of “table stakes,” while enhancement represents a measure of investment for competitive advantage.⁸ 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.

We will measure the dispersion of Internet technology across locations and industries. Since there is no single way to measure dispersion, we will modify our analysis to the data available. Our first research strategy involves identifying leaders and laggards, and comparing their features. Given that this study is the first to examine such data, our primary goal is to document and rank. Because we are interested in measuring the dispersion of Internet use across industry and location rather than its evolution across time, an analysis of the cross-section data is sufficient for our purposes.

3. Data and Method

The data we use for this study come from the Harte Hanks Market Intelligence CI Technology database (hereafter CI database). 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

⁷ See for example, Malone, Yates, and Benjamin (1987), Hubbard (2000), Hitt and Brynjolfsson (1997), or Bresnahan, Brynjolfsson, and Hitt (2002).

⁸ Careful readers will notice that this varies from the definitions employed by Porter (2000). 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 differ from firm to 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.

divisions at technology companies. Interview teams survey establishments throughout the calendar year; our sample contains the most current information as of December 2000.⁹

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.¹⁰ Our sample contains all commercial establishments from the CI database that contain over 100 employees, 115,671 establishments in all;¹¹ 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.¹² This necessitates routine adjustments of the data for the timing and type of the survey given by HH. See the appendix.

3.1. Data Description and Sample Construction

In Table 1, we show a few features of our final sample. We sample corporate America well. The largest establishment in our sample has 56,000 employees.¹³ Forty-five percent of establishments are part of a multi-establishment firm. Nine hundred twenty-one of the Fortune 1000 are represented. However, we also have broad representation among smaller firms. The median establishment in our sample has 174 employees.

⁹ Using rotating teams of interviewers, HH collects data for the CI database. While HH selects some establishments for a detailed interview on technology usage, others receive a shorter interview that highlights the most important uses of IT.

¹⁰ Noncommercial establishments have distinct patterns of Internet use from commercial establishments. First, participation is given at virtually every educational establishment in the US. Second, military establishments often use a technically separate network from that used by commercial establishments. Third, the impact of the use by these establishments, while important for the provision of many public goods, is distinct from that by commercial firms.

¹¹ 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.

¹² 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% 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.

¹³ This is the Walt Disney World Resort.

Establishments vary in their use of Internet technology. The number of PCs per employee varies from 0 to 26.92.¹⁴ The average firm has 0.37 PCs per employee, and the standard deviation is large (0.53). Fifty-seven percent of establishments have a LAN, and 39% have a server, mainframe or some other kind of non-PC computing hardware. In all, we sample a wide range of establishments.

In Table 2 our final sample is compared to the County Business Patterns data from the 1999 Census. The first row shows that our sample contains slightly less than half of all establishments with over 100 employees in the United States. While this is only 1.3% of all establishments, our data represents roughly one-third of all employment. The table shows that in terms of company size, region, industry and urban versus rural location the numbers are generally close. We slightly under-represent MSAs (a proxy for urban counties) and Consolidated Metropolitan Statistical Areas, or CMSAs, (a proxy for large cities). Most industries are also represented in proportion to their actual distribution. The regional representation is close, with a slight under-sample of the Northeast and over-sample of the Mid-west. Our sample also includes a disproportionate number of (1) companies in rural areas and (2) large establishments (over 500 employees).

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.¹⁵ 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

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

¹⁴ For example, the Allen Memorial nursing home in Mobile, AL has no PCs. A Worcester research center for the University of Massachusetts has 26.92 PCs per employee.

¹⁵ We used 50 employees because many of our HH employment data comes later than 1999. Consequently, firms may have grown. Using 50 employees instead of 100 gives a comprehensive measure of the number of medium and large firms without the number of firms in our data ever being larger than the number in the census. We used two-digit NAICS instead of three digit NAICS for sample size reasons.

In other words, the weights are the proportion of establishments in a location that are a given NAICS code, divided by the proportion of times it is in our database. This means that if our data under-samples a given two-digit NAICS at a location, then each observation in that NAICS-location is given more importance. The weights for industry are calculated similarly, but instead of each location being split into NAICS, each NAICS is split by state.¹⁶

Using two survey forms, HH surveyed establishments at different times. To adjust for differences in survey time and type, we econometrically 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 US workforce. The more observations we have for a given region or industry the more statistical confidence we have in the estimate. See the appendix for further detail.

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

¹⁶ We also adjusted our data because of the establishment definition: HH's definition of an establishment does not always match the Census. In particular, what HH lists as two different establishments may only be one establishment under the Census definition. Where this occurred, we aligned the HH data with the definition listed in the Census. If the same firm was observed to operate in the same five-digit zip code with the same six-digit NAICS code, it is likely that the Census would consider it one establishment. There were 2440 establishments in our data that fit the above criteria. If two establishments were to be combined, then the weights were multiplied by one-half. Similarly, if there were n establishments, the weights would be multiplied by $1/n$. The number of firms in each location would also take these changes into account.

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. Again, see the appendix.

In Table 3 we show the results of these definitions. Participation by establishments within the sample is at 80.7%. The sample under-represents adopters, and our estimate of economy-wide distribution (using the true distribution of establishments from the Census) is 88.6%. We list the same number for those engaging in enhancement. It is 11.2% in our sample (see Unweighted Average in Table 3) and 12.6% in the true distribution (see Weighted Average in Table 3). 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% for the unweighted average and 23.2% 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. Leading industries

In Tables 4a and 4b we list the estimates for participation and enhancement organized by two-digit NAICS industry; we list industries in the order of highest to lowest adoption rates. We first show the results for all two-digit NAICS industries in the left half columns, and then break them into their three-digit NAICS industries in the right half columns. We identify leading and laggard industries. We also list the standard errors and number of observations.

4.1. Participation

Our first finding is quite apparent in Table 4a – participation is high in every industry, reaching over 92% -- near saturation -- in a majority of them. Of course, this is not a surprise after

Table 3, since the average rate of participation was 88%. The striking feature in Table 4a is the skew of these results. Establishments in all but four two-digit NAICS industries are at 90% or higher. With rare exception, the Internet reaches almost everywhere.¹⁷ Participation clearly represents a low cost “table stakes”.

We conclude that participation is virtually ubiquitous in all establishments excepting – at worst – a few industries. This dispersion is consistent with the popular perception that (1) adoption costs were low, (2) the Internet was available almost everywhere, (3) virtually any business experienced some benefit from adoption, (4) this diffusion saturated potential adopters sometime before the decline in Internet technology spending in 2001 and (5) the Internet became a necessity for US business by the end of the millennium.

This is remarkable for a technology that is less than a decade old. To our knowledge, no major historical technology diffused this fast to such a disparate set of using industries right after introduction -- not electricity, telephony, the steam engine, or the automobile (Helpman 1998, Rogers 1995).¹⁸

4.2. Enhancement

In Table 4b, we provide the estimates for adoption of enhancement. The lead adopters exceed adoption rates of 25%. These are NAICS 55, management of companies and enterprises (27.9%), and NAICS 51, media, telecommunications and data processing (26.8%). These two industries are not statistically different from each other, but they are statistically higher than all other NAICS 2

¹⁷ The two major low outliers are the two components of retail trade, each at 80% adoption rates. Looking more closely at the NAICS three-digit industries in retail trade, we see there are a few outliers. These are (more narrowly) NAICS 452, general merchandising stores (69%); NAICS 447, gasoline stations (75%); NAICS 444, building materials and garden equipment and supply dealers (73.7%); and NAICS 445, food and beverage stores (72.1%), all of which contribute many observations to their respective NAICS two-digit category. NAICS 452 has some apparent nonresponse bias, so we believe these estimates are a lower bound. That said, nonresponse bias cannot fully explain why retailing is lower than other industries. For example, if all of Walmart’s establishments answered in the affirmative to participating in the Internet, then the estimate for general merchandising would increase from 36% to 60%.

¹⁸ Speed is usually associated with an incremental technical advance aimed at a narrow set of adopters, such as the replacement of iron by steel rails, of steam by diesel engines, of black and white by color broadcasting, and so on. Even so, these canonical innovations did not diffuse to all potential adopters in less than a decade, as observed here.

industries. These first two lead user industries are remarkably different. NAICS 55 represents the financial side of the Internet revolution. It includes corporate headquarters for multidivisional firms, securities firms and financial holding companies. NAICS 51 includes publishing firms, thus representing the change the Internet brings to media. It also includes information and data processing services (NAICS 514), an industry that includes firms like America Online and other Internet access providers. This variety at the top is not a surprise, as the business press has largely described the wide impact of this technology's diffusion. The Internet has been used in a variety of industries to create competitive advantage. However, it confirms how varied was the impact of the diffusion of Internet technology – a theme that we will repeat as we look further down the table.

The second tier of lead users again includes a wide mix from two-digit industries, such as finance and insurance, professional and scientific services, utilities, and wholesale trade. These latter two industries include heavy users of sophisticated applications combining database software with communication technologies. The third tier of enhancement adopters includes NAICS 32 and 33, which together cover over 80% of manufacturing. Within this group a few notable lead industries at the NAICS three-digit level are NAICS 334, computer and electronic manufacturing (23.5%), NAICS 323, printing and related support activities (18.%), and NAICS 211, oil and gas extraction (18.4%). These are all long-time lead users in computing, but for very different reasons.

Low adopters (under 6% adoption) at the NAICS three-digit level do not surprise us. These include transit and ground passenger transportation (NAICS 485, 4.7%), food services and drinking places (NAICS 722, 5.6%), social assistance (NAICS 624, 5.9%), and amusement (NAICS 731).

4.3. Comparison with others' findings

We compared our findings against two other recent studies of Internet technology use and a summary of historical adoption. First, we compared our estimates with Census estimates for 1999 on the use of networking by manufacturing plants, as reported in Atrostic and Gates (2001). This data

was compiled from 40,000 surveys of large and small plants. The large plants in their samples and ours largely overlap; but their sample contains plants with fewer than 100 employees and ours does not. Atrostic and Gates focus only on three measures of business process adoption in manufacturing: percentage of firms that use networks; percentage of employees that use networks; and percentage of plants with fully integrated enterprise software. However, we find that our data and theirs give a similar picture. Despite differences in sampling frame, our estimate of enhancement is close to theirs for adoption of networking and enterprise software (correlation coefficients for NAICS three-digit manufacturing industries is 0.40 and 0.48). Not surprisingly, their question about employee use of networking is less correlated with our estimate (0.18). We conclude that our measure partially overlaps with the Census results because we both measure similar phenomena. But we also conclude that our measure captures something distinct beyond just networking.

Second, we also compared our estimates with Bureau of Economic Analysis (BEA) data on communications and capital service flows per industry, as used by Stiroh (2002b). Although the BEA data uses Standard Industrial Classification (SIC) codes rather than NAICS codes, we matched forty-three industry categories. We found that investment in computers and communication is positively but weakly correlated with both participation ($\rho=0.121$) and enhancement ($\rho=0.080$). A weak result is not surprising since the two series use different units, which are not very comparable. Our estimates measure enhancement adoption per establishment in an industry, whereas the BEA numbers measure dollars for all firms in an industry. The Spearman Rank Coefficient eliminates this mismatch of unit scale and, accordingly, is much higher and statistically significant for both participation and enhancement (respectively 0.37 and 0.34). In other words, Internet technology-intensive industries

tend to be those where a high fraction of establishments are adopting the Internet for enhancement. In addition, that Internet technology investment goes for more than just Internet business processes.¹⁹

Finally, we compared our list of lead industries with similar lists from more than two decades ago. The list of “leading” computer users in the late 1970s to early 1980s remains on our list of medium to large adopters. Cortada (1996) lists lead industries as banking and finance, utilities, electronic equipment, insurance, motor vehicles, petroleum refining, petroleum pipeline transport, printing and publishing, pulp and paper, railroads, steel, telephone communications and tires. However, wholesale trade is a low user, so too is water transportation. How did these industries change status in two decades? In short, these industries include many establishments that use communications to enhance logistical operations, which was difficult to do electronically more than two decades ago. Aside from this exception, his list of laggards also corresponds with our list. Cortada does not list broadcasting at all, nor retailing, so we cannot make a comparison there.²⁰ We conclude that the leading and lagging users of the new economy look a lot like leading and lagging users in the old computing economy. This also opens questions about why the costs and benefits of innovative information technology have not changed much in decades.

4.4. Industry investment in broader perspective.

Our findings lead us to four areas of inquiry. First, our findings warn against inferring too much from the experience in manufacturing. The Census collected a lot of detail about manufacturing, but its establishments are medium to high adopters, neither leaders nor laggards.

¹⁹ We also experimented with separating communications and computing, following Stiroh (2002a, 2002b). The results are qualitatively similar. The rank correlation between communications enhancement is mildly lower. There is a high rank correlation between computing and participation that is mildly higher.

²⁰ Our estimates cannot be directly compared against another historical study of lead users, Bresnahan and Greenstein (1997). That study examines the diffusion of client-server technology to former mainframe users in the early 1990s. First, the Bresnahan and Greenstein study concerns mainframe users, and it over-samples some industries relative to this population. Second, the results highlight the role of co-invention costs, which overwhelmed the benefits of adjusting at many traditional information-intensive users. This prevented or slowed down adoption of new technology on a large scale in many industries, except those with scientific or engineering users. In contrast, after several years of the diffusion of the Internet, the benefits were large enough to induce new investment activity in virtually every industry. See Forman (2002) for a discussion of co-invention costs in Internet technology when it first diffused.

Establishments in other industries are outside this picture. Finance and media have many more lead adopters--as a fraction of total establishments within each sector--and possibly a very different set of applications.

Second, we find that Internet technology producers (as well as their distributors) are frequent adopters. This echoes a finding that information technology and electronics manufacturers are intensive users of computing and communications as inputs (e.g., Stiroh 2002a). However, there are two differences: Manufacturers and *distributors* of electronics both are lead adopters. Moreover, these establishments are far from being the *only* lead adopters. They are two among a crowd.

Third, the composition of this distribution has old as well as new information to investigate. There are the familiar lead industries from information service industries, scientific and technical industries, and finance, insurance and real estate. The flip side of the coin is similar: Most laggard industries (i.e., infrequent computing and computer adopters two decades ago) did not suddenly become Internet-intensive. The exceptions are informative about the nature of building competitive advantage using Internet technologies. The appearance of transportation and warehousing as lead industries shows that the Internet influenced establishments where logistical processes played a key role. At the same time, it raises a large open question about why there is such durability in the factors shaping the dispersion of innovation information technology across industry.

Fourth and finally, these estimates foreshadow our findings about the geographic distribution of enhancement. First, participation is almost at saturation, so the same will have to be true across most locations – simply for the sake of statistical consistency. It is also well known that some lead industries in enhancement, such as corporate headquarters and financial firms, disproportionately locate establishments in dense urban settings. That said, there are many industries from disparate settings that are close to these leaders. If the location of establishments from these industries does not overlap much (and they will not), then adoption will disperse widely across locations.

5. Distribution Across Metropolitan Areas

In this section we present estimates of the dispersion of Internet technology to urban businesses. We identify features of urban leaders and laggards. We also develop our argument that the (preexisting) geographic distribution of industries is responsible for the Internet technology's geographic distribution.

Tables 5a and 5b 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.²¹

In Tables 6a, 6b and 6c we summarize results for all MSAs by population. We list one row for MSAs with over one million in population (hereafter termed *large MSAs*), then MSAs between one-quarter million and one million (hereafter termed *medium MSAs*), and then MSAs under one-quarter million (hereafter termed *small MSAs*). Finally, we show the estimates for the top ten areas for enhancement in Tables 7a, b and c, which cover all urban areas. As before, we also list the standard errors²² and number of observations to show where we have statistical confidence in the estimates.

5.1. Participation

Table 5a 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 (CMSAs) are above 90%. All but five are within a 95% confidence interval of 90%. Big differences among metropolitan areas are

²¹ 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 Table 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 tables 6 and 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 Tables 5b and 7a.)

²² These are again computed using the delta method. See the previous footnote on computation of standard errors.

apparent only at the extreme. The bottom ten areas range from 89.1% in Pittsburgh to 84.6% in Nashville. Although these are the lower adopting areas, they are not very low in absolute value.

From Table 6a we see that large MSAs are somewhat exceptional with their average participation of 90.4%. Participation in medium MSAs averages 84.9%. In small MSAs the participation rates are even lower, 75.5% on average.²³

We examined participation across 320 MSAs in the country (unweighted by population size).²⁴ The median MSA in the United States has participation at 84.3%. The lower quartile is 76.4%. 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.

5.2. Enhancement

In Table 5b we examine the use of enhancement at establishments in CMSAs with over one million people. We estimate that thirty-eight of the forty-nine areas are above 12.5%. All but one are within a 95% confidence interval of 12.5%. The top ten include a set of areas that partially overlaps with the list in Table 5a. It begins with the greater Denver area (with 18.3%) at number one and the greater Portland area at number ten (with 15.1%). 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% in Phoenix to 9.0% 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 6a shows the adoption of enhancement in MSAs of

²³ The last column of Table 6 partly hints at the explanation for these differences: The fraction of establishments from retailing is higher in smaller MSAs. Judging from the low adoption rate by some retail establishments, particularly Wal-Mart, it seems likely that some may have responded negatively to adoption questions for strategic reasons. However, that alone cannot fully account for the difference. Even if we assume retail adoption is 100%, it will explain at most 43.6% of the difference between large and medium MSAs and 17% of the difference between medium and small MSAs. There are still large differences by MSA size.

different population size, highlighting again that large MSAs are somewhat exceptional.

Establishments in large MSAs have adoption rates of 14.7%. In medium MSAs, it averages 11.2%. In small MSAs the rates are even lower, 9.9% on average. The second and third columns of Table 6b strongly hint at the explanation for these differences. Remember that in Table 4b 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), profession, scientific and technical services (54) and wholesale trade (42). The fraction of the number of these establishments over the total number of establishments in an MSA is highest in large MSAs (27.5%). That accounts for much of the difference between larger and smaller MSAs.

Table 6c provides a test of this proposition. It shows the results from a simple regression that predicts enhancement for an MSA, illustrating the effect of area size and industry presence. 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% 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 and other measures of laggard industries.²⁵ 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% of the variance in enhancement.

In Table 7 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 tables

²⁴ Since these results are simple, we discuss them only in the text. They are not reported in any table.

²⁵ We tried a number of variations on the same type of regression, with similar qualitative results. Hence, we show the simplest result here.

reinforce the results in Table 6, 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 7a 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 (29.6%) exceeds the fraction (21.7%) in the bottom ten large MSAs (note that the laggards are not shown in this table).

In Table 7b and 7c we can see that the levels of adoption among the leaders of medium MSAs are very similar to those shown in Table 7a, but the standard errors are much larger due to smaller sample size. These standard errors make us cautious to emphasize any details about particular locations in these ranking, but we are able to make broad statements. As before, among medium and small MSAs the average fraction of leading industries in the top ten medium MSAs (24.4% and 16.4%) exceeds the average fraction of leading industries in the ten laggard medium MSAs (16.3% and 11.1%). However, while leading medium and small MSAs are just as likely to be as advanced as leading large MSAs, there are a many 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.

5.3. 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 took the same raw survey data from 2000, which appeared in summary form in the NTIA 2001 report, and aggregated it up to MSAs. We were able to compute household adoption rates for PCs and the Internet for 231 MSAs, a sample

weighted toward large to medium MSAs.²⁶ 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 influenced 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 to Internet business processes did not depend on local household behavior because these factors were widespread throughout the urban areas of the United States.

Internet technology spread to commercial businesses in many areas of the United States. Unlike much previous literature,²⁷ 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. The determinant of differences between MSAs of different size occurs at the bottom tail. Large MSAs have fewer laggards than medium and small MSAs. We conjecture that these laggard small and medium MSAs may suffer

²⁶ 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.

²⁷ See, e.g., Kolko (2002), Moss and Townsend (1997), Zooks (2000a, 2000b), Saxenian (1994), Castells (2002).

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.

5.4. Urban dispersion in broader perspective

We close by noting that the geographic distribution of establishments largely existed prior to the commercialization and diffusion of the Internet. This leads to three conclusions. First, the preexisting distribution of establishments from different industries shaped the diffusion of networking technology.

Second, this technology was adopted across many industries -- not all of which share similar geographic distributions. Hence, there are straightforward economic reasons why this 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.²⁸ 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.

6. Urban/rural divides across states

Tables 8a and 8b 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.²⁹ This is also a useful framing for policy, since many policies for encouraging universal service within rural communities are determined by state regulators and legislatures.

6.1. Participation and enhancement

The estimates for participation in Table 8a 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%, and eighteen below 87%; however, this is still worse than in urban areas. There are two states with urban areas below 80% adoption (Vermont and Montana) and only six below 87%.³⁰

The estimate for rural enhancement adoption in Table 8b has a distinct distribution. The enhancement rates in the leading states are comparable with the leading metropolitan areas. The lead

²⁸ 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).

²⁹ New Jersey has only one rural establishment in our data and D.C. has none.

³⁰ Note, too, that the lower adoption rate for rural areas is a phenomenon common to many states, not just the states with high rural participation. Indeed, urban and rural participation in the same state are not especially related. Participation rates are positively correlated but small (at $\rho=0.021$).

state is Minnesota with a rate of 15.5%. 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%, while only three states have urban rates under 10%.

We compare the rank ordering of 8a and b. 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. Again, this is further evidence that participation and enhancement are distinct.

6.2. 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 US farmers, summarized at the state level.³¹ We also compared our estimates with the NTIA estimates for household adoption at the state level, which combine urban and rural households. The correlation between participation at rural commercial establishments and farm computer use is 0.41, and between rural participation and farm Internet use it is 0.28. The correlation between enhancement at rural commercial establishments and farm computer use is 0.18, and between rural enhancement and farm Internet use it is 0.17. These correlations are positive. Only the first one is large.

We conclude that the USDA survey is an incomplete assessment of nearby commercial Internet use. This should not come as a surprise. 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 motives for adoption differ between farming and nonfarming

³¹ 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/>.

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 9a and b include adoption rates for states. As indicated by many previous tables, this level of aggregation hides much variance at 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; no state is exceedingly higher than others. The highest state (Massachusetts at 92.4%) is hardly higher than the median state (Arkansas at 89.4%). Only six states are below 87%. Next, we examine enhancement across states. Again, there is not much of a spread. The highest state (Colorado at 16.7%) is not much higher than the median (Nebraska at 12.8%), and the difference in point estimates are not statistically significant at a 95% confidence level. Only three states are less than 10% in their point estimates, and none are below 10% 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 positively correlated (at 0.40).

We also compared our estimates with the NTIA estimates of Internet household use at the state level.³² This differs from the comparison above because it is at a different level of aggregation (state instead of MSAs). The present comparison also includes households from thinly populated areas, which were dropped in the previous comparison due to privacy concerns. We find that participation is not correlated with estimates of household use of the Internet (at 0.05). At best, enhancement is correlated with household adoption of the Internet (at 0.37). The results follow the same reasoning as above. These are positive, reflecting differences in regional labor markets.

³² See National Telecommunications Information Administrations, 2001.

However, these are also small enough to suggest that the NTIA survey provides an incomplete picture of commercial Internet use without further detail.

6.3. 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. 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. That said, the scope of the problem is limited: Laggard areas do not come from major urban areas.

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. Because the investment is linked to competitive settings, multi-establishment organizations, if they had a choice, would implement new business processes in more hospitable settings in major urban areas.

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.

At the same time, we recognize that our findings raise a large open question. What role, if any, did location play in the adoption of the Internet once industry effects are taken into account? We cannot answer this question without close examination of micro-evidence about factors such as size of establishments, controlling for regional effects at a detailed level. This is a topic for further research.

7. Conclusions

Our study contains three major conclusions about the adoption of the Internet at commercial establishments. First, in a majority of industries the establishments participate in the Internet at near saturation levels, while the Internet is used for enhancement to create competitive advantage at much lower rates. Second, geography shapes the dispersion of Internet use. We find a geographic digital divide in commercial adoption of the Internet, where leading areas are widespread and laggards are more common among smaller urban areas. However, the distribution of industries across geographic space has much to do with the different rates of Internet adoption in different areas. Third, commercial Internet use is quite dispersed, more so than previous studies show. We highlight implications below.

7.1 Layered dispersion

We demonstrated the importance of distinguishing between different layers of Internet technology. Rapid diffusion in participation did not necessarily imply rapid diffusion in enhancement. Though the two activities were technically complementary, they are only weakly related in their dispersion across geography or industry. Each provides distinct strategic and productivity benefits to private firms. Each should be the focus of distinct economic policies. The economic transactions associated with participation diffused quickly. As of late 2000 there was not much room left for growth. Its diffusion both took advantage of existing capital and motivated additional expenditure on

software, hardware and networking service. In addition, the dispersion associated with participation became table stakes for most firms, a necessity for doing business. We conclude that if there was an economic benefit to GDP as a result of participation, it was a one-time benefit affiliated with outfitting establishments with the equipment to support participating in email and browsing.

Enhancement diffused less widely and its diffusion may be far from over. As opposed to participation, enhancement was optional--motivated by the development of competitive advantage—and it had variable benefits and co-invention costs. There are strong hints in our results that the incidence of these costs and benefits fell primarily on traditionally intensive users of computers. If there is an economic benefit to GDP as a result of enhancement, these benefits were widely dispersed, but dependent on industry. There is still a large possibility that the economic gains will manifest itself in the future. This conclusion also varies with standard approaches to measuring productivity from investment in information technology, where prevailing research makes no allowance for the composition of capital, nor its motivation.

Finally, while we found GPT theory useful for formulating our measurement framework, we relied on the principle that dispersion should reflect economic constraints that foster different behavior across industry and location. These constraints are necessarily localized in contemporary experience. Therefore, we speculate that historical comparisons of the dispersion of the Internet with the dispersion of other GPTs are apt to be badly posed unless the comparisons are heavily qualified. It is misleading to compare the diffusion of the Internet with agricultural improvements, the railroad, electrical networks, telegraph, telephone or PC without accounting for the unique factors that shape co-invention costs and produce dispersion in each episode. Although aspects of similar economic issue arise in historical cases, the Internet's combination of economic motives, speeds, and environments has no precise historical precedent.

7.2. Dispersion and regional economic growth

We motivated this study with the assumption that the diffusion of Internet technology does have consequences for comparative regional economic growth. We were careful to provide links between private economic incentives for adoption and regional consequences. We conclude that the link is easily misunderstood without careful examination of commercial adoption behavior.

The economic use and dispersion of Internet technology are often characterized in terms of very limited regional rivalries, such as between Silicon Alley and Silicon Valley and Route 128. Tendencies toward localized commercial “boosterism” favor such a framing and often dominate popular discussion. Previous studies emphasizing concentrated dispersion of technology reinforce the examination of regional rivalries. This is an analytical error in four senses.

First, it is factually incorrect to characterize regional rivalry in use of the Internet as if use were concentrated. Second, analysis of discrete rivalries between two locations can confuse analysis of regional concentration in output markets with concentration in input markets. In this case, there is little concentration in the input market. There are over a dozen different industries comprised of thousands of establishments – from printing to information to finance to warehousing -- intensively using a new technology, such as the Internet. In this setting, any particular regional rivalry in output is of minor relevance to economy-wide outcomes in the use of inputs. For example, the rivalry between Silicon Alley and Silicon Valley in producing Internet content is irrelevant to whether most of the country benefits from the Internet’s use in warehousing or insurance contracting. To be sure, the labor markets for supplying Internet technology to warehouses and printing establishments and financial firms may either positively or negatively reinforce each other at a geographically local level (e.g., create knowledge that is useful in both domains or bid up wages for scarce talent), but this phenomenon requires an analytical treatment distinct from the one for output markets.

Third, analysis of discrete rivalries often focuses on the wrong policy question. Standard analysis supports economic policies for alleviating divisions -- a real problem for a minority of

locations -- and neglects policy questions that assume disperse use of technology, which is the issue facing the majority of locations. That is, dispersion changes competitive policies, because a common facet to business growth – in this case, advanced Internet technology – is quickly becoming the new table stakes for business. These table stakes cannot determine the outcome of regional competitive advantage. That is, when many areas are comparatively similar in terms of use of the GPT and co-inventive activities, they compete on similar terms. Regional rivalry then will be determined by the less common factors – *other than the Internet* (Furman, Porter, and Stern 2002). The proper framing for regional development policy for most locations should begin with such a premise.

Fourth, and related, failing to account for dispersion of technologies leads to misleading economic measurement for policy. A widely dispersed input can be essential for competitive rivalry and yield little direct productivity benefit. That is, if a firm must adopt common technology to match rivals, such a technology usually will not yield higher profits, nor, if the gains in price are competed away, necessarily more value-added in that industry in that location. The key benefit to technology adoption accrues to buyers of final output markets, or from an unmeasurable benefit to suppliers, that is, the losses avoided. Statistics about regional growth, therefore, are apt to be misleading. Participation in one region should not yield measurable productive advance compared to the vast majority of regions who are also participating. Regional productivity might be linked to the investment of local firms in technology that provides competitive advantage, but this economic phenomenon, once again, requires an understanding of the comparative achievement of competing establishments across regions.

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 rare and possibly complementary 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.

7.3. Further research

The US government statistical agencies have the apparatus – though perhaps not the funding – to collect comprehensive data about the behavior of commercial establishments. We find it remarkable that there are no plans to generate comprehensive statistics at any government agency, nor any plans at the Census even to follow up on its extensive survey of manufacturing. Without such data there are only indirect statistical means available for computing the contribution of the Internet to the GDP, capital accumulation, or productivity growth.³³ Recent private studies are commendable for their attempts to understand the use of Internet in business or the size of the Internet economy by extrapolating from selected surveys.³⁴ Extrapolation is the best any research can do when there is no data, but comprehensive data is better.

We show the value of collecting such data. In this study we focus on aggregate trends in the dispersion of Internet technology. But this represents only the beginning of uses for such data. Our study raises many questions about the microdeterminants of use of this GPT. Our conclusion begs the question of why some industries use Internet technology more intensively. While we show that the identities of leading industries tended to be the same over decades, we did not offer an explanation for this phenomenon. Why did the dispersion of the Internet not alter these rankings except in a few industries? What does this say about the strategic benefits to using the Internet and the co-inventive expenses during this GPT's diffusion in comparison to those of the past?

³³ See e.g., Atrostic and Gates (2001), Census (2001), Stiroh (2002b).

³⁴ See e.g., Varian et. al. 2001, Whinston et. al. 2001; Kraemer, Dedrick, and Dunkle 2002.

We also did not measure a third of all employment, namely, small commercial establishments of less than 100 employees. We conjecture that these establishments follow similar patterns in participation and different patterns in enhancement, but this is an open question. We also raised questions about the medium- to large-scale firms in our sample. Do co-invention costs differ between single- and multi-establishment organizations? Between different applications of enhancement? What part of co-invention costs are attributable to local economic factors and what parts are attributable to costs imposed by competition between establishments from similar industries? Forman (2002) offers a framework for addressing these questions using microlevel data, which is a step in the right direction.

Our study also raises questions about the distribution of the economic impact from the use of the Internet. How did local and industrial applications influence the intensity of use of information technology? To what extent can state and local development policies foster a positive environment for lowering these costs? There is room for much economic research applying the estimates in our study to models of regional growth.

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Table 1
Descriptive Statistics

Variable	Mean	Std. Dev.	Minimum	Maximum
Employment	310.90	600.81	100	56,000
PCs per employee	0.37	0.53	0	26.92
Part of multi-establishment firm?	0.45	0.50	0	1
Member of Fortune 1000?	0.27	0.44	0	1
Has ticker symbol?	0.33	0.47	0	1
Has LAN?	0.57	0.49	0	1
Has mainframe?	0.04	0.19	0	1
Has workstation, minicomputer, or mainframe?	0.39	0.49	0	1

Number of observations=86,879

Table 2: Harte Hanks Sample Versus the Census of Business Establishments

	Sample	Census
# establishments over 100 employees	86,879	168,372
% MSA	82.5%	86.7%
% CMSA	37.2%	42.5%
% >500 employees given have 100 employees	12.7%	10.6%
% Northeast	17.7%	19.6%
% Midwest	27.9%	25.5%
% South	34.8%	34.0%
% West	19.6%	21.0%
% Agriculture, Forestry, Fishing and Hunting (NAICS=11)	0.2%	0.1%
% Mining (NAICS=21)	0.6%	0.5%
% Utilities (NAICS =22)	0.8%	0.8%
% Construction (NAICS =23)	2.9%	4.1%
% manufacturing (NAICS =31,32,33)	27.9%	20.8%
% Wholesale Trade (NAICS =42)	6.0%	4.8%
% Retail Trade (NAICS =44,45)	17.1%	14.7%
% Transportation & Warehousing (NAICS =48, 49)	2.9%	3.1%
% Media, Telecommunications and Data Processing (NAICS =51)	3.7%	3.7%
% Finance and Insurance (NAICS =52)	4.5%	4.6%
% Real Estate and Rental and Leasing (NAICS =53)	0.5%	1.0%
% Professional, Scientific and Technical Services (NAICS =54)	5.2%	5.0%
% Management of Companies and Enterprises (NAICS =55)	0.3%	3.2%
% Administrative and Support and Waste Management and Remediation Services (NAICS =56)	2.7%	10.2%
% Educational Services (NAICS =61)	0.01%	1.2%
% Health Care and Social Assistance (NAICS =62)	16.7%	12.8%
% Arts, Entertainment, and Recreation (NAICS =71)	1.6%	1.5%
% Accommodation and Food Services (NAICS =72)	5.5%	5.1%
% Other Services (except Public Administration) (NAICS =81)	0.9%	2.2%

**Table 3:
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%

Table 4a
Participation by Industry

Two-Digit NAICS	Two-Digit NAICS Adoption Rate	Standard Error	Two-Digit # Obs.	Three-digit NAICS	Three-Digit NAICS Adoption Rate	Standard Error	Three-Digit # Obs.
51- Media, Telecommunications, & Data Processing	99.1%	0.1%	3181	511-Publishing industries	99.3%	0.2%	1475
22-Utilities	99.0%	0.2%	680	512-Motion picture & sound recording industries	90.3%	1.0%	129
54- Professional, Scientific, & Technical Services	98.9%	0.1%	4556	513-Broadcasting & telecommunications	99.2%	0.2%	1076
52- Finance & Insurance	97.8%	0.2%	3933	514-Information & data processing services	98.0%	0.4%	501
33- Manuf. 3: metals, machinery, computers & electronics, appliances, transportation equipment, furniture, & other manufacturing	97.8%	0.1%	12679	221-Utilities	99.0%	0.2%	680
55- Mngmt of Companies & Enterprises	97.2%	0.5%	291	541-Professional, scientific & technical services	98.9%	0.1%	4556
32- Manuf. 2: wood, paper, printing, petroleum, chemical, plastics & rubber, non-metallic minerals	97.0%	0.2%	7161	522-Credit intermediation & related activities	96.9%	0.4%	1369
23-Construction	95.9%	0.3%	2518	523-Security, commodity contracts, etc.	96.3%	0.4%	503
				524-Insurance carriers & related activities	98.4%	0.2%	1707
				525-Funds, trusts, & other financial vehicles	86.1%	0.6%	74
				331-Primary metal mfg	96.7%	0.4%	1019
				332-Fabricated metal product mfg	97.2%	0.3%	2257
				333-Machinery mfg	98.4%	0.2%	2575
				334-Computer & electronic product mfg	99.0%	0.2%	2026
				335-Electrical equip, appliance & component mfg	97.4%	0.4%	962
				336-Transportation equipment mfg	97.8%	0.3%	1825
				337-Furniture & related product mfg	94.3%	0.6%	912
				339-Miscellaneous mfg	97.8%	0.3%	1103
				551-Management of companies & enterprises	97.2%	0.5%	291
				321-Wood product mfg	94.6%	0.5%	964
				322-Paper mfg	96.5%	0.4%	1243
				323-Printing & related support activities	97.6%	0.3%	1030
				324-Petroleum & coal products mfg	92.7%	0.8%	213
				325-Chemical mfg	98.1%	0.3%	1440
				326-Plastics & rubber products mfg	97.0%	0.3%	1513
				327-Nonmetallic mineral product mfg	94.8%	0.6%	758
				233-Building, developing & general contracting	95.8%	0.6%	703
				234-Heavy construction	96.2%	0.5%	652

							235-Special trade contractors	94.7%	0.5%	1163
42- Wholesale Trade		95.8%	0.3%		5197		421-Wholesale trade, durable goods	96.7%	0.3%	2814
							422-Wholesale trade, nondurable goods	94.7%	0.4%	2383
21-Mining		95.6%	0.6%		529		211-Oil & gas extraction	88.6%	0.7%	63
							212-Mining (except oil & gas)	92.7%	1.0%	269
							213-Mining support activities	96.5%	0.9%	197
62- Health Care & Social Assistance		94.1%	0.3%		14506		621-Ambulatory health care services	96.5%	0.3%	2129
							622-Hospitals	97.5%	0.2%	4406
							623-Nursing & residential care facilities	91.1%	0.4%	6516
							624-Social assistance	93.7%	0.5%	1455
49- Transportation & Warehousing2: couriers & warehousing		93.6%	1.0%		283		492-Couriers & messengers	92.9%	1.2%	127
							493-Warehousing & storage	94.0%	1.3%	156
71- Arts, Entertainment, & Recreation		93.6%	0.5%		1363		711-Performing arts, spectator sports, etc.	95.8%	0.7%	260
							713-Amusement, gambling & recreation industries	92.6%	0.6%	1103
56- Administrative & Support & Waste Management & Remediation Services		92.9%	0.5%		2303		561-Administrative & support services	93.0%	0.5%	2078
							562-Waste management & remediation services	91.1%	1.3%	225
							311-Food mfg	92.6%	0.5%	1983
							312-Beverage & tobacco product mfg	93.7%	0.9%	415
31- Manufacturing 1: food & textiles		92.7%	0.4%		4400		313-Textile mills	91.6%	0.8%	612
							314-Textile product mills	93.8%	0.8%	368
							315-Apparel manufacturing	90.8%	0.8%	873
							316-Leather & allied product mfg	85.3%	1.8%	149
							531-Real estate	94.8%	0.7%	480
53- Real Estate & Rental & Leasing		92.3%	1.0%		467		532-Rental & leasing services	86.1%	1.3%	256
							533-Lessors of other non-financial intangible assets	47.4%	3.2%	11
							481-Air transportation	90.5%	1.0%	152
							482-Rail transportation	88.6%	2.2%	137
							483-Water transportation	76.8%	1.1%	40
48- Transportation & Warehousing 1: transportation		92.0%	0.5%		2273		484-Truck transportation	90.2%	0.9%	856
							485-Transit & ground passenger transportation	86.7%	1.2%	509
							486-Pipeline transportation	81.4%	2.0%	40
							487-Scenic & sightseeing transportation	75.8%	0.6%	28
81- Other Services (except Public Administration)		90.5%	0.8%		791		488-Transportation support activities	94.7%	0.7%	511
							811-Repair & maintenance	92.3%	0.9%	321
							812-Personal & laundry services	87.3%	1.2%	470

72- Accommodation & Food Services	90.4%	0.5%	4775	721-Accommodation	97.0%	0.2%	3066
				722-Food services & drinking places	79.4%	1.1%	1709
				441-Motor vehicle & parts dealers	96.5%	0.3%	1892
				442-Furniture & home furnishing stores	88.6%	1.5%	184
				443-Electronics & appliance stores	96.0%	0.6%	421
44- Retail Trade1: durables	80.1%	0.7%	9069	444-Bldg material & garden equip & supp dealers	73.7%	1.7%	675
				445-Food & beverage stores	72.1%	0.9%	5319
				446-Health & personal care stores	86.1%	2.0%	140
				447-Gasoline stations	75.0%	3.3%	109
				448-Clothing & clothing accessories stores	90.1%	1.2%	329
11-Agriculture, Forestry, Fishing & Hunting	80.0%	1.5%	145	113-Forestry & logging	68.5%	1.4%	22
				114-Fishing, hunting & trapping	55.3%	3.5%	7
				115-Agriculture & forestry support activities	80.4%	1.8%	116
45- Retail Trade2: nondurables	72.1%	0.9%	5767	451-Sporting goods, hobby, book & music stores	84.6%	1.2%	172
				452-General merchandise stores	69.0%	1.0%	5083
				453-Miscellaneous store retailers	90.0%	1.2%	278
				454-Nonstore retailers	88.9%	1.1%	234
61- Educational Services	29.0%	0.9%	12	611-Educational services	29.0%	0.9%	12

Table 4b
Enhancement by Industry

Two-Digit NAICS	Two-Digit NAICS Adoption Rate	Standard Error	Two-Digit # Obs.	Three-Digit NAICS	Three-Digit NAICS Adoption Rate	Standard Error	Three-Digit # Obs.
55- Mngmt of Companies & Enterprises	27.9%	2.7%	291	551-Management of companies & enterprises	27.9%	2.7%	291
51- Media, Telecommunications, & Data Processing	26.8%	0.9%	3181	511-Publishing industries	28.5%	1.3%	1475
				512-Motion picture & sound recording industries	24.6%	3.7%	129
				513-Broadcasting & telecommunications	21.7%	1.3%	1076
				514-Information & data processing services	33.0%	2.2%	501
22-Utilities	21.1%	1.7%	680	221-Utilities	21.1%	1.7%	680
52- Finance & Insurance	19.9%	0.7%	3933	522-Credit intermediation & related activities	20.5%	1.2%	1369
				523-Security, commodity contracts, etc.	25.7%	2.0%	503
				524-Insurance carriers & related activities	18.8%	1.0%	1707
				525-Funds, trusts, & other financial vehicles	11.2%	3.6%	74
54- Prof'l, Scientific, & Technical Svcs	19.6%	0.7%	4556	541-Professional, scientific & technical services	19.6%	0.7%	4556
42- Wholesale Trade	17.2%	0.6%	5197	421-Wholesale trade, durable goods	18.5%	0.8%	2814
				422-Wholesale trade, nondurable goods	15.5%	0.8%	2383
				331-Primary metal mfg	16.0%	1.2%	1019
				332-Fabricated metal product mfg	13.6%	0.8%	2257
33- Manuf. 3: metals, machinery, computers & electronics, appliances, transportation equipment, furniture, & other manufacturing	15.7%	0.4%	12679	333-Machinery mfg	13.9%	0.8%	2575
				334-Computer & electronic product mfg	23.5%	1.0%	2026
				335-Electrical equip, appliance & component mfg	15.6%	1.3%	962
				336-Transportation equipment mfg	14.4%	0.9%	1825
				337-Furniture & related product mfg	11.0%	1.1%	912
				339-Miscellaneous mfg	14.0%	1.1%	1103
53- Real Estate & Rental & Leasing	15.6%	1.8%	467	531-Real estate	13.9%	1.6%	480
				532-Rental & leasing services	15.9%	2.3%	256
				533-Lessors of other non-financial intangible assets	14.4%	6.9%	11
49- Transportation & Warehousing2: couriers & warehousing	15.5%	2.2%	283	492-Couriers & messengers	15.8%	3.1%	127
				493-Warehousing & storage	13.7%	2.7%	156
32- Manuf. 2: wood, paper, printing,	14.4%	0.5%	7161	321-Wood product mfg	11.6%	1.1%	964

petroleum, chemical, plastics & rubber, non-metallic minerals					322-Paper mfg	15.8%	1.1%	1243
					323-Printing & related support activities	18.0%	1.3%	1030
					324-Petroleum & coal products mfg	16.0%	2.5%	213
					325-Chemical mfg	16.3%	1.1%	1440
					326-Plastics & rubber products mfg	12.0%	0.9%	1513
					327-Nonmetallic mineral product mfg	10.9%	1.2%	758
					211-Oil & gas extraction	18.4%	4.8%	63
21-Mining	12.4%	1.5%	529	212-Mining (except oil & gas)	9.9%	1.9%	269	
				213-Mining support activities	12.6%	2.5%	197	
				481-Air transportation	12.4%	2.7%	152	
48- Transportation & Warehousing I: transportation				482-Rail transportation	12.4%	3.0%	137	
				483-Water transportation	23.6%	5.9%	40	
	12.0%	0.7%	2273	484-Truck transportation	11.8%	1.2%	856	
				485-Transit & ground passenger transportation	4.7%	1.0%	509	
				486-Pipeline transportation	21.4%	6.0%	40	
				487-Scenic & sightseeing transportation	12.2%	5.5%	28	
				488-Transportation support activities	16.2%	1.7%	511	
				311-Food mfg	11.2%	0.8%	1983	
				312-Beverage & tobacco product mfg	13.5%	1.8%	415	
				313-Textile mills	8.1%	1.2%	612	
31- Manufacturing I: food & textiles	11.5%	0.6%	4400	314-Textile product mills	12.1%	1.8%	368	
				315-Apparel manufacturing	12.6%	1.2%	873	
72- Accommodation & Food Services				316-Leather & allied product mfg	12.4%	2.8%	149	
	11.2%	0.5%	4775	721-Accommodation	14.4%	0.7%	3066	
				722-Food services & drinking places	5.6%	0.6%	1709	
				113-Forestry & logging	14.1%	6.1%	22	
11-Agriculture, Forestry, Fishing & Hunting	11.1%	2.6%	145	114-Fishing, hunting & trapping	0.0%	0.0%	7	
				115-Agriculture & forestry support activities	10.2%	2.8%	116	
81- Other Services (except Public Administration)	10.7%	1.2%	791	811-Repair & maintenance	14.1%	2.0%	321	
				812-Personal & laundry services	8.2%	1.4%	470	
56- Administrative & Support & Waste Management & Remediation Services	10.6%	0.7%	2303	561-Administrative & support services	11.0%	0.8%	2078	
				562-Waste management & remediation services	6.7%	1.8%	225	
62- Health Care & Social Assistance	9.8%	0.3%	14506	621-Ambulatory health care services	10.8%	0.8%	2129	
				622-Hospitals	10.1%	0.5%	4406	
				623-Nursing & residential care facilities	10.1%	0.5%	6516	

						624-Social assistance	5.9%	0.7%	1455
						441-Motor vehicle & parts dealers	20.5%	1.1%	1892
						442-Furniture & home furnishing stores	15.9%	2.8%	184
						443-Electronics & appliance stores	25.6%	2.2%	421
44- Retail Trade1—durables	9.7%	0.4%	9069			444-Bldg material & garden equip & supp dealers	5.1%	0.9%	675
						445-Food & beverage stores	4.6%	0.4%	5319
						446-Health & personal care stores	10.7%	2.7%	140
						447-Gasoline stations	4.3%	2.0%	109
						448-Clothing & clothing accessories stores	16.2%	2.1%	329
71- Arts, Entertainment, & Recreation	9.6%	0.9%	1363			711-Performing arts, spectator sports, etc.	15.7%	2.4%	260
						713-Amusement, gambling & recreation industries	8.1%	0.9%	1103
23-Construction	9.4%	0.6%	2518			233-Building, developing & general contracting	8.7%	1.1%	703
						234-Heavy construction	12.8%	1.4%	652
						235-Special trade contractors	7.9%	0.9%	1163
						451-Sporting goods, hobby, book & music stores	20.4%	3.0%	172
45- Retail Trade2—non-durables	7.0%	0.4%	5767			452-General merchandise stores	5.3%	0.4%	5083
						453-Miscellaneous store retailers	14.6%	2.2%	278
						454-Nonstore retailers	21.2%	2.7%	234
61- Educational Services	6.2%	3.6%	12			611-Educational services	6.2%	3.6%	12

Table 5a: 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
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 5b 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
5	Houston--Galveston--Brazoria, TX	15.7%	1.0%	1413	4,669,571
6	Atlanta, GA	15.4%	1.0%	1426	4,112,198
7	Oklahoma City, OK	15.4%	2.0%	339	1,083,346
8	Dallas--Fort Worth, TX	15.3%	0.9%	1720	5,221,801
9	San Antonio, TX	15.3%	1.9%	395	1,592,383
10	Portland--Salem, OR--WA	15.1%	1.3%	776	2,265,223
11	Providence--Fall River--Warwick, RI--MA	14.9%	2.2%	290	1,188,613
12	Austin--San Marcos, TX	14.7%	1.9%	344	1,249,763
13	Cleveland--Akron, OH	14.7%	1.2%	1099	2,945,831
14	Tampa--St. Petersburg--Clearwater, FL	14.6%	1.3%	812	2,395,997
15	Memphis, TN--AR--MS	14.5%	1.8%	437	1,135,614
16	Seattle--Tacoma--Bremerton, WA	14.5%	1.2%	1012	3,554,760
17	Hartford, CT	14.4%	1.6%	500	1,183,110
18	San Diego, CA	14.3%	1.3%	738	2,813,833
19	Cincinnati--Hamilton, OH--KY--IN	14.2%	1.3%	772	1,979,202
20	Washington--Baltimore, DC--MD--VA--WV	14.2%	0.8%	2222	7,608,070
21	Chicago--Gary--Kenosha, IL--IN--WI	14.1%	0.7%	3431	9,157,540
22	Rochester, NY	14.1%	1.9%	373	1,098,201
23	Boston--Worcester--Lawrence, MA--NH--ME--CT	13.9%	0.8%	2231	5,819,100
24	Detroit--Ann Arbor--Flint, MI	13.8%	0.9%	1621	5,456,428
25	Kansas City, MO--KS	13.7%	1.3%	753	1,776,062
26	Raleigh--Durham--Chapel Hill, NC	13.7%	1.7%	398	1,187,941
27	Pittsburgh, PA	13.6%	1.3%	727	2,358,695
28	Indianapolis, IN	13.6%	1.4%	646	1,607,486
29	Charlotte--Gastonia--Rock Hill, NC--SC	13.6%	1.5%	618	1,499,293
30	West Palm Beach--Boca Raton, FL	13.6%	2.0%	299	1,131,184
31	Los Angeles--Riverside--Orange County, CA	13.5%	0.6%	4099	16,373,645
32	Miami--Fort Lauderdale, FL	13.5%	1.1%	1010	3,876,380
33	New York--Northern New Jersey--Long Island, NY-NJ-CT-PA	13.5%	0.6%	4775	21,199,865
34	Philadelphia--Wilmington--Atlantic City, PA--NJ--DE--MD	13.3%	0.9%	1745	6,188,463
35	St. Louis, MO--IL	13.2%	1.2%	936	2,603,607
36	Louisville, KY--IN	13.2%	1.6%	448	1,025,598
37	Columbus, OH	13.0%	1.5%	574	1,540,157
38	Buffalo--Niagara Falls, NY	12.9%	1.7%	393	1,170,111
39	Phoenix--Mesa, AZ	12.4%	1.1%	988	3,251,876
40	Greensboro--Winston-Salem--High Point, NC	12.2%	1.4%	570	1,251,509
41	Grand Rapids--Muskegon--Holland, MI	12.0%	1.5%	503	1,088,514
42	New Orleans, LA	11.9%	1.7%	386	1,337,726
43	Milwaukee--Racine, WI	11.7%	1.2%	855	1,689,572
44	Nashville, TN	11.7%	1.5%	466	1,231,311
45	Jacksonville, FL	11.3%	1.7%	373	1,100,491
46	Sacramento--Yolo, CA	11.8%	1.6%	427	1,796,857
47	Norfolk--Virginia Beach--Newport News, VA--NC	10.8%	1.7%	374	1,569,541
48	Orlando, FL	10.5%	1.3%	622	1,644,561
49	Las Vegas, NV--AZ	9.0%	1.4%	417	1,563,282

Table 6a
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 6b
Percentage of Establishments in Top Quartile Industry for Enhancement, by Size of MSA

Population	Percentage of Establishments in Top Quartile	Percentage of Establishments in Top Quartile of Non-retail Adopters	Percentage of Establishments that are Retailing	# of Areas
> 1 million	27.5%	32.1%	14.3%	57
250,000-1 million	19.5%	23.5%	16.7%	116
<250,000	19.0%	23.3%	18.3%	143

TABLE 6c:
Importance of industry and population on enhancement
(standard errors in parentheses)

	(1) enhancement	(2) enhancement	(3) enhancement	(4) enhancement	(5) enhancement
(a) Percent firms in top quartile	0.259*** (0.0291)	0.214*** (0.0388)	0.200*** (0.0498)	0.212*** (0.0612)	0.177*** (0.0615)
(b) MSA population greater than 1 million		0.0127* (0.00719)		0.0189 (0.0221)	0.0183 (0.0219)
(c) MSA pop. between 250,000 & 1 million		0.00331 (0.00479)		0.000163 (0.0132)	0.00231 (0.0131)
(a)*(b)			0.0560 (0.0360)	-0.0250 (0.105)	-0.0302 (0.103)
(a)*(c)			0.0238 (0.0322)	0.0199 (0.0876)	0.00881 (0.0866)
% retailing					-0.187*** (0.0622)
Constant	0.0706*** (0.00496)	0.0739*** (0.00538)	0.0758*** (0.00598)	0.0742*** (0.00768)	0.112*** (0.0146)
R-sq	0.1995	0.2074	0.2060	0.2079	0.2302

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

Table 7a
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%

Table 7b
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%

Table 7c
Leading Adopters of Enhancement Among MSAs With 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	18.0%			16.4%
Average of Bottom Ten Small MSAs	2.1%			11.1%

Table 8a: 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
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

Table 8b: Enhancement in Rural Areas by State

Rank	State	Rural Rate	Std Error	Observations	Urbana 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
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

Table 9a: Participation Among States

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
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

Table 9b: 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
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

A.1. Data Appendix

Our analysis sample was constructed to address three general types of measurement error: non-response bias, timing bias, and sampling bias. Non-response bias occurs when survey respondents do not answer all questions they are asked. This occurs because HH makes the CI database publicly available, and establishments may not want to reveal all of their strategic IT investments. In addition, HH used two types of surveys on IT usage, one short and one long. Because we apply a uniform standard when identifying Internet usage, this creates a kind of non-response bias. HH survey methodology may also create timing bias. HH uses teams of interviewers to survey establishments throughout the calendar year. Because this technology may still be diffusing over our sample, establishments surveyed earlier will be less likely to participate or enhance than an otherwise identical establishment that is surveyed later. Last, the sample of establishments in the CI database may not be representative. Because HH collected the CI database as a marketing tool, it may over-sample industries or locations that are particularly interesting to its customers.

Each problem requires correction, though none has more than a limited impact on our sample. A combination of econometric estimation and weighting mitigates the effects of these biases.

A.2. How large a bias, if any?

We first looked for non-response bias. An establishment will not report any use of IT for one of three possible reasons. First, the establishment may refuse to answer questions on IT usage. Second, HH may not have surveyed the establishment on IT (though it may have surveyed the establishment about other aspects of the organization). Third, the establishment may in fact have no IT investments.

Accordingly, we dropped establishments who left too many incomplete answers. This accounted for approximately 13,000 of the dropped establishments. We also excluded a small number of observations for which there was obvious coding error.³⁵ After these observations were dropped, there remained 664 observations that still reported no IT investment. Many were small firms in industries that are not traditionally technologically intensive.³⁶ We retained these establishments because dropping them would have created too optimistic a picture in the sample.³⁷

³⁵ There were less than 20 such observations.

³⁶ For example, Route 66 Bingo of Albuquerque, NM and Lake Shore Little League of Athol Springs, NY had no IT investments. These are quite plausible results, and should be included.

³⁷ This does not fully eliminate non-response bias, but we checked for it where we had outside information. We discovered a mild non-response bias among retail establishments, particularly for participation. This may reflect strategic non-reporting by firms (Wal-Mart in particular) who consider information technology a key strategy. Thus, our estimates should be viewed as conservative in retailing.

We now discuss timing bias. Establishments in our sample were surveyed between July 1998 and August 2000. Since participation and enhancement technologies diffused between 1998 and 2000, earlier respondents are likely to have a lower likelihood of adopting. We correct for this in our econometrics below.

In addition, HH changed survey methodology during our sample period. HH introduced more IT questions to the short survey in June 1999; prior to then only the long survey contained IT questions. As a result, we dropped any establishments surveyed before June 1999 that received the shorter survey. This accounted for over sixteen thousand observations dropped. Consequently, in our final sample most establishments were surveyed between June 1999 and December 2000, after the change in sampling methodology. Only 11.5% of all respondents were surveyed prior to June 1999.

This leaves a subtle bias that still needs correction. HH surveyed 38.7 percent of remaining establishments with the short form. Since these establishments provided less information to HH on Internet usage, it will be mildly more difficult to identify their adoption of participatory or business process enhancing technologies.³⁸ The fraction of respondents responding to the short survey, and the potential response bias, also varies over time. We address this bias in our econometrics.

A.3. Econometric procedure

To be precise, we assume that the value to an establishment j of participating in the Internet is

$$y_j = \sum_i \alpha_i d_{ij} + \sum_l \beta_l d_{lj} + \sum_t \gamma_t d_{tj} + \sum_{t>19905} \delta_t d_{tj} d_{pj} + \varepsilon_j,$$

where d_{ij} and d_{lj} are dummy variables indicating the industry and location of the establishment, d_{tj} indicates the month in which the establishment was surveyed, and d_{pj} indicates whether the establishment responded to the long survey.³⁹ The variable y_j is latent, we observe only whether or not the establishment adopts participation. If we assume the error term ε_j is i.i.d. normal, then the probability that establishment j adopts will be a probit,

$$P_j = \Phi \left[\sum_i \alpha_i d_{ij} + \sum_l \beta_l d_{lj} + \sum_t \gamma_t d_{tj} + \sum_{t>19905} \delta_t d_{tj} d_{pj} \right]$$

where $\Phi[\square]$ represents the univariate normal cumulative distribution function. The probability of adopting enhancement to business processes can be written similarly. We then use the parameter

³⁸ In the establishments where both forms of data were collected, we checked for similar responses to different questions. Hence, our methods will align results in spite of source of data.

³⁹ We interact the long survey dummy with time. If establishments are selected for the long survey endogenously by HH, then this suggests the impact of receiving the long survey on adoption may vary over time.

estimates of the probit to estimate the predicted probability that an establishment will adopt as if the survey date occurred in the latter half of 2000 and the establishment has responded to the long survey. We next adjusted the predicted results by the sample weights, adjusted for establishment definition. The resulting numbers are the average adoption rate in a location or an industry in the second half of 2000. These estimates equal data when every establishment is surveyed in the latter part of 2000.

A.4 Definitions

The CI database includes several measures of establishment Internet usage. From these we constructed measures of participation and enhancement. Identifying participation was simple, while identifying enhancement was comparatively more difficult.

We desire a definition of participation that involves using Internet technologies to lower communications costs while maintaining existing production, sales, and distribution techniques. It should be unrelated to whether an establishment has a presence on the World Wide Web, or makes available products and services to consumers on the web. Moreover, participatory investment assumes nothing about *intensity*. Establishments that participate in the Internet are not necessarily "light" users.⁴⁰

To be counted as participating in the Internet, an establishment must engage in two or more of the following activities: (1) have an Internet service provider; (2) indicate it has basic access; (3) use commerce, customer service, education, extranet, homepage, publications, purchasing or technical support; (4) use the Internet for usage, or has an intranet or email based on TCP/IP protocols; (5) indicate there are Internet users or Internet developers on site; or (6) outsource some Internet activities. We looked for two or more activities to guard against "false positives". As it was, this was a minor issue. Most respondents responded affirmatively to many of these criteria.

We construct a definition for enhancement. Business process enhancement is the type of investment commonly described in books on electronic commerce.⁴¹ Typically this involves altering sales, manufacturing, production, or distribution systems within the firm. We aggregate many applications under this umbrella. Business-to-business or business-to-consumer e-commerce fall in this category, so too does TCP/IP versions of software such as enterprise resource planning or customer relationship management. Again, enhancement assumes nothing about the *intensity* of use, nor about complexity.⁴² Most establishments that do enhancement are intensive users. They also may face

⁴⁰ Thus, our study is distinct from those that examine the difference between adoption and usage in IT (e.g., Fichman and Kemerer 1997, 1999).

⁴¹ See e.g., Kalakota and Whinston (1996), Kalakota and Robinson (1999), Choi and Whinston (2000).

⁴² While participation can involve straightforward application of new technologies, business process transformation requires disruption to the existing sales, distribution, and production techniques. For example, adoption of e-commerce often involves

considerable co-invention costs to effectively integrate these investments with legacy investments and processes. Still, we expect there is much heterogeneity in intensity and complexity of use among adopters of enhancement, given any definition we employ. We hope to explore this further in future work.

To be defined as performing enhancement, an establishment must first surpass a threshold for participatory investment. We initially tried a definition that was isomorphic to participation, with a more demanding threshold. That is, an establishment is counted as enhancing business processes when two or more hold: (1) the establishment uses two or more languages commonly used for web applications, such as Active-X, Java, CGI, Perl, VB Script, or XML; (2) the establishment has over five Internet developers; (3) the establishment has two or more “e-business” applications such as customer service, education, extranet, publications, purchasing, or technical support; (4) the establishment reports LAN software that performs one of several functions: e-commerce, enterprise resource planning, web development, or web server; (5) the establishment has an Internet server that is a UNIX workstation or server, mainframe, or minicomputer, or has 5 or more PC servers, or has Internet storage greater than 20 gigabytes; (6) the establishment answers three or more questions related to Internet server software, Internet/web software, or intranet applications.

We tested this definition and found that it generated many false positives. These false positives arose more frequently when an establishment was experimenting with, but not actually regularly using, Internet business processes. In other words, they were trying something small or contracting out for a test. To correct for this, we exclude establishments in one of three cases: 1. They indicate they have outsourced hosting of their Internet/web servers; 2. These experimenters responded affirmatively to exactly two of (1) through (6) but not any question about commerce; or 3. They have commerce but respond affirmatively to less than two of (1) through (6). Such establishments typically had not yet done very much (but might someday). We show the results of this difference in Table 3.

Our definition is mildly sensitive to the survey used by HH for an establishment, so we correct for this.⁴³ In our estimated predictions, we normalize on results as if all establishments responded to the long survey.

the creation of an entirely new distribution channel; a distribution channel that requires considerable organizational change in firm sales and distribution techniques.

⁴³ The long survey is particularly useful in identifying business process establishments, and is the only source of information on business process criteria (5) and (6) and is also the only source of information on outsourcing. Because we apply a consistent definition of adoption across all establishments, there exists a natural bias in that long survey establishments will be more likely adopters. Some of these might reflect our definition and some of it certainly reflects HH’s tendency to survey big adopters with the long form.