

**Cities Online:
Urban Development and the Internet**

John B. Horrigan

The PEW Internet & American Life Project

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The Progress & Freedom Foundation

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Quantifying the Economic and Demographic Factors Affecting Internet Connectivity

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EXECUTIVE SUMMARY

The information technology revolution has been the principal driving force behind the acceleration in productivity and growth of the U.S. economy during the last decade. More recently, the Internet has become an increasingly ubiquitous vehicle for communication, research and commerce in both households and workplaces. The utility of the Internet is reflected in the dramatic surge in the proportion of the U.S. population online during the past two years and in the increasingly varied range of activities—from instant messaging to music downloading—in which online users can and do engage. During the last six months of 2000 alone, the overall Internet penetration rate has increased from 47 percent to 56 percent of U.S. adults.¹⁴ Because Internet access and use will be a significant determinant of future economic performance, it is important to understand the process by which the Internet is being adopted and diffused.

Because Internet access and use will be a significant determinant of future economic performance, it is important to understand the process by which the Internet is being adopted and diffused.

Adoption of the Internet by different demographic groups and geographic regions has not been uniform. Some of the reasons for the variation in penetration rates—educational levels and household incomes, for example—are linked to consumption of not just Internet services, but of goods and services generally. Researchers have also focused on other demographic variables, and a number of recent studies have concluded that race is a significant determinant of Internet access even after variables such as education and income are accounted for.¹⁵ The Department of

¹⁴ Lee Rainie et. al., *More Online, Doing More*, Pew Internet & American Life Project, February 18, 2001.

¹⁵ See, for example, *Falling Through the Net: Toward Digital Inclusion*, National Telecommunications and Information Administration/Economics and Statistics Administration, Department of Commerce, October 2000; Donna L. Hoffman, Thomas P. Novak and Ann E. Schlosser, *The Evolution of the Digital Divide: How Gaps in Internet Access May Impact Electronic Commerce*, Owen Graduate School of Management, Vanderbilt

Our research confirms that most of the variation in Internet penetration rates can be explained by five factors.

Commerce study, for example, concludes that “[d]ifferences in income and education do not fully account for this facet of the digital divide.”¹⁶ In addition, some writers on this subject—most notably, Leigh/Atkinson and Hoffman et.al.—believe that the impact of race on Internet access has been growing over time.

In this paper, we present a statistical model that tests how well a variety of economic and demographic factors explain observed differences in Internet penetration rates for a diverse sample of 44 of the nation’s largest metropolitan areas. The sample includes some of our largest cities like New York, Los Angeles and Chicago; high-technology clusters such as the San Francisco Bay area and Seattle; government centers like Washington D.C.; and regional and national business hubs such as Dallas or Atlanta.

The top metropolitan areas are a diverse group in terms of Internet penetration as well. While more than two-thirds of adult residents of the San Jose, Seattle, and Washington D.C. areas are online either at home or at work, less than half of the adult population in major cities such as New York, Cleveland, Detroit and Miami is online. Given the role that the IT sector and the Internet now appear to be playing in fostering economic growth, these differences have obvious implications for those interested in regional economic development.

Our research confirms that most of the variation in Internet penetration rates can be explained by five factors:

1. Educational attainment.

University, March 2000; Andrew Leigh and Robert D. Atkinson, *Clear Thinking on the Digital Divide*, Progressive Policy Institute, June 2001; and Mark N. Cooper, *Disconnected, Disadvantaged, and Disenfranchised: Explorations in the Digital Divide*, Consumer Federation of America/Consumers Union, October 11, 2000.

¹⁶ At p. xvii.

2. The relative size of the high-tech sector in the local economy.
3. Population growth.
4. Median household income.
5. Median age.

These results are not surprising and are largely consistent with our *a priori* expectations. Our findings also corroborate to some extent those of previous studies, in which income and education have been identified as the key demographic variables that determine Internet connectivity.¹⁷ What is somewhat surprising, however, is that we are able to explain nearly 80 percent of the variation in Internet penetration rates with these five variables. In fact, the first three variables—education, the size of the high-tech sector and recent population growth—account for over 73 percent of the variation in Internet access. By contrast, other studies of Internet connectivity have only been able to explain 20-25 percent of the differences in access rates.¹⁸

Once the influence of the five variables in the basic model is accounted for, Internet penetration is not closely correlated with a number of other variables, including race. In our model, the access rate gaps associated with race are accounted for by a strong correlation with education and income, variables that are confirmed determinants of Internet access and use. This finding is corroborated by the actual pattern of Internet penetration rates: four of the five most connected cities (San Jose, Washington DC, San

Once the influence of the five variables is accounted for, Internet penetration is not closely correlated with race. Four of the five most connected cities (San Jose, Washington DC, San Francisco and Oakland) have significant African-American and/or Hispanic populations.

¹⁷ See, for example, Donna L. Hoffman and Thomas P. Novak, *Bridging the Digital Divide: The Impact of Race on Computer Access and Internet Use*, Vanderbilt University working paper, February 2, 1998, and U.S. General Accounting Office, "Characteristics and Choices of Internet Users," Report to the Ranking Minority Member, Subcommittee on Telecommunications, Committee on Energy and Commerce, U.S. House of Representatives (GAO-01-345), February 2001.

¹⁸ See Andrew Leigh and Robert Atkinson, "Clear Thinking on the Digital Divide", *PPI Policy Report*, June 2001, and Mark N. Cooper, *Disconnected, Disadvantaged, and Disenfranchised: Explorations in the Digital Divide*, Consumer Federation of America/Consumers Union, October 11, 2000.

Our statistical results do a good job predicting the Internet penetration rates of the five cities highlighted in John Horrigan's study.

San Francisco and Oakland) have significant African-American and/or Hispanic populations.

Our statistical results do a good job predicting the Internet penetration rates of the five cities highlighted in John Horrigan's study, which is a companion to this paper. Horrigan presents case studies for five very diverse metropolitan areas: Austin, Cleveland, Portland (Oregon), Nashville and Washington, DC. Our model performs very well for these cities, despite the fact that they have very different characteristics.

Austin and Washington illustrate the importance of education and the high-tech sector to Internet penetration. Both cities have a highly educated population and a high proportion of high-tech industry, and both have very high Internet penetration. Washington also has a very high median household income.

Portland has above-average penetration, reflecting its above-average high-tech sector and population growth rate.

Nashville has below-average penetration, despite the fact that its education level is essentially average. However, Nashville's high-tech sector and population growth rate are both substantially below average.

Finally, Cleveland's low Internet penetration reflects the fact that Cleveland is below average with respect to all the variables, except age, which is inversely related to penetration. Of all the five cities, Cleveland is lowest in education, high-tech and population growth, the three most important explanatory variables.

The ability of the factors that we identify to explain differences in Internet penetration rates among metropolitan areas does not necessarily translate into a recipe for effecting dramatic improvements in a particular city's standing in the short run. Fairly substantial changes in the educational attainment or income of city residents, for example, are associated with relatively modest increases in Internet penetration rates.

It remains to be seen whether regional penetration rates will converge over time or whether disparities will remain, possibly based on the variables we have identified.

In contrast, penetration rates have increased significantly over time. From January 1999 to January 2000, penetration rates in our sample of 44 cities increased by an average of nearly five percent. It remains to be seen whether regional penetration rates will converge over time or whether disparities will remain, possibly based on the variables we have identified.

I. INTRODUCTION

It is now widely recognized that the information technology (IT) revolution has been the principal driving force behind the acceleration in productivity and growth the U.S. economy enjoyed during the last decade. More recently, the Internet has become an increasingly ubiquitous vehicle for communication, research and commerce in both households and workplaces. The utility of the Internet is reflected in the dramatic surge in the proportion of the U.S. population online during the past two years and in the increasingly varied range of activities—from instant messaging to music downloading—in which online users can and do engage. During the last six months of 2000 alone, the overall Internet penetration rate has increased from 47 percent to 56 percent of U.S. adults.¹⁹

Some of the reasons why access rates may differ across individuals or households—educational levels and household incomes, for example—are linked to consumption of not just Internet services, but of goods and services generally.

This rapid expansion in the online population has been accompanied by an extensive, ongoing assessment of the factors that influence Internet access and use. Some of the reasons why access rates may differ across individuals or households—educational levels and household incomes, for example—are linked to consumption of not just Internet services, but of goods and services generally. Researchers have focused on demographic components of the “digital divide”: variables such as race, sex and age that may influence the ability or interest of specific groups to become “connected.” In particular, a number of recent studies have concluded that race is a significant determinant of Internet access even after variables such as education and income are accounted for.²⁰

¹⁹ Lee Rainie et. al., *More Online, Doing More*, Pew Internet & American Life Project, February 18, 2001.

²⁰ See, for example, *Falling Through the Net: Toward Digital Inclusion*, National Telecommunications and Information Administration/Economics and Statistics Administration, Department of Commerce, October 2000; Donna L. Hoffman, Thomas P. Novak and Ann E. Schlosser, *The Evolution of the Digital Divide: How Gaps in Internet Access May Impact Electronic*

A number of recent studies have concluded that race is a significant determinant of Internet access even after variables such as education and income are accounted for.

The Department of Commerce, for example, has concluded that “[d]ifferences in income and education do not fully account for this facet of the digital divide.”²¹ In addition, some writers on this subject—most notably, Leigh/Atkinson and Hoffman et.al.—believe that the impact of race on Internet access has been growing over time.

Some of the studies that conclude that race is associated with relatively large differences in Internet access rates do not take into account—or “control for” in the language of statisticians—related factors such as income and education. Those that have attempted to do so have not been able to develop statistical models with convincing levels of explanatory power. A recent study by Leigh and Atkinson for the Progressive Policy Institute found that income, education and race all had significant effects on computer ownership and Internet access rates, but that all of these factors explained only about one-fifth of the variance in access to technology across households.²² A study by Mark Cooper for the Consumer Federation of America and Consumers Union had similar explanatory power.²³

Another aspect of the “digital divide” concerns variations in Internet penetration rates across regions, cities and states. In fact, the differences in access levels across metropolitan areas are quite large. While more than two-thirds of adult residents of the San Jose, Seattle, and Washington, DC, areas are online either at

Commerce, Owen Graduate School of Management, Vanderbilt University, March 2000; Andrew Leigh and Robert D. Atkinson, “Clear Thinking on the Digital Divide,” *Progressive Policy Institute*, June 2001; and Mark N. Cooper, *Disconnected, Disadvantaged, and Disenfranchised: Explorations in the Digital Divide*, Consumer Federation of America/Consumers Union, October 11, 2000.

²¹ At p. xvii.

²² Andrew Leigh and Robert Atkinson, *Clear Thinking on the Digital Divide*, Progressive Policy Institute, June 2001. In contrast to our study, which is based on metropolitan area data, the PPI study uses household data.

²³ Mark N. Cooper, *Disconnected, Disadvantaged, and Disenfranchised: Explorations in the Digital Divide*, Consumer Federation of America/Consumers Union, October 11, 2000. The CFA/CU study also uses household data.

home or at work, less than half of the adult population in major cities such as New York, Cleveland, Detroit and Miami is online. Given the role that the IT sector and the Internet now appear to be playing in fostering economic growth, these differences have obvious implications for those interested in regional economic development.

Thus far, relatively little attention has been devoted to systematically examining the underlying factors that explain the differences in Internet access rates across cities.

Thus far, however, relatively little attention has been devoted to systematically examining the underlying factors that explain the differences in Internet access rates across cities. Perhaps the most frequently cited explanation is the prominence of the IT sector, or, more generally, “high-tech” industries. A high concentration of high-tech businesses should increase Internet access rates both directly through employment and investment in the region and, indirectly, by attracting more technology-receptive individuals as workers and as city residents.

In this paper, we present a statistical model that tests how well a variety of factors—education, income, demographic characteristics and the role of the high tech sector—explain observed differences in Internet penetration rates for a sample of 44 of the nation’s largest metropolitan areas. Our research confirms that five factors provide a substantial amount of explanatory power:

1. Educational attainment, measured by the percentage of adults 25 or older that are college graduates, is the single most important determinant of differences in Internet penetration rates. Higher education is positively associated with access rates because it permits individuals and businesses to make more productive use of Internet access, and thus increases the returns from securing access. Furthermore, people with higher education are more likely to use the Internet at home as well as in the office.

Our research confirms that five factors provide a substantial amount of explanatory power.

2. There is also a strong positive statistical association between Internet penetration rates and the relative size of the high-tech sector in the local economy. Cities with larger-than-average concentrations of high-tech industries are likely to have higher access rates at both work (because of the higher level of Internet utilization in these firms) and home (since high-tech workers are more likely to have both interest in, and the ability to use, Internet access for a wide range of activities). A significant portion of the differential in economic growth across regions and metropolitan areas can be attributed to the high-tech sector.
3. The third most useful explanatory variable is population growth, measured by the percentage change in the metropolitan area Census population from 1990 to 2000. Population growth is positively associated with penetration rates because it is a benchmark of how well a metropolitan area is able to attract people and companies due to quality of life, job prospects and infrastructure.
4. Median household income is also positively associated with Internet access rates, although it accounts for a relatively small portion of the variation in these rates among cities after the first three variables are included in our basic model. Higher income levels support a higher rate of home computer ownership, a prerequisite to home access, and higher average wages are reflective of a more productive workforce.
5. Finally, median age is negatively associated with Internet penetration. This result is mostly due to the impact of age on labor force participation, with retired people much less likely to use the Internet than older people who are still working.

These results are not surprising and are largely consistent with our *a priori* expectations. Our findings also corroborate to some extent those of previous studies, in which income and education have been identified as the key demographic variables that determine Internet connectivity.²⁴ What is somewhat surprising, however, is that we are able to explain about 80 percent of the variation in Internet penetration rates with these five variables. In fact, the first three variables—education, the size of the high-tech sector and recent population growth—account for over 73 percent of the variation in Internet access. As indicated, other studies of Internet connectivity, such as those by Leigh/Atkinson and by Cooper, have only been able to explain 20-25 percent of the differences in access rates at the individual household level.

We are able to explain about 80 percent of the variation in Internet penetration rates with five variables.

Those variables that do not add significant explanatory power to the basic model are equally interesting. Once we account for the influence of the five variables defined above, Internet penetration is not closely correlated with a number of other variables, including those measuring differences in the racial composition of cities. Including variables for city size and/or region also did not improve the explanatory power of the basic model. Instead, our results indicate that education, income and other factors included in our basic model adequately account for disparities in Internet access rates across cities with different racial demographics.

We also present an alternative version of the model in Appendix Two. This specification replaces four of the five explanatory factors in our basic model with two other variables—the proportion of the population employed as executives or professionals and the proportion of the population that is female. While this

²⁴ See e.g., Donna L. Hoffman and Thomas P. Novak, "Bridging the Digital Divide: The Impact of Race on Computer Access and Internet Use", Vanderbilt University working paper, February 2, 1998, p. 1.

Once we account for the influence of the five variables, Internet penetration is not closely correlated with differences in the racial composition of cities.

alternative model does not, in our view, do as good a job at capturing the underlying factors that explain differences in Internet penetration, the omission of the educational attainment variable means that it can be used to estimate “predicted” penetration rates for a much larger sample of cities.²⁵

It will be important to revisit these results as Internet access rates both increase generally and converge among different demographic groups. By the end of 2000, for example, online rates for men and women had become nearly identical. As this convergence takes place, we expect to see validation, in the form of continued statistical effectiveness, from our basic model of differences in penetration rates, which is built on factors that we think are more causally related to Internet access and use. By contrast, we anticipate that the alternative specification, which relies on the present degree of correlation between occupational and gender mix proportions and the underlying explanatory factors, will do less well at predicting inter-metropolitan variation in Internet access rates.

²⁵ While educational attainment levels for smaller metropolitan areas are not published in the Current Population Survey (CPS) reports, it is possible to calculate estimates for these cities from the detailed survey data. Because the CPS collects fewer responses from households in these (relatively) smaller cities, the resulting estimates do not meet the Census/Bureau of Labor Standards criteria for statistical precision. Accordingly, in this study, we did not perform these calculations for the entire 89-city sample of metropolitan areas. We did, however, compute educational attainment for Austin and Nashville to determine how well the model predicted Internet penetration in the cities discussed in John Horrigan’s companion study.

II. THE DIGITAL ECONOMY AND INTERNET ACCESS RATES

A. Productivity and the I.T. Sector

The U.S. economy enjoyed a remarkable resurgence in growth and productivity during the 1990s. From 1996 to 2000, the economy grew at an average annual rate of 4.5 percent, up sharply from the 3.1-percent rate at which it grew during the first half of the decade, and the 3.3-percent rate at which it grew during the previous 20 years.²⁶

It is now widely accepted by economists that information technology is primarily responsible for this extraordinary performance. As Dale Jorgenson observed in his recent Presidential Address to the American Economic Association, "computers have now left an indelible imprint on the productivity statistics."²⁷ While the IT sector (consisting of computer hardware, software, and telecommunications) accounted for only about seven percent of national output from 1996 to 1998, these industries accounted for more than 30 percent of the growth in output during this period.²⁸

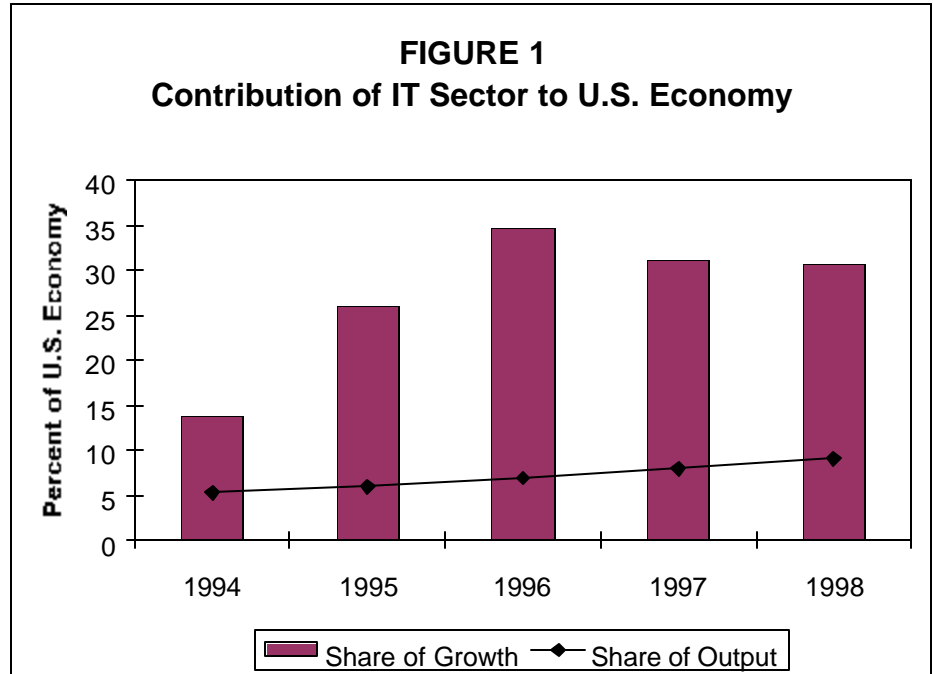
It is now widely accepted by economists that information technology is primarily responsible for the extraordinary performance of the U.S. economy during the 1990's.

²⁶ Bureau of Economic Analysis, U.S. Department of Commerce.

²⁷ Dale Jorgenson, "Information Technology and the U.S. Economy," *American Economic Review*, March 2001.

²⁸ Jeffrey Eisenach, Thomas Lenard and Stephen McGonegal, *The Digital Economy Fact Book*, 2nd ed., The Progress and Freedom Foundation, July 2000, p. 81.

The Internet makes possible a whole array of interactions between consumers and businesses that enhance economic performance.



SOURCE: THE PROGRESS & FREEDOM FOUNDATION

The estimates of the effect of information technology on growth and productivity during the 1990's reflect the widespread adoption of computers—both hardware and software. They do not yet incorporate much of the effect of the Internet, a second stage in the information technology revolution that is now well under way.

The Internet makes possible a whole array of interactions between consumers and businesses that enhance economic performance. Individuals communicate, shop, manage finances, look for jobs, read their newspaper, and look for information on specific topics (particularly education and health) while connected to the Internet.

The Internet is also being utilized by businesses in ways that will undoubtedly be reflected in future productivity studies. Many industries are shifting into more information-intensive forms of production.²⁹ An increasing number of companies are framing work around the Internet, enabling them to leverage the resources most important in the digital economy—human capital and information. Because the Internet will be an important determinant of economic performance, it is important to understand the process by which it is being adopted and diffused.

Because the Internet will be an important determinant of economic performance, it is important to understand the process by which it is being adopted and diffused.

²⁹ For example, the increased availability and use of market information has enabled many companies to shorten production times and product cycles (See *The State New Economy Index*, Progressive Policy Institute, July 1999, p. 3). Some businesses are also engaging in “mass customization” (See *The Economist Survey: “The Young”*, Dec. 21, 2000).

TABLE 1
Most Common Internet Activities

<u>Activity</u>	<u>Percent of those with Internet access</u>
Send email	93
Look for info on a hobby	79
Research product/service	73
Get travel information	68
Check the weather	64
Get New	63
Look for health/med info	57
Buy a product	52
Do research for job	52
Get financial information	45
Send an instant message	44
Check sports scores	38
Play a game	34
Chat in a chat room	26
Download music files	25
Bank online	18
Make a phone call	10
Go to a dating site	9
Gamble	5

Source: Pew Internet & American Life Project Surveys, 2000

Virtually all Americans now have access to a competitive local Internet Service Provider (ISP).

B. Internet Access

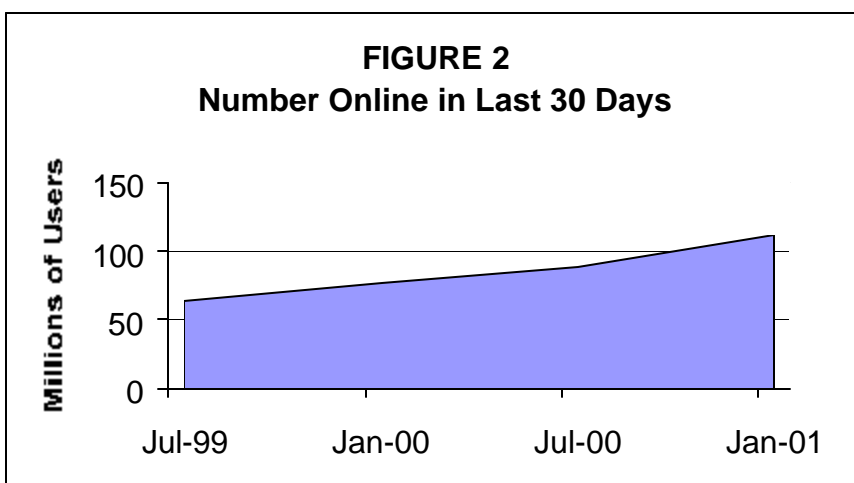
Virtually all Americans now have access to a competitive local Internet Service Provider (ISP) market, and they are increasingly taking advantage of the services that market provides.³⁰ As of the end of 2000, 56 percent of American adults were online, up from 47 percent six months earlier,³¹ according to survey data from the Pew Internet & American Life Project. This is consistent with data collected by Nielsen//NetRatings, which indicate that there were 111 million adults online

³⁰ Shane Greenstein, "Computers and the Internet," *NBER Reporter*, Fall 2000.

³¹ Lee Rainie et. al., *More Online, Doing More*, Pew Internet & American Life Project, February 18, 2001.

in January 2001, compared with 77 million in January of the previous year.³²

Average connection speeds for home users have increased during the past two years.



SOURCE: NIELSEN // NET RATINGS

Online households are also doing more with the Internet, as e-commerce, streaming media, and instant messaging have grown in capability and popularity. The number of home users of software that plays digital audio or video increased 33 percent during 2000. At least eight million unique users log on monthly to each of four different instant messaging applications, which enable online users to conduct real-time conversations.³³

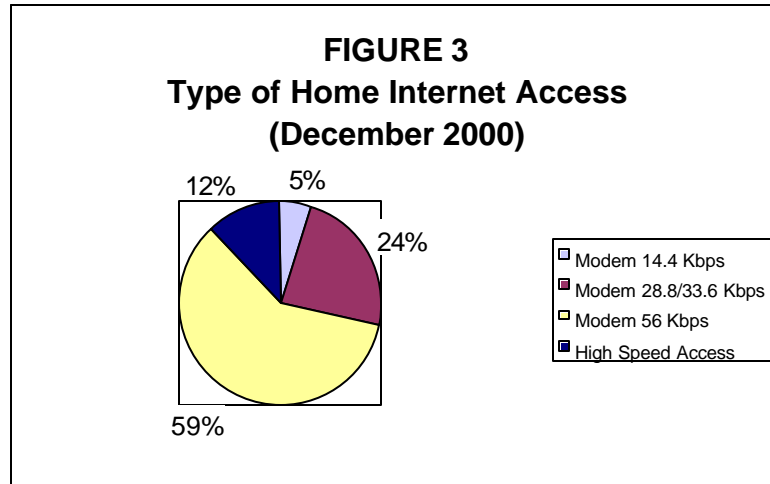
Access to these features is enhanced by higher-speed connections to the Internet, and average connection speeds for home users have increased during the past two years as well. About 60 percent of all users surveyed by Nielsen//Net Ratings connected with a 56Kbps modem in December 2000, up 40 percent from December 1999. The number of home users with high-speed access (primarily DSL or cable modem access) surged 148 percent over the same

³² Nielsen//NetRatings, "Internet Penetration Reaches 60 Percent in the U.S.," Press Release, February 14, 2001; and "January At-Home Internet Ratings," Press Release, February 2000.

³³ Jupiter Media Metrix, "Users of Media Player Applications Increased 33 Percent Since Last Year", Press Release, April 4, 2001; and CyberAtlas, "Online Chatters among Heaviest Web Users," February 7, 2001.

Penetration rates exceeded 60 percent in a dozen cities by early last year, with San Jose, Washington DC, and Seattle heading the list of most-connected cities.

time period; one out of every eight Internet households had broadband access by the end of last year.³⁴



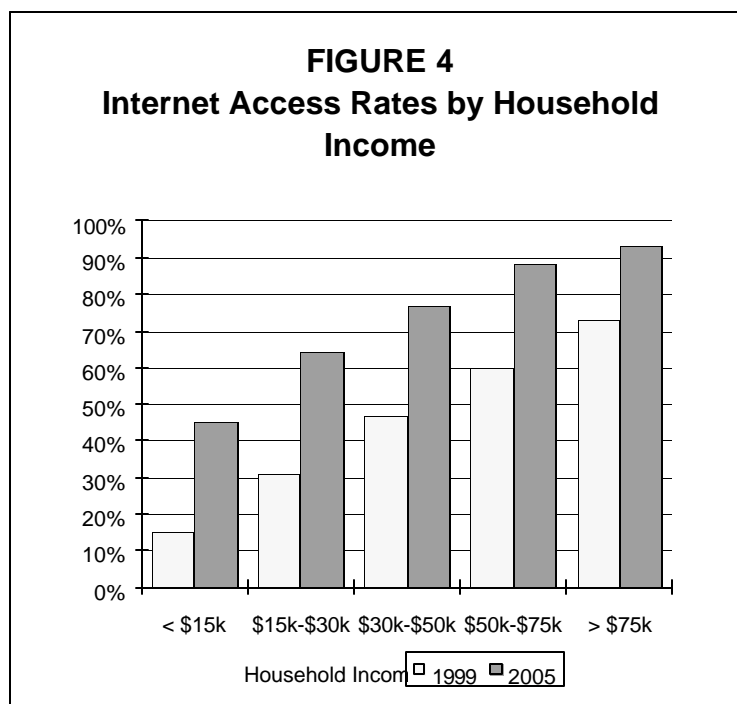
Source: Nielsen//Net Ratings

While access to the Internet is expanding rapidly, there are still substantial variations in the proportion of individuals in different demographic groups that are connected, a phenomenon that has come to be known as the “digital divide.” A number of studies have examined disparities in access across individuals at different income levels, ages, and other demographic characteristics.³⁵ Of these characteristics, income is the most commonly cited. One source estimates that 73 percent of households earning more than \$75,000 were online in July 1999, while only 15 percent of those making less than \$15,000 annually were on the Internet during that month.³⁶ Other studies have focused on lower-than-average access rates for minority group members, women and older Americans.

³⁴ Nielsen//NetRatings, “Broadband Access Soars Nearly 150 Percent at Home,” Press Release, February 8, 2001.

³⁵ See Department of Commerce, *Falling through the Net*, October 2000, and Walsh et. al., *The Truth about the Digital Divide*, April 2000.

³⁶ Jupiter Communications estimates reported in Eisenach et. al., *The Digital Economy Fact Book*, 2nd Edition.



Source: Jupiter Communications

C. Internet Access Rates across Metropolitan Areas

While Internet access has grown dramatically in recent years, that growth has not been uniform across cities. Appendix Table 3.1 presents estimates of Internet penetration rates for 44 major metropolitan areas in January 1999 and January 2000.³⁷

The 44 metropolitan areas shown in Table 3.1 had an average penetration rate of 56 percent in early 2000. This group of large urban centers, all of which have populations of at least one million, is on average slightly ahead of the nation as a whole in terms of access levels. Penetration rates exceeded 60 percent in a dozen cities by early last year, with San Jose, Washington DC, and Seattle heading the list of most-

Penetration rates exceeded 60 percent in a dozen cities by early last year, with San Jose, Washington D.C., and Seattle heading the list of most-connected cities

³⁷ Data are available from Scarborough Research for a larger set of metropolitan areas. In general, smaller metropolitan areas and rural areas have lower penetration rates than the larger cities that are the subject of this analysis.

By 2000, penetration rates had yet to reach the 50-percent mark in several of the nation's largest cities, including Miami, Pittsburgh, Detroit and Cleveland.

connected cities. Among these MSAs, San Jose exhibited a particularly strong continuing growth in connectivity, with an 11.7 percent increase in its access rate from 1999 to 2000. Other cities with above-average penetration rates that experienced high rates of growth from 1999 to 2000 include Atlanta, Houston, Boston and San Diego.

On the other hand, by 2000, penetration rates had yet to reach the 50-percent mark in several of the nation's largest cities, including Miami, Pittsburgh, Detroit and Cleveland. However, many of the cities with lower-than-average 1999 penetration rates experienced significant growth in access levels during the past year. In fact, five (Pittsburgh, Cleveland, Tampa, Buffalo and San Antonio) of the ten cities with the lowest penetration rates in 1999 ranked among the top ten in percentage growth in access from 1999 to 2000.

III. FACTORS THAT MAY EXPLAIN INTER-CITY DIFFERENCES IN INTERNET PENETRATION

Education is positively associated with computer ownership, the first step to web access at home.

What accounts for differences in Internet penetration rates? Researchers have cited a large number of factors as possible explanations, including income, education and other demographic characteristics, as well as the mix of industry sectors and/or occupations that characterize the area economy. In this section, we summarize the reasons why each of these factors acts as a determinant of access rates.

A. Educational Attainment

Education is at the top of the list of explanatory factors we expect to be important, in part because so many individuals learn to use the Internet during the course of their education. As *The Economist* observed, "although only 10 percent of American university students graduate with technical degrees, nearly all of them use e-mail, the web and the latest Internet music-piracy technology."³⁸ Once people have started using the Internet, they are unlikely to stop.

Education is also positively associated with computer ownership, the first step to web access at home.³⁹ The reverse is also true: surveys of "Internet dropouts" reveal that their education levels are below average.⁴⁰ Moreover, this status is self-perpetuating. The U.S. Department of Commerce's *Digital Economy Report 2000* warns that less-educated individuals are missing out on Internet-based opportunities to address

³⁸ The Economist Survey: "The Young," Dec. 21 2000.

³⁹ Donna L. Hoffman et. al., "The Evolution of the Digital Divide: How Gaps in Internet Access May Affect Electronic Commerce," *Journal of Computer-Mediated Communication*, vol. 5, no. 3, March 2000.

⁴⁰ Phillip Asden and James Katz, "Internet Dropouts in the U.S.A.: The Invisible Group," *Telecommunications Policy*, Vol. 22. Nr. 4 - 5, 1998.

Education is also important in explaining differences in Internet penetration rates at work.

past deficits in schooling and skills that limit their earning potential.⁴¹

However, while many studies have cited the importance of education as a factor in explaining Internet access rates, some have concluded that income was a more powerful predictor. Cooper and Kimmelman, for example, conclude that “[i]ncome is the most important factor. The Digital Divide is first, and foremost, an economic divide”.⁴² On the other side of the digital divide debate, Forrester Research also argues that income is the strongest predictor of Internet access.⁴³

Education is also important in explaining differences in Internet penetration rates at work, because the advent of information technology has increased demand for skilled labor. Bresnahan et. al. find that human capital is a good predictor of the level of a company’s IT capital stock, especially information network technology. Specifically, they demonstrate that changes in the proportion of a business’s wage and salary expense that is paid to college graduates is positively related to present and past levels of computerization.⁴⁴ This result is consistent with Hoffman and Novak, who found that better-educated workers—both African American and white—are more likely to use the Internet at work.⁴⁵

⁴¹ U.S. Department of Commerce, *Digital Economy 2000*, p. vii.

⁴² Mark Cooper and Gene Kimmelman, *The Digital Divide Confronts the Telecommunications Act of 1996*, Consumer Federation of America/Consumers Union, February 1999, p. 23.

⁴³ Walsh et. al., “*The Truth about the Digital Divide*”.

⁴⁴ Bresnahan, et. al., “Information Technology, Workplace Organization, and the Demand for Skilled Labor”, *Quarterly Journal of Economics*, November 2000. Studies cited in Bresnahan et al. are: Edward Wolff, *The Growth of Information Workers in the U.S. Economy 1950 – 1990: The Role of Technological Change, Computerization, and Structural Change*. New York, 1996; and David Autor et. al., “Computing Inequality: Have Computers Changed the Labor Market?,” *Quarterly Journal of Economics*, Vol. XIII, November 1998, pp. 1169 – 1214.

⁴⁵ Hoffman and Novak, *Bridging the Digital Divide*, p. 4.

More specifically, information technology and educational attainment act as complements because the spread of advanced network technologies has increased the volume of transmitted data, thereby increasing the need for workers with the analytical capabilities to process this information.⁴⁶ Tasks involving relatively simple decision-making have been computerized, whereas complex management tasks and cognitively demanding work have not lent themselves to automation. More educated workers also are more likely to take advantage of the new learning opportunities presented by online training and information exchange, which reinforces the statistical connection between penetration rates and education over time.

Better-educated workers—both African American and white—are more likely to use the Internet at work.

Higher educational levels also influence the penetration rate in indirect ways. The causal relationship between education and productivity growth is well-established and has been substantiated by many studies and public policies aimed at improving educational attainment.⁴⁷ A study by James Rauch (based on 1990 census data), covering over 200 MSAs found that a one-year increase in the average education level of a metropolitan area was associated with a productivity increase of approximately three percent.⁴⁸

B. Share of Output from High-Tech Industries

During most of the 1990s, high-tech industries have been growth engines for local and regional economies. Economic activity has moved away from

⁴⁶ Bresanan et al.

⁴⁷ Paul Gottlieb and Michael Fogarty, *Educational Attainment and Metropolitan Growth*, Center for Regional Economic Issues, Case Western Reserve University, p. 11; and Edward L. Glaeser et. al., *Consumer City*, Harvard Institute of Economic Research working paper, June 2000, p. 13. Because economic growth and human capital are closely associated, educational attainment may account for some of the impact economic growth has on Internet penetration rates.

⁴⁸ John M. Quigley, *Urban Diversity and Economic Growth*, University of California, Berkeley, p. 13.

During most of the 1990's, high-tech industries have been growth engines for local and regional economies.

traditional sectors as high-tech industries created high-paying jobs for qualified workers and attracted large infusions of investment dollars. With demand for their products soaring up until the second half of 2000, high-tech companies created wealth for their stockholders and for their local communities as well. Companies in less-technology-intensive sectors have also benefited by adopting the product development processes (such as "continuous innovation") and therefore the dynamics of the high-tech industry.⁴⁹

Not all communities have been able to enjoy the benefits—or will bear the costs of this year's IT slowdown—of technology clusters within their boundaries, however. High-tech industries are relatively concentrated in a few metropolitan areas. The 20 areas with the highest levels of high-tech production in 1999 accounted for nearly 50 percent of the national output of high-tech goods and services.⁵⁰

A 1999 Milken Institute study estimates that geographically mobile information industries account for nearly two-thirds of the differential in economic growth between regions.⁵¹ In a more recent report Kotkin and DeVol further suggest that the Internet has profoundly altered the business mix of MSAs. Information-intensive industries, an amalgam of activities encompassing financial services, entertainment, public relations, telecommunications, computer technology and scientific research, have grown with the spread of network technology.⁵² These high-tech companies, especially those in the services

⁴⁹ Joseph Cortright and Heike Mayer, *High Tech Specialization: A Comparison of High Technology Centers*, Brookings Center on Urban & Metropolitan Policy, January 2001, p. 2.

⁵⁰ Standard & Poors, *U.S. Metro Economies: Leading America's New Economy*, June 6, 2000.

⁵¹ Ross DeVol et al., *America's High-Tech Economy: Growth, Development and Risks for Metropolitan Areas*, Milken Institute, July 13, 1999, p. 4. Their analysis is based on a time series ranging from 1990 to 1998.

⁵² Joel Kotkin and Ross DeVol, *Knowledge-Value Cities in the Digital Age*, Milken Institute, February 13, 2001, p. 6.

sector, are more likely to use the Internet in their business processes.⁵³

Workers in high-tech industries earn above-average wages.

The importance of the high-tech sector is also related to income levels. A rising share of local high-tech output will increase average metropolitan area incomes:⁵⁴

- Workers in high-tech industries earn above-average wages. The average high-tech employee in Seattle topped the rankings in 1998 with a whopping \$129,259 per year, 200 percent more than the average private sector worker in the same city. Other cities with high high-tech wage levels include San Jose (\$85,149), Middlesex NJ (\$78,835), and Austin (\$76,307).⁵⁵ High-tech firms in Seattle employ 66 out of every 1,000 private sector workers; in San Jose, 250 out of 1,000; in Middlesex, 100 per 1,000; and in Austin, 148 out of 1,000.⁵⁶
- As high-tech clusters develop, a supplier and services network emerges, which includes legal and financial services, accounting and management consulting. High-tech services will increase demand for local products and services, since their local content is high. But manufacturing will kick-start local economies as well: a semiconductor plant can cost \$3 billion to construct.⁵⁷ The Milken Institute has calculated that, in a metropolitan area with

⁵³ Jed Kolko, "The Death of Cities? The Death of Distance? Evidence from the Geography of Commercial Internet Usage," presentation at the Cities in the Global Information Society Conference, November 22-24, p. 7.

⁵⁴ Cortright and Mayer, p. 2. Also see DeVol et al., p. 8. The presence of high-tech companies may also increase income inequality.

⁵⁵ AeA (formerly American Electronics Association)/NASDAQ, *Cybercities: A City-by-City Overview of the High-Technology Industry*, December 2000, p. 31.

⁵⁶ AeA/NASDAQ, "Cybercities Finds that all but one of 60 U.S. Tech Cities Grew in Past Five Years," Press Release, December 5, 2000.

⁵⁷ DeVol et al., p. 54.

Population growth is a proxy for a broad range of indicators of urban expansion, including a vibrant labor market, solid economic growth, and a high quality of life.

an average proportion of high-tech industries, an increase in high-tech output of one percent may raise non-high-tech output by as much as 0.2 percent.⁵⁸

C. Rate of Population Growth

Population growth is a proxy for a broad range of indicators of urban expansion, including a vibrant labor market, solid economic growth, and a high quality of life. All of these factors will serve to attract workers and companies.

One component of population growth is the influx of what Kotkin and DeVol call “new urbanites” to some areas. They note that many of the “new” urban settlers tend to be young, well-off and highly educated. For example, they note that “[i]n lower Manhattan, 88 percent of residents are under 45, most are single and earn upwards of \$120,000.”⁵⁹

The “new urbanites” come from a variety of occupational categories—not just technical professions—since the Internet industries’ need for creative talent in marketing and design is increasing rapidly. Many large urban areas, especially the technology hubs, have grown due to the influx of these new urbanites. According to the Milken Institute, Chicago is the city whose urban core has grown the most from the in-migration of affluent knowledge-economy workers. Between 1995 and 1999, the Windy City’s number of jobs in computer and data processing services increased 10–15 percent annually, accounting for a total increase of 25,000 jobs. This increase took place concurrently with the continuing exodus of older, publicly-traded companies that started three decades ago.⁶⁰

⁵⁸ DeVol et al., p. 50. The direction of causation here is open to discussion, however, since other variables that may account for the covariance, such as low business costs, would attract high-tech and low-tech companies alike.

⁵⁹ Kotkin and DeVol, p. 16

⁶⁰ Kotkin and DeVol, p. 38.

D. Income

Internet penetration rates from both home and work are likely to be influenced by income. One critical element in this relationship is the impact of income on computer purchases and use, because computers are still the primary means of accessing the Internet.⁶¹ As would be expected, household income correlates positively with home computer ownership. In "Bridging the Racial Divide on the Internet," Hoffman and Novak isolate income as the primary explanation for apparent racial differences in computer-ownership rates. Among those with incomes of \$40,000 or more, African-American households actually had a higher computer ownership rate than white households.⁶²

Internet access is directly related to income.
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Home computer penetration rates differ across metropolitan areas as well. Ownership levels are highest in San Jose, Colorado Springs, Portland (OR), Salt Lake City and Washington D.C., each of which had computers in at least 65 percent of homes as of August 2000.⁶³

Obviously, richer households are more likely to have Internet access as well, so Internet access is also directly related to income. Steve Mitra and Mitchell Moss report that there is a negative statistical association between the proportion of per capita incomes below \$40,000 per year and Internet Service Provider (ISP) subscriptions.⁶⁴ There may also be a

⁶¹ Computers will become a less important determinant of internet access in the next few years if current projections of a rapid increase in sales of Internet appliances—such as Web-enabled phones and personal digital assistants (PDAs), game consoles, and TV set top boxes—materialize. Sales projections for information appliances are provided in Eisenach et. al., *The Digital Economy Fact Book*, 2nd ed., p. 27.

⁶² Moreover, according to Hoffman and Novak, computer access is the only variable that explains the correlation between household income and Internet access – if individuals have other means of accessing the Internet, the statistical impact of income is lost. See Hoffman and Novak (1998), p. 6.

⁶³ AEA, Cybercities Report Press Release, December 5, 2000.

⁶⁴ These results are based on 1998 subscriber data from one major ISP for 20 metropolitan areas. See Steve Mitra and Mitchell Moss,

Internet access and use rates have historically been lower among older age groups.

supply-side response to higher incomes. Kolko observed that higher incomes go hand in hand with increased domain name density in the area. He suspects that local businesses use the Internet to satisfy growing local consumer demand, and that higher incomes lead to higher online demand for local goods and services.⁶⁵

With respect to the relationship between income and Internet access in the workplace, the evidence cited above suggests that labor productivity has increased in response to the spread of the Internet in the business world. Higher labor productivity means higher incomes.

E. Age-Profile of Metro Area Population

Internet access and use rates have historically been lower among older age groups. For example, the Pew Internet and American Life Project estimated that a disproportionate share of the 70 million Americans that do not have computer access is 65 years of age or older. In the most recent Pew surveys, only 15 percent of seniors were online during the previous 30 days.⁶⁶

Labor force participation plays a key role in explaining this phenomenon. According to the NTIA study, individuals who are over 50 years old are among the least likely to be Internet users, with a usage rate of only about 30 percent in 2000. When broken down between those that were, and those that were not, in the labor force, however, the ratio of Internet to non-Internet users was almost 3:1. The Internet usage rate

"Net Equity: A Report on Income and Internet Access," *Journal of Urban Technology*, Vol. 5: No. 3, Dec. 1998. In the past two years, however, lower income groups appear to be catching up. Between February 2000 and 2001, individuals with an annual income below \$25,000 had the highest growth in Internet penetration rates at home of all surveyed income group. Nielsen//NetRatings, "Lower Income Surfers are the Fastest Growing Group on the Web," Press Release, March 13, 2001.

⁶⁵ Kolko, "The Death of Cities?," p. 7.

⁶⁶ Rainie et. al., *More Online, Doing More*, p. 2.

for those in the labor force was 46 percent, compared to 17 percent for those who were not.⁶⁷

This gap in online access is rapidly diminishing, however, because the growth rate in the number of seniors accessing the Internet is higher than for any other age cohort. Future studies may find that this factor has diminished explanatory power.

A 2001 General Accounting Office (GAO) study states that "access to and use of the Internet are influenced by a person's race, education and income level."

F. Race

The 2001 release of the General Accounting Office (GAO) study on characteristics and choices of Internet users states that "access to and use of the Internet are influenced by a person's race, education, and income level."⁶⁸ Similarly, the NTIA found large gaps relative to the national average for Blacks and Hispanics.⁶⁹ The Vanderbilt study found that "the overall gap between whites and African Americans in Internet access and having ever used the Internet have actually increased over time."⁷⁰ The Leigh/Atkinson study, based on a statistical model similar to ours, also concluded that the white/non-white gap in Internet access had increased between 1997 and 2000.⁷¹

Other studies have questioned the extent to which there is a digital divide due to race differences. In an April 2000 report, Forrester Research noted that Hispanic, African American, and Asian groups were signing up for Internet access faster than whites. "There is no digital divide in terms of race," the study asserted.⁷² Thierer also argued that the problem of access to the Internet had been overstated and that, as was the case with almost all previous technological innovations, the pace and pattern of dispersion is never

⁶⁷ Department of Commerce, *Falling Through the Net*, October 2000, pp. 44-45.

⁶⁸ United States General Accounting Office, "Characteristics and Choices of Internet Users," February 2001, p. 11

⁶⁹ Department of Commerce, *Falling Through the Net*, October 2000.

⁷⁰ Hoffman et.al. p. 10.

⁷¹ Leigh/Atkinson, p. 4.

⁷² Walsh et. al. "The Truth Behind the Digital Divide".

The gender gap has diminished rapidly and may be eliminated entirely in the near future.

perfectly uniform.⁷³ The February 2001 Pew study shows that over the second half of 2000, Internet access grew from 88 million to 104 million, with “substantial gains across the demographic board” as millions more signed up or expanded Internet use and access.⁷⁴

G. Gender

This trend toward convergent rates of access is already very evident across men and women. Earlier studies revealed a gap between the Internet access of male and female groups with males enjoying greater access. In 1996, women made up only 42 percent of the U.S. online population.⁷⁵ Similarly, a Miami University study conducted in 1997 and 1998 found that a significantly higher proportion of men used the Web, newsgroups and chat rooms, although women were more likely to use email.⁷⁶

However, the gender gap has diminished rapidly and may be eliminated entirely in the near future. The October 2000 NTIA study, for example, reported that the disparity between the two groups has largely disappeared. In December 1998, the study showed a 34 percent Internet usage rate among men and a 31 percent rate for women. By August 2000, 45 percent of men and 44 percent of women were online.⁷⁷

⁷³ Adam D. Thierer, “A Digital Divide or a Digital Deluge of Opportunity?,” *The Heritage Foundation*, February 1, 1999.

⁷⁴ Rainie, Lee et al, *More Online, Doing More*, p. 2

⁷⁵ Jeffrey Eisenach et. al., *The Digital Economy Fact Book*, 1st edition, Progress and Freedom Foundation, July 1999, p. 10.

⁷⁶ Richard C. Sherman et. al., “The Internet Gender Gap: Is It Narrowing or Widening?,” Presentation at the 107th Annual Meeting of the American Psychological Association, August 20, 1999.

⁷⁷ Department of Commerce, “*Falling Through the Net*”.

IV. DATA ON FACTORS THAT MAY INFLUENCE ACCESS RATES FOR METROPOLITAN AREAS

A summary of the primary variables used in the statistical estimation of the model is presented in Table 2. We provide a discussion of the variables of greatest interest below; additional detail on the data used in developing this model is provided in Appendix One.

TABLE 2
Economic and Social Factors Affecting Internet Connectivity

Dependent Variable	
Penetration Rate = % of Adults with Home and/or Work Access, Jan. 2000	
Independent Variables	
<u>Economic Factors</u>	<u>Demographic Factors</u>
Household Income Median Income Over \$75,000 (%)	Educational Attainment College Graduates (%) High School Graduates (%)
Size of IT/High Tech Sector High Tech Sector Value (relative to other cities) Venture Capital Funding	Race, Sex and Age of Population African-, Hispanic-, Asian-American (%) Female (%) Median Age, Percent 55 and Over
Occupational Mix Proportion White Collar Executive, Professional (%)	Population and Population Growth Population (2000) Growth in Population (1999-2000)

Seven cities with the highest penetration rates — Washington D.C., San Francisco, Oakland, Seattle, Denver, San Jose, and Minneapolis—also rank in the top ten for educational attainment.

A. Educational Attainment

Our preferred measure of educational attainment, the percentage of adults over 25 with a Bachelor's Degree or higher, was taken from the Census Bureau's Current Population Survey for March 1999. We also had available the percentage of high school graduates in the adult population, which produced similar (but somewhat less significant) results when included in the statistical model.⁷⁸(See Appendix Table 3.2).

The ten cities with highest penetration rates also score well in the educational attainment rankings. Seven of these—Washington D.C., San Francisco, Oakland, Seattle, Denver, San Jose, and Minneapolis—also rank in the top ten for educational attainment. However, while Baltimore, Newark, and Hartford are the other three cities included in the top ten in the education rankings, their penetration rates are all below the sample mean.

It is worth noting that cities can change their standing in the education rankings over long periods of time. Comparing the educational attainment levels of 75 metropolitan areas between 1980 and 1997, Gottlieb and Fogarty found that the level of attainment in cities like Buffalo and Providence had improved considerably.⁷⁹ At the same time, attainment rates in highly wired metropolitan areas, such as San Francisco/San Jose, Oakland, Orange, Denver, Seattle, and Washington D.C., increased by more than 10 percent between 1990 and 1999. Other areas with high penetration rates, such as Minneapolis and Portland, have been able to improve on their considerable ability to retain educated workers in the

⁷⁸ The two measures are highly correlated, as would be expected. Simon previously found that the college level variable to be a better predictor of metropolitan economic growth than high school attainment Curtis Simon, "Human Capital and Metropolitan Employment Growth," *Journal of Urban Economics* vol. 43, 1998, pp. 223 - 243.

⁷⁹ Gottlieb and Fogarty, *Educational Attainment and Metropolitan Growth*, pp. 13-14.

same time period. Still other cities, most notably Hartford, have bettered their own good attainment records, but their penetration rates have as yet failed to rise above our sample average.

B. Importance of the High Tech Sector

Our preferred measure of the relative importance of high-tech industries to metropolitan economies was developed by the Milken Institute, which has done extensive work on the impact of high-tech industries on urban development. The high-tech index used in our model is equal to the share of local product generated by the high-tech industry divided by the same national percentage. Thus, an index value greater than one indicates that the MSA's local share of high-tech output is above the national average. A value smaller than one reflects a local share of high-tech output below the national mean.

San Jose, Seattle, Washington D.C., Oakland, Orange County and Denver are among the top ten in both Internet connectivity and the high-tech concentration rankings. (See Appendix Table 3.3). Other metropolitan areas with above-average concentrations of high-tech industries, such as San Diego and Atlanta, also have access levels above the sample mean, but Dallas and Phoenix (the third and fifth most specialized high-tech urban centers, according to the Milken index) have significantly lower penetration rates than would be expected. On the other hand, all of the ten least connected cities have smaller than average contributions from their local high-tech sectors

We also explored measuring the high-tech sector by its inputs—which in the case of many firms is venture capital. Venture capital tends to emphasize existing differences in local high-tech industry concentration, since it drives the creation of high-technology enterprises and jobs.⁸⁰ However, one problem is that venture-capital-backed firms are geographically

San Jose, Seattle, Washington D.C., Oakland, Orange County and Denver are among the top ten in both Internet connectivity and the high-tech concentration rankings.

⁸⁰ Cortright and Mayer, *High Tech Specialization*, p. 6.

Of the ten MSAs with the highest penetration rates, seven had population growth above the sample mean.

concentrated. Companies in three CMSAs—the San Francisco Bay Area, Boston, and New York—received 8 percent of all venture capital investment in 1999.⁸¹ Because of this lack of dispersion, as well as the more direct relationship between a measure of high-tech sector *outputs* and Internet penetration, using a measure of venture capital in our model did not improve its explanatory power.

C. Population Growth Rates

Population growth rates from 1990 to 2000 were calculated by Applied Geographic Solutions and provided by the American Community Network (AGS/ACN). Only two of the ten most connected metros in our sample—Denver and Portland—were among the top ten cities ranked according to population growth. However, of the ten MSAs with the highest penetration rates, seven had population growth above the sample mean. On the other hand, only two of the ten least connected cities—San Antonio and Miami—experienced above average rates of population growth during the 1990s. (See Appendix Table 3.4).

D. Income

Our preferred measure of income is median household income. Data for this and other measures of income were developed by Applied Geographic Solutions and supplied by American Community Networks. Estimates of the percentages of households falling into specific income ranges are also available from this source. One of these, the proportion of households with annual incomes of \$75,000 or more, was tested in alternative specifications of the model.

The majority of the top ten areas in terms of Internet penetration also rank in the top ten with respect to median household income. (See Appendix

⁸¹ Matthew Zook, *Grounded Capital: The Geographic Nature of Venture Financing in the United States*, draft working paper, University of California, Berkeley, 2000, p. 19-23.

Table 3.5). San Jose, Washington D.C., San Francisco, Oakland, Orange County, and Bergen-Passaic are part of this group. Of the top ten wired metropolitan areas, only Denver and Portland-Vancouver are characterized by much higher penetration rates than their median household incomes would suggest. There are, however, several other urban areas in the sample of 44 that have above-average Internet penetration rates, but household incomes that fall below the mean—most notably, Houston, Norfolk, Salt Lake City and Columbus. Newark and Hartford are notable as MSAs with relatively high median incomes and below-average penetration rates.

The majority of the top ten areas in terms of Internet penetration also rank in the top ten with respect to median household income.

E. Age Profile of Residents

Our preferred summary measure of the age profile of residents, median age, was calculated from data on the distribution of age groups obtained from the American Community Network. An alternative measure, the proportion of adults who are 55 or older, is also available from these data. Both performed equally well in our statistical model.

None of the ten most connected cities rank in the top ten in terms of (lowest) median age of their residents. (See Appendix Table 3.6). Moreover, there are fairly significant differences in median age among the top ten MSAs in terms of Internet penetration. The populations of San Jose, Minneapolis, and Orange County fall below the sample mean of 33.8 years, but San Francisco and Bergen-Passaic both have an average age three years or more above the average for the 44 urban areas in our sample.

F. Racial Profile

We also obtained data on the racial composition of MSAs from AGS/ACN and included these variables in alternative specifications of the basic statistical model.

There is a great deal of variation in the racial profiles of the ten most-wired cities. In four cities—San

There is a great deal of variation in the racial profiles of the ten most-wired cities.

Jose, Washington DC, San Francisco and Oakland—less than two-thirds of the MSA population is white, while nine out of ten Minneapolis and Portland OR residents are white. The range of variation is even more pronounced for African Americans (who represent anywhere from three to 24 percent of the population), Hispanics (two to 32 percent) and Asian-Americans (three to 27 percent) in the ten most -connected MSAs. (See Appendix Table 3.7).

G. Gender Proportions

AGS/ACN data on the proportion of the population that is female show that gender proportions are nearly uniform across all 44 MSAs in the sample, with no city deviating from the overall balance (51.3 percent female) by as much as two percentage points. (See Appendix Table 3.7).

H. Occupational/Employment Variables

Data are also available from AGS/ACN on the proportions of U.S. adults employed in various occupational groups. While occupational groups are often categorized using a white-collar/blue-collar division, the proportions of adults employed in two specific occupational groups—executives and professionals—were of most interest for our purposes. (See Appendix Table 3.8).

Nine of the top ten cities (Bergen-Passaic is the lone exception) in terms of connectivity rank well above the national mean in the proportion of adults employed in executive and professional jobs. Washington, DC occupies the top spot by a large margin, with more than one out of five adults employed in these occupations. Relatively large proportions of adults in San Jose, Boston and San Francisco are also employed in these jobs.

By contrast, out of the ten least connected urban areas, only New York has a higher than average proportion of adults employed in executive and

professional jobs. New York has a substantial influx of commuters from other MSAs (including a significant number from Bergen-Passaic), and, thus, a higher contribution to its overall penetration rate from access at work.

V. A STATISTICAL MODEL OF INTERNET PENETRATION RATES

A. Use of Regression Modeling to Identify Determinants of Internet Access

Regression modeling is a technique that can be used to disentangle the effects of the factors that affect variations in Internet access rates across metropolitan areas. In addition to measuring the strength of the association between each independent variable and the dependent variable of interest (in this case, penetration rates), it provides a quantitative assessment of the impact on penetration rates of given changes in any variable of interest.

In this case, some of the variables thought to be determinants of Internet penetration rates are fairly closely correlated with each other as well as with the dependent variable. We therefore developed our basic statistical model of access rates using a technique that takes into account, and controls for, this multicollinearity. The stepwise regression approach takes into account these partial correlations and adds successive variables to the regression equation only if they significantly increase its explanatory power after taking into account the influence of the variables already included in the model. By this method, variables that do not independently influence the dependent variable of interest—in this case, Internet penetration rates—are excluded from the final statistical model.

B. Basic Model of Internet Access Rates

For this study we developed a statistical model that examines the relative strengths of the relationships between a large number of these factors and city Internet access rates. This basic model uses—in

Internet penetration is higher in those areas where the population is better educated, where the high-tech sector is more prominent, and where population has been growing more rapidly. These three variables alone explain 73 percent of the variation in access rates across cities.

Cities that have richer and younger populations are also likely to have higher penetration rates.

descending order of importance—measures of educational attainment (COLLEGE), local concentration of high-tech enterprises (HITECH), population growth (POPGR), household income (MEDHHINC), and median age (MEDAGE). Summary descriptions and statistics for these variables are shown in Table 4; the regression equation estimated as our basic model is presented in Table 5; and the quantitative impact of each of these factors on internet access rates in 2000 (PEN2000) is shown in Table 6.

Our statistical model confirms that Internet penetration is higher in those areas where the population is better educated, where the high-tech sector is more prominent, and where population has been growing more rapidly. These three variables alone explain 73 percent of the variation in access rates across cities.

Cities that have richer and younger populations are also likely to have higher penetration rates, although adding these to the model provides only modest increases in its explanatory power. Overall, we found that it was possible to account for nearly 80 percent of the variation in Internet penetration rates across our sample of metropolitan areas with these five variables.⁸²

- Educational attainment (COLLEGE), measured as the percent of the adult population with a Bachelor's Degree or higher. Internet penetration is positively correlated with the percent of the population

⁸² This study does not purport to show that these five variables "cause" Internet access. Rather, we expect that the relationship between our "independent" variables and the Internet penetration rate is two-way, as is the case with studies of telecommunications penetration levels. See Lars-Hendrik Röller and Leonard Waverman, "The Impact of Telecommunications Infrastructure on Economic Development," *The Implications of Knowledge-Based Growth for Micro-Economic Policies*, University of Calgary, 1996, pp. 365 - 366, on the external effects of telecommunications development.

that are college graduates. A five-percent increase in the proportion of adults over 25 years of age with a Bachelor's Degree or more is associated with an increase in Internet penetration rates of 2.8 percent. Educational attainment is statistically significant at the 99 percent level in all variations of the model. By itself, it has more explanatory power than any other single variable.

By itself, education has more explanatory power than any other single variable.

- The contribution of the high-tech sector to the local economy (HITECH), measured as the ratio of the share of output from high-tech industries in a given metropolitan area relative to that for the U.S. economy as a whole. Internet penetration is positively correlated with the importance of the high-tech sector. In our basic model, a doubling of the relative size of the high-tech sector in the local economy is associated with a change in the Internet penetration rate of 2.6 percent. The high-tech variable is statistically significant at the 95-percent level.
- Population growth from 1990 to 2000 (POPGR). Internet penetration is positively correlated with growth over the previous decade. A ten percent increase in the population growth rate is associated with an increase in Internet penetration rates of 1.9 percent. Population growth is significant at the 99-percent level.
- Median household income (MEDHHINC). Internet penetration is also positively correlated with income, even after controlling for differences in educational attainment. In our model, a \$10,000 increase in median household income is associated with a rise in the penetration rate of 1.8 percent. In our model, median household income is statistically significant at the 99-percent level.

- Median age (MEDAGE). Internet penetration is inversely related to the median age of the population in a metropolitan area.

A one-year *decrease* in the median age of the population is associated with a one-half percent increase in the Internet penetration rate. Median age is statistically significant at the 95-percent level.

TABLE 4
Basic Model Equation and Variable Definitions

$$\text{PEN2000} = 42.59^* + 0.56^*\text{COLLEGE} + 2.59^*\text{HITECH} + 0.19^*\text{POPGR} + 0.18^*\text{MEDHHINC} - 0.51^*\text{MEDAGE}$$

		Mean Value	Standard Deviation
PEN 2000	Percent of adults with Internet access at home or work (Jan. 2000)	56.7	6.6
C	Mathematical constant		
COLLEGE	Proportion of population 25 years of age or older with Bachelor's Degree or higher (March 1999).	30.0	5.9
HITECH	Value of high-tech output as share of total output in a metro area relative to the national average (1998)	1.09	0.61
POPGR	Population growth rate (1990–2000)	12.0	10.4
MEDHHINC	Median household income (2000, in current \$1,000s)	50.6	10.6
MEDAGE	Median age (2000)	33.8	2.3

TABLE 5
Statistical Results for Stepwise Regression Model

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
C	31.942 **	33.346 **	29.549 **	25.305 **	42.594 **
COLLEGE	0.820 **	0.596 **	0.685 **	0.565 **	0.559 **
HITECH	-	4.923 **	3.844 **	2.822 **	2.592 *
POPGR	-	-	0.191 **	0.232 **	0.190 **
MEDHHINC	-	-	-	0.167 *	0.184 **
MEDAGE	-	-	-	-	-0.508 *
Summary Statistics					
Adj. R-Squared	0.507	0.661	0.733	0.767	0.788
S.E. of Regression	4.741	3.932	3.489	3.260	3.111
F-Statistic	45.307	42.956	40.406	36.403	32.949

* Significant at the 95% level.

** Significant at the 99% level.

TABLE 6
Responsiveness of Internet Penetration Rates to Changes in Explanatory Factors

	Amount of Change in Explanatory Factor	Predicted Change in Penetration Rate
COLLEGE	5 percent	2.80
HITECH	100 percent	2.59
POPGR	10 percent	1.90
MEDHHINC	\$10,000	1.84
MEDAGE	5 years (decrease)	2.54
PENCHG	Average change in penetration rate from 1999	4.86

After the five characteristics in the basic model are taken into account, racial composition was not a significant determinant of Internet access rates.

C. Other Factors that did not Provide Additional Explanatory Power

By including more variables in the statistical model, we can determine if they provide additional explanatory power. Most critically, we examined the impact of adding variables to capture inter-city differences in racial composition. However, after the five characteristics in the basic model are taken into account, racial composition was not a significant determinant of Internet access rates at home or at work. We found a positive relationship between the proportion of the city population that is Asian American and Internet access rates and a negative relationship between access rates and the proportion of Hispanic Americans. However, neither of these relationships was significant at the statistician's usual 95-percent level of confidence. There was, moreover, not a statistically significant relationship between Internet access and the proportion of metropolitan area residents who identify themselves as African American, after controlling for the other five factors in the basic model.

VI. DISCUSSION OF RESULTS

A. Ordinal Rankings of City Internet Access Rates

Although most of the cities in our sample are large metropolitan areas (only a few have core cities with less than 100,000 inhabitants), the top metropolitan areas in terms of Internet penetration are a diverse bunch. At the top of our rankings, we find very large cities like New York, Los Angeles and Chicago; high-technology clusters such as the San Francisco Bay area and Seattle; government centers like Washington D.C.; and regional and national business hubs such as Dallas or Atlanta. The mean penetration rate for our sample of 44 cities is 56 percent, which is above the national average at the same point in time.

The variables that this study identifies as being closely correlated with Internet penetration can be used to explain the relative positions of areas with respect to Internet penetration. Appendix Table 3.9 shows that the ordinal ranking of MSAs according to the independent variables do a reasonably good job of “forecasting” the ordinal ranking of metros according to Internet penetration rates.

For instance, front-runner San Jose also tops the rankings in high-tech concentration, occupies the second slot in the household-income rankings and is seventh in educational attainment. Washington D.C., number two in the connectivity rankings, also has attained a top ten position in these three variables. Houston, twelfth in our Internet penetration rankings, does not crack the top 20 in the high-tech, income or education categories. However, Houston has a young and growing population. Both in median age and in population growth, Houston ranks among the top ten areas in our sample.

Front-runner San Jose also tops the rankings in high-tech concentration, occupies the second slot in the household-income rankings and is seventh in educational attainment.

Austin and Washington illustrate the importance of education and the high-tech sector to internet penetration.

B. Five-City Results

In a companion to this study, John Horrigan presents case studies for five very diverse metropolitan areas: Austin, Cleveland, Portland (Oregon), Nashville and Washington, DC. Table 7 shows that our model performs very well for the five cities highlighted in Horrigan's study, despite the fact that they have very different characteristics. All of the predicted Internet penetration rates are quite close to the actual rates.⁸³

TABLE 7
RESULTS FOR FIVE CITIES

	Austin	Cleveland	Portland	Nashville	Washington
INTERNET PENETRATION					
PREDICTED	68.5	49.6	57.4	55.7	67.4
ACTUAL	68.7	47.7	61.2	50.3	73.0
COLLEGE	41%	28%	30%	30%	41%
HITECH	1.5	0.5	1.3	0.6	1.5
POPGR	40.2%	0.07%	23.5%	20.6%	14.1%
MEDHHINC	\$37,949	\$43,280	\$42,721	\$42,961	\$66,465
MEDAGE	30.2	35.5	34.7	33.5	33.5

Austin and Washington illustrate the importance of education and the high-tech sector to Internet penetration. Both cities have a highly educated population and a high proportion of high-tech industry, and both have very high Internet penetration. Washington also has a very high median income. The fact that the model slightly under-predicts Washington's penetration may be due to city's population growth during the 1990s, which was about average. Population growth is an important variable in the model.

⁸³ The regression sample does not include observations for COLLEGE for Austin and Nashville, because the Current Population Survey estimates for these cities do not meet Census/Bureau of Labor Standards criteria for precision. We were, however, able to compute Austin and Nashville estimates in order to calculate predicted penetration rates.

Portland has above-average penetration, reflecting its above-average high-tech sector and population growth rate. The model slightly under-predicts Portland's penetration rate (by about four percentage points) possibly because Portland has only an average education level and a below-average income level.

Of all the five cities, Cleveland is lowest in education, high-tech, and the population growth, the three most important explanatory variables.

Nashville has below-average Internet penetration, despite the fact that its education level is essentially average. However, Nashville's high-tech sector and population growth rate are both substantially below average. The model slightly over-predicts Nashville's penetration rate (by about five percentage points), illustrating the importance of the education variable in the model.

Finally, Cleveland's low Internet penetration, which the model predicts accurately, reflects the fact that Cleveland is below average with respect to all the variables, except age, which is inversely related to penetration. Of all the five cities, Cleveland is lowest in education, high-tech, and population growth, the three most important explanatory variables.

C. The Role of Race as an Explanatory Factor

Once the influence of the five variables in the basic model is accounted for, Internet penetration is not closely correlated with a number of other variables, including those measuring differences in the racial composition of cities. The gaps that are associated with these demographic factors are due to their strong correlation with education and income, variables that are confirmed determinants of Internet access and use.

More importantly, racial (and age-related) differences are found to be disappearing with the continued dispersion of Internet access. According to the Stanford Institute for the Quantitative Study of Society, "once people have access to the Internet, there are more similarities than differences in terms of

Once the influence of the five variables is accounted for, Internet penetration is not closely correlated with the racial composition of cities.

how much they use it and the activities they use it for." The Institute's report also states that "once people have access, blacks look like whites, the college-educated look like the non-college educated, and age groups tend to be more homogenous than we might have thought, except for those above age 65."

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D. Home and Work-Specific Access Rates

Internet penetration rates can be further disaggregated into home and work access, although the distinction between these two environments has become less well-defined in recent years for an increasing proportion of the labor force. As Appendix Table 3.10 shows, there is a substantial degree of variation between lists of the top-ranked cities for home and work access.

However, the explanatory factors identified as potential determinants of Internet access do not turn out to be particularly specific to one location or the other. While the statistical model presented in this paper is based on overall penetration rates, separate models based specifically on home and work penetration rates yield results that are consistent with those of the basic model. Specifically, the coefficients in the home- and work-access versions of the model retain their signs and orders of magnitudes, although some of the relationships are statistically weaker in the home (median age) and work (high-tech sector, population growth, and median income) equations than in the basic model.

As noted above, we tested alternative measures of education, income and age. Additional estimates were also developed using some other variables of potential interest. The results of these regressions are presented in Appendix Two.

⁸⁴ Norman H. Nie and Lutz Erbring, *Internet and Society: A Preliminary Report*, Stanford Institute for the Quantitative Study of Society, February 17, 2000; p. 24.

VII. CONCLUSION

While the online rates for various demographic groups of individuals in the U.S. appear to be converging, there are still substantial disparities in Internet access rates among major metropolitan areas. This study focuses attention on the factors that might explain those differences and presents a model that indicates the relative importance that five of these factors play in determining Internet penetration rates at the metropolitan area level. These five factors—education, the high-tech sector, population growth, income and age-profile—were able to account for most of the variation in access rates, measured in early 2000. Further, once these five variables are taken into account, including other variables such as racial composition does not materially improve the ability of the model to explain these differences.

Moreover, most of the explanatory power of the basic model is provided by three variables: education, the high-tech sector, and population growth. In contrast to some other studies of differences in household access rates, income and age provide relatively modest contributions to the statistical explanation of inter-city variation in access levels.

The ability of these factors to explain differences in Internet penetration rates among metropolitan areas does not, however, translate into a recipe for effecting dramatic improvements in a particular city's standing. This study shows that fairly substantial changes in the educational attainment or income of city residents, for example, are associated with relatively modest increases in Internet penetration rates.

In contrast, there has been a quantitatively significant trend in access rates over time. From January 1999 to January 2000, access rates in our sample of 44 cities increased by an average of nearly five percent. This underscores the importance of revisiting this research to determine if the explanatory factors that were more useful in explaining differences

In contrast to some other studies of differences in household access rates, income and age provide relatively modest contributions to the statistical explanation of inter-city variation in access level.

in access rates last year remain those that are most relevant in the future.

Finally, our data cover a period of high consumer demand, high business investment and general economic prosperity. It is unclear how the relationships we have estimated are affected by a slowdown in economic growth. Some impact on Internet penetration rates should be expected, possibly due to changes in household incomes and a slowdown in the high-tech sector.

APPENDIX ONE

DATA AVAILABILITY AND USE

A. Metropolitan Areas: Defining the Units of Analysis

The basic unit of study is the Metropolitan Statistical Area (MSA), a concept coined by the OMB's predecessor, the Bureau of the Budget.⁸⁵ A MSA encompasses a recognized population nucleus, usually associated with a city of 50,000 inhabitants or more. The MSA comprises the central county (or counties) containing the core, plus adjacent outlying counties that have a high degree of economic and social integration with the central county indicated by the number of commuters. In 1990, the categories for metropolitan areas were expanded to include Consolidated Metropolitan Areas (CMSAs) and Primary Metropolitan Statistical Areas (PMSAs). CMSAs are MSAs with a population of at least one million, which meet certain statistical and other criteria. If recognized, component areas of the CMSA are called PMSAs, which also contain counties.⁸⁶

For the most part, this study utilizes the MSA and the PMSA as the basic units of measurement. However, in the case of four New England cities in the sample, the definition of the metropolitan area is not consistent across all variables. While most of the data on potential explanatory factors were estimated using the MSA/PMSA definitions, Scarborough Research reports New England penetration rates on a NECMA (New England Consolidated Metropolitan Area) basis. The

⁸⁵ New standards for defining statistical areas will be applied to the 2000 Census data. See "Standards for Defining Metropolitan and Micropolitan Statistical Areas," *Federal Register*, Vol. 65, No. 249, December 27, 2000. The previously applicable standards were used in this analysis.

⁸⁶U.S. Census Bureau, *About Metropolitan Areas*, <www.census.gov/population/estimates/aboutmetro.html> (04/09/2001). If no PMSAs can be recognized, the entire area is designated as a single MSA.

impact of this discrepancy is small, however, with the differences in population figures amounting to only a couple thousand area residents in each case.

B. Data on Internet Penetration Rates and Potential Explanatory Factors

Data on Internet penetration rates are available from several leading market research firms, including Scarborough Research and Nielsen//Net-Ratings. For this study we obtained data from Scarborough on home, work and combined Internet access levels for 89 major metropolitan areas, measured as the percent of MSA adults online in January 1999 and January 2000.

Data on potential explanatory factors were obtained from a variety of sources, including those detailed in the paper. A more comprehensive listing of the data utilized in development and testing of our model is provided in the table below.

For most variables, data are available for the entire sample of 89 cities. However, estimates of educational attainment are available for only 44 metro areas, because of sample size limitations in the Census' *Current Population Survey*. Because this variable provided the largest single contribution to explaining inter-city differences in penetration rates, development of the basic model and testing of alternative specifications was done using the 44-city limited sample. However, as we note in Appendix Two, the statistical results for specifications that do not include any measure of educational attainment are reasonably consistent for the 44- and 89-city data sets.

C. Data Used in Development of Statistical Model

Name	Description	Mean*	Standard
			Deviation*
AFRAM	African-Americans as percent of MSA population, 2000 (est.)	12.1%	8.0%
AGE17	Percent of MSA population under 17 years of age, 2000 (est.)	25.0%	2.5%
AGE1834	Percent of MSA population between 18 and 34 years of age, 2000 (est.)	23.0%	2.4%
AGE3554	Percent of MSA population between 35 and 54 years of age, 2000 (est.)	30.3%	1.8%
AGE5574	Percent of MSA population between 55 and 74 years of age, 2000 (est.)	15.5%	2.7%
AGE75	Percent of MSA population beyond 75 years of age, 2000 (est.)	6.2%	2.0%
AMERIN	Native Americans as percent of MSA population, 2000 (est.)	0.7%	1.2%
ASIPAC	Asians/Pacific Islanders as percent of MSA population, 2000 (est.)	4.2%	4.9%
CENTRAL#	MSAs in Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Ohio, Wisconsin		
COLLEGE	Percent of MSA adults over 25 with Bachelor's Degree or higher, March 1999	29.8%	6.0%
FEMPOP	Female percent of MSA population, 2000 (est.)	51.3%	0.8%
HITECH	Ratio of MSA high-tech output to MSA total output relative to national average, 1998	0.91	0.65
	A value greater than 1 indicates that the high-tech sector's share of total output is higher than the national average.		
HSCHOOL	Percent of MSA adults over 25 that are high school graduates, March 1999	85.5%	4.9%
LATAM	Hispanics as percent of MSA population, 2000 (est.)	11.3%	13.4%
MEDAGE	Median age by MSA, 2000 (est.)	34.36	2.79
MEDHHINC	Median household income, 2000 (est.), in \$1,000 dollars (current)	46.05	10.08
MHINC35	Percent of MSA population with less than \$35,000 in annual income, 1999 (est.)	39.0%	8.7%
MHINC75	Percent of MSA population with more than \$75,000 in annual income, 1999 (est.)	21.5%	8.7%
NEAST#	MSAs in Connecticut, Massachusetts, New York, New Jersey, Pennsylvania, Rhode Island		
OCCCL	Percent of MSA Population working as clerks, 2000 (est.)	9.2%	1.3%
OCCEX	Percent of MSA Population working as executives, 2000 (est.)	5.7%	1.2%
OCCLA	Percent of MSA Population working as laborers, 2000 (est.)	1.8%	0.3%
OCCMA	Percent of MSA Population working in transportation/materials moving occupations, 2000 (est.)	1.8%	0.3%
OCCOP	Percent of MSA Population working as machine operators, assemblers & inspectors, 2000 (est.)	2.6%	1.1%
OCCPD	Percent of MSA Population working in precision production, craft & repair occupations, 2000 (est.)	5.5%	0.7%
OCCPH	Percent of MSA Population working in private household occupations, 2000 (est.)	0.3%	0.1%
OCCPM	Percent of MSA Population working in primary occupations, 2000 (est.)	1.1%	0.8%
OCCPR	Percent of MSA Population working as professionals, 2000 (est.)	7.5%	1.4%
OCCPS	Percent of MSA Population working in protective services, 2000 (est.)	1.0%	0.2%
OCCSA	Percent of MSA Population working in sales, 2000 (est.)	5.9%	0.6%
OCCSE	Percent of MSA Population working in services, 2000 (est.)	6.6%	1.1%
OCCTE	Percent of MSA Population working as technicians, 2000 (est.)	1.9%	0.4%
PEN2000	MSA Internet penetration rates at home and at work, percent of total adults, Jan. 2000	54.0%	7.3%
PEN99	MSA Internet penetration rates at home and at work, percent of total adults, Jan. 1999	49.1%	7.4%
POPGR	Population growth rate by MSA, 1990 - 2000 (est.)	12.9%	11.3%
POPL	Population by MSA in 1,000s, 2000 (est.)	1,789	1,680
SOUTH#	MSAs in Alabama, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia		
VENCAP	Total amount of venture capital by MSA, as of Q1 2000, in \$million	79.15	222.71
WHITE	Caucasians as percent of MSA population, 2000 (est.)	79.6%	9.9%

*Means and standard deviations based on 89 observations where available.

D. Industries included in the "High Tech Sector"

The HITECH variable used in our model was provided by the Milken Institute, which utilizes the following definition to classify industries as "high tech":

Manufacturing

Drugs & Pharmaceuticals
Computer & Office Equipment
Communications Equipment
Electronic Components & Accessories
Aircraft & Parts
Guided Missiles, Space Vehicles & Parts
Search, Detection, Navigation, Guidance,
Aeronautical Nautical Systems, Instruments, &
Equipment
Laboratory Apparatus and Analytical,
Optical, Measuring, & Controlling Instruments
Surgical, Medical, & Dental Instruments &
Supplies

Services

Telephone Communications Services
Computer Programming, Data Processing, &
Other Computer Related Services
Motion Picture Production & Allied Services
Engineering, Architectural, & Surveying
Services
Research, Development, & Testing Services

Source: America's High Tech Economy,
Milken Institute, 1999, based on Data from
the BLS and the BEA.

E. Correlation Matrix for Penetration Rates and Selected Economic Variables

Multicollinearity is a potential problem in many types of statistical analyses. Moreover, in this study education, income, and the value of the high-tech sector are all known to have direct and feedback effects on each other. However, the matrix of correlation coefficients shows that the three variables are only somewhat related at the MSA level, and all three turned out to be significant in the basic statistical model.

	PEN2000	PEN99	COLLEGE#	HSCHOOL#	HITECH	VENCAP	MEDHHINC	POPL	POPGR	MEDAGE
PEN2000	1	0.94768**	0.42423**	0.33199**	0.62922**	0.34322**	0.62529**	0.20339	0.24844*	-0.28482**
PEN99	0.94768**	1	0.43059**	0.33245**	0.61920**	0.34564**	0.62411**	0.22960*	0.23484*	-0.36944**
COLLEGE#	0.42423**	0.43059**	1	0.97210**	0.28695**	0.36131**	0.48813**	0.53916**	-0.07599	-0.17864
HSCHOOL#	0.33199**	0.33245**	0.97210**	1	0.22342*	0.27484**	0.39630**	0.54486**	-0.06314	-0.18964
HITECH	0.62922**	0.61920**	0.28695**	0.22342*	1	0.28324**	0.48245**	0.20559	0.16009	-0.23035*
VENCAP	0.34322**	0.34564**	0.36131**	0.27484**	0.28324**	1	0.31352**	0.34210**	-0.00821	-0.01518
MEDHHINC	0.62529**	0.62411**	0.48813**	0.39630**	0.48245**	0.31352**	1	0.37752**	-0.10773	-0.05380
POPL	0.20339	0.22960*	0.53916**	0.54486**	0.20559	0.34210**	0.37752**	1	-0.02624	-0.20033
POPGR	0.24844*	0.23484*	-0.07599	-0.06314	0.16009	-0.00821	-0.10773	-0.02624	1	-0.23742*
MEDAGE	-0.28482**	-0.36944**	-0.17864	-0.18964	-0.23035*	-0.01518	-0.05380	-0.20033	-0.23742*	1

Legend: * Significant at the 5 percent level
 ** Significant at the 1 percent level
 # Variable has missing values

VARIABLE	PERIOD	DESCRIPTION
PEN2000	JAN. 2000	INTERNET PENETRATION RATES BY MSA, % OF TOTAL ADULTS
PEN99	JAN. 1999	INTERNET PENETRATION RATES BY MSA % OF TOTAL ADULTS
COLLEGE	MARCH 1999	% OF POP. 25 YEARS AND OVER WITH BACHELOR'S/HIGHER DEGREE
HIGHSCHOOL	MARCH 1999	% OF POP. 25 YEARS AND OVER THAT ARE HIGH SCHOOL GRADUATES
HITECH	1998	VALUE OF MSA HIGH-TECH OUTPUT AS A SHARE OF MSA TOTAL OUTPUT, RELATIVE TO THE NATIONAL AVERAGE
VENCAP	2000	TOTAL AMOUNT OF VENTURE CAPITAL BY MSA, AS OF Q1 2000
MEDHHINC	2000	MEDIAN HOME INCOME BY MSA, IN THOUSANDS OF DOLLARS
POPL	2000	POPULATION BY MSA
POPGR	1990-2000	POPULATION GROWTH RATE BY MSA
MEDAGE	2000	MEDIAN AGE IN EACH MSA

APPENDIX TWO

OTHER VARIABLES/MODELS EVALUATED

A. Alternative Specifications of the Model

In addition to estimating basic model, we explored the sensitivity of the results to alternative specifications of each of the five variables of interest. We also performed the stepwise regression procedure using other sets of variables, and found that two—occupational and gender proportions—served as useful summary predictors of Internet access. Once these two factors were included in the estimation process, only one of the five variables in the basic model (POPGR) provided any additional explanatory value.

While the statistical properties of this alternative model are essentially equivalent to those of the basic model presented in our paper, we do not believe this version illuminates the underlying determinants of differences in Internet access as well as our preferred specification. However, one advantage of the alternative equation is that the model can be extended to include another 45 metropolitan areas in the sample. This is because the educational attainment variable is replaced by a measurement of the extent to which the workforce is comprised of people in executive and professional jobs.⁸⁷

B. Other Variables Tested for Possible Contributions to the Model

In both the text of the paper and the previous section of this appendix, we discussed some of the variables that were included in alternative specifications of the basic model. We also tested a

⁸⁷ The educational attainment estimates available for these 45 cities do not meet Bureau of Census standards for statistical estimates (and thus are not published). These cities are generally smaller than those in our sample, and are thus not as well represented as larger cities in the Current Population Survey, the source of these estimates.

few additional variables that did not turn out to be significant in the stepwise regression estimation, although they were positively associated with MSA Internet penetration rates.

1. Venture Capital

Since venture capital can play an important role in forming high-tech clusters, it could have a similar impact on penetration rates as our HITECH variable. However, even though our measure of venture capital was significant in a univariate regression on the penetration rate, it was insignificant in conjunction with our basic model, even when the HITECH variable was excluded.⁸⁸

⁸⁸ Venture capital was specified as total amount of venture capital by MSA, as of Q1 2000, in \$millions.

TABLE A
Comparison of Basic Model and Alternative Specification

	Basic Model (44 cities)	Alternative (44 cities)	Alternative (89 cities)
C	42.594 **	234.533 **	121.327 **
COLLEGE	0.559 **		
HITECH	2.592 *		
POPGR	0.190 **		12.142 **
MEDHHINC	0.184 **		
MEDAGE	-0.508 *		
OCCEXP		191.128 **	226.205 **
FEMSPOP		-400.455 **	-192.477 **
Summary Statistics			
Adj. R-Squared	0.788	0.841	0.726
S.E. of Regression	3.111	2.692	3.838
F-Statistic	32.949	114.932	78.786

* Significant at the 5% level.
 ** Significant at the 1% level.

PEN 2000	Percent of adults with Internet access at home or work (Jan. 2000)
C	Mathematical constant
COLLEGE	Proportion of population 25 years of age or older with Bachelor's Degree or higher (March 1999).
HITECH	Value of high-tech output as share of total output in a metro area relative to the national average (1998)
POPGR	Population growth rate (1990–2000)
MEDHHINC	Median household income (2000, in current \$1,000s)
MEDAGE	Median age (2000)
OCCEXP	Percent of adults working as executives or professionals (2000)
FEMSPOP	Percent of population female (2000)

2. Labor Market Variables

A univariate regression also suggests that local Internet connectivity is associated with lower local unemployment rates. However, the unemployment rate however does not add any explanatory power to our basic model. After controlling for educational attainment and population growth, the unemployment rate becomes insignificant at the 95% level when regressed on the penetration rate.

3. Regional Differences

Finally, it is possible that there are persistent regional differences not captured by our basic model, due to demographic differences, variations in economic development and even differences in the way culture influences the spread of Internet access across metropolitan areas. In studies of other Internet activity-related variables, regional differences are evident. Moss, for instance, has found that the concentration of domain names is higher in coastal and western MSAs.⁸⁹ The same is true for the availability of bandwidth.⁹⁰

Dummy variables were used to test for possible regional differences not captured by our basic model. We controlled for the location of MSAs in one of the four main regions (Northeast, Central, West, South). None of the dummy variables used added to the explanatory power of our model. Even though the regions differ in their average penetration rates as measured by our sample, our basic model seems to explain these variations fairly well.

⁸⁹ Mitchell Moss, "Technology and Cities," *Cityscape*, Vol. 3, No. 3, 1998, p. 116.

⁹⁰ Mitchell Moss and Anthony Townsend, *Spatial Analysis of the Internet in U.S. Cities and States*, Technological Futures-Urban Futures Conference in Durham, England, April 1998, pp. 12-15.

**APPENDIX THREE:
DATA TABLES**

TABLE 3.1
Internet Penetration Rates for 44 Metropolitan Statistical Areas, 1999-2000

MSA	2000		1999		1999-2000	
	Penetration Rate	Rank	Penetration Rate	Rank	Percent Change	Rank
1 San Jose, CA	73.6%	1	65.9%	2	11.7%	14
2 Washington, DC	73.0%	2	71.4%	1	2.2%	44
3 Seattle-Bellevue-Everett, WA	68.1%	3	64.5%	3	5.6%	37
4 San Francisco, CA	65.0%	4	62.0%	4	4.8%	40
5 Oakland, CA	63.8%	5	61.2%	6	4.2%	42
6 Minneapolis-St. Paul, MN	63.7%	6	58.5%	7	8.9%	25
7 Orange County, CA	63.4%	7	61.9%	5	2.4%	43
8 Denver, CO	61.3%	8	57.2%	8	7.2%	31
9 Bergen-Passaic, NJ	61.2%	9	55.5%	11	10.3%	21
10 Portland-Vancouver, OR	61.2%	10	56.7%	10	7.9%	28
11 Atlanta, GA	60.7%	11	53.1%	16	14.3%	8
12 Houston, TX	60.5%	12	53.6%	14	12.9%	10
13 Norfolk-Virginia Beach-Newport News, VA	60.0%	13	57.0%	9	5.3%	38
14 Boston-Worcester-Lawrence, MA	59.9%	14	52.3%	20	14.5%	7
15 San Diego, CA	59.8%	15	52.6%	19	13.7%	9
16 Nassau-Suffolk, NY	59.6%	16	53.8%	13	10.8%	18
17 Salt Lake City-Ogden, UT	59.3%	17	55.1%	12	7.6%	29
18 Fort Worth-Arlington, TX	58.1%	18	52.0%	22	11.7%	13
19 Columbus, OH	57.9%	19	52.6%	17	10.1%	22
20 Dallas, TX	57.4%	20	52.6%	18	9.1%	24
21 Indianapolis, IN	56.6%	21	51.3%	24	10.3%	20
22 Kansas City, MO	56.4%	22	53.4%	15	5.6%	36
23 Baltimore, MD	55.3%	23	49.3%	29	12.2%	11
24 Phoenix-Mesa, AZ	55.3%	24	49.4%	28	11.9%	12
25 Hartford, CT	55.2%	25	50.3%	26	9.7%	23
26 Newark, NJ	55.1%	26	52.1%	21	5.8%	33
27 Los Angeles-Long Beach, CA	54.0%	27	51.5%	23	4.9%	39
28 Chicago, IL	53.5%	28	50.6%	25	5.7%	34
29 Philadelphia, PA	53.2%	29	48.2%	31	10.4%	19
30 Charlotte-Gastonia-Rock Hill, NC	53.1%	30	47.9%	32	10.9%	16
31 Riverside-San Bernardino, CA	52.6%	31	49.3%	30	6.7%	32
32 Fort Lauderdale, FL	52.1%	32	49.9%	27	4.4%	41
33 Cincinnati, OH	51.0%	33	42.9%	37	18.9%	2
34 Milwaukee-Waukesha, WI	49.9%	34	47.2%	33	5.7%	35
35 New Orleans, LA	49.9%	35	46.1%	34	8.2%	27
36 San Antonio, TX	49.5%	36	42.0%	40	17.9%	3
37 New York, NY	49.0%	37	44.2%	36	10.9%	15
38 Buffalo-Niagara Falls, NY	48.6%	38	41.3%	43	17.7%	4
39 St. Louis, MO	48.5%	39	44.6%	35	8.7%	26
40 Tampa-St. Petersburg-Clearwater, FL	48.3%	40	41.7%	41	15.8%	5
41 Cleveland-Lorain-Elyria, OH	47.7%	41	41.5%	42	14.9%	6
42 Detroit, MI	47.2%	42	42.6%	38	10.8%	17
43 Pittsburgh, PA	46.6%	43	38.5%	44	21.0%	1
44 Miami, FL	45.4%	44	42.2%	39	7.6%	30
Average for 44 MSAs	56.4%		51.5%		9.8%	
Standard Deviation	6.8%		7.3%		4.4%	

Source: Scarborough Reserch

TABLE 3.2
Internet Penetration Rates and Educational Attainment

MSA	2000		Graduate (1999)		Graduate (1999)	
	Penetration Rate	Rank	Percent College	Rank	Percent High School	Rank
1 San Jose, CA	73.6%	1	36.7%	7	85.1%	25
2 Washington, DC	73.0%	2	41.4%	2	89.2%	12
3 Seattle-Bellevue-Everett, WA	68.1%	3	38.9%	4	92.4%	2
4 San Francisco, CA	65.0%	4	41.4%	1	87.6%	17
5 Oakland, CA	63.8%	5	39.6%	3	91.7%	4
6 Minneapolis-St. Paul, MN	63.7%	6	36.6%	8	94.0%	1
7 Orange County, CA	63.4%	7	29.6%	20	84.1%	30
8 Denver, CO	61.3%	8	38.7%	5	90.4%	6
9 Bergen-Passaic, NJ	61.2%	9	31.9%	14	87.8%	16
10 Portland-Vancouver, OR	61.2%	10	29.9%	19	88.5%	15
11 Atlanta, GA	60.7%	11	30.9%	16	89.9%	7
12 Houston, TX	60.5%	12	26.1%	34	76.8%	40
13 Norfolk-Virginia Beach-Newport News, VA	60.0%	13	32.8%	13	89.7%	9
14 Boston-Worcester-Lawrence, MA	59.9%	14	33.0%	12		
15 San Diego, CA	59.8%	15	28.9%	24	82.0%	35
16 Nassau-Suffolk, NY	59.6%	16	31.0%	15	86.9%	20
17 Salt Lake City-Ogden, UT	59.3%	17	29.1%	22	92.1%	3
18 Fort Worth-Arlington, TX	58.1%	18	26.6%	31	89.9%	8
19 Columbus, OH	57.9%	19	29.3%	21	85.4%	22
20 Dallas, TX	57.4%	20	34.3%	11	84.3%	29
21 Indianapolis, IN	56.6%	21	28.6%	26	82.3%	34
22 Kansas City, MO	56.4%	22	27.6%	28	89.3%	11
23 Baltimore, MD	55.3%	23	36.2%	9	83.9%	31
24 Phoenix-Mesa, AZ	55.3%	24	25.3%	36	85.1%	24
25 Hartford, CT	55.2%	25	38.5%	6	87.4%	18
26 Newark, NJ	55.1%	26	35.4%	10	87.1%	19
27 Los Angeles-Long Beach, CA	54.0%	27	26.3%	33	73.9%	43
28 Chicago, IL	53.5%	28	30.2%	18	85.2%	23
29 Philadelphia, PA	53.2%	29	28.8%	25	86.4%	21
30 Charlotte-Gastonia-Rock Hill, NC	53.1%	30	27.3%	30	81.0%	37
31 Riverside-San Bernardino, CA	52.6%	31	15.5%	44	78.4%	39
32 Fort Lauderdale, FL	52.1%	32	25.2%	37	83.8%	32
33 Cincinnati, OH	51.0%	33	30.7%	17	84.7%	27
34 Milwaukee-Waukesha, WI	49.9%	34	25.7%	35	88.9%	13
35 New Orleans, LA	49.9%	35	24.1%	38	84.8%	26
36 San Antonio, TX	49.5%	36	20.7%	42	79.1%	38
37 New York, NY	49.0%	37	29.0%	23	76.4%	41
38 Buffalo-Niagara Falls, NY	48.6%	38	27.3%	29	90.6%	5
39 St. Louis, MO	48.5%	39	22.3%	41	83.3%	33
40 Tampa-St. Petersburg-Clearwater, FL	48.3%	40	19.5%	43	81.5%	36
41 Cleveland-Lorain-Elyria, OH	47.7%	41	28.1%	27	88.5%	14
42 Detroit, MI	47.2%	42	23.1%	40	84.6%	28
43 Pittsburgh, PA	46.6%	43	26.6%	32	89.7%	10
44 Miami, FL	45.4%	44	23.4%	39	74.0%	42
Average for 44 MSAs	56.4%		29.8%		85.5%	
Standard Deviation	6.8%		5.9%		4.9%	

Sources: Scarborough Research, Bureau of the Census

TABLE 3.3
Internet Penetration Rates and Importance of High Tech Industries

MSA	2000		(Milken Index)		\$1,000s (1999)	
	Penetration Rate	Rank	High Tech Ratio	Rank	Venture Capital	Rank
1 San Jose, CA	73.6%	1	4.09	1	523.0	3
2 Washington, DC	73.0%	2	1.45	6	186.4	10
3 Seattle-Bellevue-Everett, WA	68.1%	3	2.06	2	435.2	5
4 San Francisco, CA	65.0%	4	1.12	17	1755.1	1
5 Oakland, CA	63.8%	5	1.43	7	0.6	35
6 Minneapolis-St. Paul, MN	63.7%	6	0.86	28	94.4	16
7 Orange County, CA	63.4%	7	1.40	8	0.0	43
8 Denver, CO	61.3%	8	1.39	9	58.5	19
9 Bergen-Passaic, NJ	61.2%	9	0.90	24	0.0	36
10 Portland-Vancouver, OR	61.2%	10	1.30	14	223.1	9
11 Atlanta, GA	60.7%	11	1.37	11	443.0	4
12 Houston, TX	60.5%	12	0.88	26	154.4	12
13 Norfolk-Virginia Beach-Newport News, VA	60.0%	13	0.47	40	0.0	42
14 Boston-Worcester-Lawrence, MA	59.9%	14	1.51	4	275.9	8
15 San Diego, CA	59.8%	15	1.37	10	359.4	6
16 Nassau-Suffolk, NY	59.6%	16	1.03	19	0.0	40
17 Salt Lake City-Ogden, UT	59.3%	17	0.90	25	6.1	31
18 Fort Worth-Arlington, TX	58.1%	18	1.03	20	2.6	33
19 Columbus, OH	57.9%	19	0.80	30	10.5	27
20 Dallas, TX	57.4%	20	1.92	3	126.5	13
21 Indianapolis, IN	56.6%	21	1.28	15	20.2	22
22 Kansas City, MO	56.4%	22	1.18	16	61.8	17
23 Baltimore, MD	55.3%	23	0.63	38	10.3	28
24 Phoenix-Mesa, AZ	55.3%	24	1.46	5	9.2	30
25 Hartford, CT	55.2%	25	0.76	31	0.0	37
26 Newark, NJ	55.1%	26	1.33	13	0.0	41
27 Los Angeles-Long Beach, CA	54.0%	27	1.35	12	167.8	11
28 Chicago, IL	53.5%	28	1.00	21	305.6	7
29 Philadelphia, PA	53.2%	29	1.05	18	48.7	20
30 Charlotte-Gastonia-Rock Hill, NC	53.1%	30	0.70	34	99.5	15
31 Riverside-San Bernardino, CA	52.6%	31	0.43	43	0.0	44
32 Fort Lauderdale, FL	52.1%	32	0.84	29	17.5	23
33 Cincinnati, OH	51.0%	33	0.67	35	3.1	32
34 Milwaukee-Waukesha, WI	49.9%	34	0.63	37	0.0	39
35 New Orleans, LA	49.9%	35	0.38	44	1.9	34
36 San Antonio, TX	49.5%	36	0.97	22	10.0	29
37 New York, NY	49.0%	37	0.87	27	744.7	2
38 Buffalo-Niagara Falls, NY	48.6%	38	0.47	41	10.6	26
39 St. Louis, MO	48.5%	39	0.95	23	60.8	18
40 Tampa-St. Petersburg-Clearwater, FL	48.3%	40	0.73	33	30.3	21
41 Cleveland-Lorain-Elyria, OH	47.7%	41	0.50	39	11.3	25
42 Detroit, MI	47.2%	42	0.66	36	17.3	24
43 Pittsburgh, PA	46.6%	43	0.75	32	119.0	14
44 Miami, FL	45.4%	44	0.44	42	0.0	38
Average for 44 MSAs	56.4%		1.07		145.5	
Standard Deviation	6.8%		0.61		299.7	

Sources: Scarborough Research, Milken Institute, PricewaterhouseCoopers

TABLE 3.4
Internet Penetration Rates and Population Growth

MSA	2000		1990-2000		2000	
	Penetration Rate	Rank	Pop. Growth	Rank	Population	Rank
1 San Jose, CA	73.6%	1	10.4%	24	1,650,069	31
2 Washington, DC	73.0%	2	14.1%	18	4,815,581	5
3 Seattle-Bellevue-Everett, WA	68.1%	3	15.9%	14	2,353,426	20
4 San Francisco, CA	65.0%	4	5.2%	30	1,684,974	29
5 Oakland, CA	63.8%	5	14.3%	17	2,365,113	19
6 Minneapolis-St. Paul, MN	63.7%	6	14.7%	16	2,908,208	13
7 Orange County, CA	63.4%	7	16.0%	13	2,794,723	15
8 Denver, CO	61.3%	8	24.4%	6	2,018,284	25
9 Bergen-Passaic, NJ	61.2%	9	5.3%	29	1,344,963	40
10 Portland-Vancouver, OR	61.2%	10	23.5%	8	1,870,730	27
11 Atlanta, GA	60.7%	11	34.0%	2	3,964,384	8
12 Houston, TX	60.5%	12	23.1%	9	4,090,883	7
13 Norfolk-Virginia Beach-Newport News, VA	60.0%	13	9.3%	25	1,549,693	36
14 Boston-Worcester-Lawrence, MA	59.9%	14	1.2%	39	3,296,772	10
15 San Diego, CA	59.8%	15	15.2%	15	2,852,166	14
16 Nassau-Suffolk, NY	59.6%	16	3.8%	33	2,704,436	16
17 Salt Lake City-Ogden, UT	59.3%	17	19.9%	11	1,285,877	42
18 Fort Worth-Arlington, TX	58.1%	18	22.3%	10	1,664,837	30
19 Columbus, OH	57.9%	19	12.0%	22	1,506,445	37
20 Dallas, TX	57.4%	20	25.4%	4	3,353,053	9
21 Indianapolis, IN	56.6%	21	12.6%	20	1,554,552	35
22 Kansas City, MO	56.4%	22	12.1%	21	1,774,448	28
23 Baltimore, MD	55.3%	23	5.0%	31	2,490,918	18
24 Phoenix-Mesa, AZ	55.3%	24	38.1%	1	3,087,296	12
25 Hartford, CT	55.2%	25	-4.0%	43	1,151,595	43
26 Newark, NJ	55.1%	26	2.4%	36	1,960,974	26
27 Los Angeles-Long Beach, CA	54.0%	27	6.4%	28	9,420,290	1
28 Chicago, IL	53.5%	28	8.9%	26	8,065,265	3
29 Philadelphia, PA	53.2%	29	0.7%	41	4,947,001	4
30 Charlotte-Gastonia-Rock Hill, NC	53.1%	30	24.8%	5	1,450,834	39
31 Riverside-San Bernardino, CA	52.6%	31	26.8%	3	3,281,960	11
32 Fort Lauderdale, FL	52.1%	32	24.4%	7	1,561,250	34
33 Cincinnati, OH	51.0%	33	7.3%	27	1,636,629	32
34 Milwaukee-Waukesha, WI	49.9%	34	2.3%	37	1,465,285	38
35 New Orleans, LA	49.9%	35	1.5%	38	1,304,679	41
36 San Antonio, TX	49.5%	36	19.9%	12	1,588,148	33
37 New York, NY	49.0%	37	2.4%	35	8,736,491	2
38 Buffalo-Niagara Falls, NY	48.6%	38	-4.7%	44	1,131,174	44
39 St. Louis, MO	48.5%	39	3.4%	34	2,581,741	17
40 Tampa-St. Petersburg-Clearwater, FL	48.3%	40	11.2%	23	2,299,811	22
41 Cleveland-Lorain-Elyria, OH	47.7%	41	0.7%	40	2,217,174	23
42 Detroit, MI	47.2%	42	5.0%	32	4,476,014	6
43 Pittsburgh, PA	46.6%	43	-3.2%	42	2,314,244	21
44 Miami, FL	45.4%	44	13.5%	19	2,197,427	24
Average for 44 MSAs	56.4%		12.0%		2,790,223	
Standard Deviation	6.8%		10.2%		1,903,989	

Sources: AGS/CAN, Scarborough Research

TABLE 3.5
Internet Penetration Rates and Household Income

MSA	2000		Income (2000)		Percent HH w/ Income > \$75k	
	Penetration Rate	Rank	Median Household	Rank	Income > \$75k	Rank
1 San Jose, CA	73.6%	1	72.2	2	45.2%	2
2 Washington, DC	73.0%	2	66.5	6	39.5%	6
3 Seattle-Bellevue-Everett, WA	68.1%	3	52.4	16	25.1%	16
4 San Francisco, CA	65.0%	4	63.8	7	39.1%	7
5 Oakland, CA	63.8%	5	60.0	10	34.9%	8
6 Minneapolis-St. Paul, MN	63.7%	6	52.4	15	24.5%	18
7 Orange County, CA	63.4%	7	69.4	4	42.7%	4
8 Denver, CO	61.3%	8	47.3	22	22.1%	21
9 Bergen-Passaic, NJ	61.2%	9	70.6	3	43.7%	3
10 Portland-Vancouver, OR	61.2%	10	42.7	34	17.7%	36
11 Atlanta, GA	60.7%	11	51.5	17	25.2%	15
12 Houston, TX	60.5%	12	44.1	30	21.2%	22
13 Norfolk-Virginia Beach-Newport News, VA	60.0%	13	42.1	37	17.9%	35
14 Boston-Worcester-Lawrence, MA	59.9%	14	62.3	8		
15 San Diego, CA	59.8%	15	50.8	20	27.7%	13
16 Nassau-Suffolk, NY	59.6%	16	75.1	1	47.8%	1
17 Salt Lake City-Ogden, UT	59.3%	17	42.3	36	16.3%	37
18 Fort Worth-Arlington, TX	58.1%	18	42.4	35	18.0%	34
19 Columbus, OH	57.9%	19	42.9	33	18.4%	33
20 Dallas, TX	57.4%	20	46.1	25	22.3%	20
21 Indianapolis, IN	56.6%	21	46.0	26	20.3%	25
22 Kansas City, MO	56.4%	22	44.9	29	19.2%	30
23 Baltimore, MD	55.3%	23	54.4	12	29.2%	11
24 Phoenix-Mesa, AZ	55.3%	24	41.8	38	19.4%	29
25 Hartford, CT	55.2%	25	60.2	9		
26 Newark, NJ	55.1%	26	67.1	5	41.0%	5
27 Los Angeles-Long Beach, CA	54.0%	27	54.5	11	32.1%	9
28 Chicago, IL	53.5%	28	53.1	14	27.5%	14
29 Philadelphia, PA	53.2%	29	54.0	13	27.8%	12
30 Charlotte-Gastonia-Rock Hill, NC	53.1%	30	46.2	24	19.9%	26
31 Riverside-San Bernardino, CA	52.6%	31	47.2	23	23.7%	19
32 Fort Lauderdale, FL	52.1%	32	45.4	28	20.5%	23
33 Cincinnati, OH	51.0%	33	43.3	31	18.9%	31
34 Milwaukee-Waukesha, WI	49.9%	34	48.1	21	19.8%	27
35 New Orleans, LA	49.9%	35	33.3	44	13.1%	42
36 San Antonio, TX	49.5%	36	35.3	43	13.5%	41
37 New York, NY	49.0%	37	51.1	18	29.4%	10
38 Buffalo-Niagara Falls, NY	48.6%	38	37.8	40	15.9%	38
39 St. Louis, MO	48.5%	39	45.9	27	19.6%	28
40 Tampa-St. Petersburg-Clearwater, FL	48.3%	40	36.5	42	14.6%	40
41 Cleveland-Lorain-Elyria, OH	47.7%	41	43.3	32	18.9%	32
42 Detroit, MI	47.2%	42	51.0	19	25.0%	17
43 Pittsburgh, PA	46.6%	43	37.4	41	15.9%	39
44 Miami, FL	45.4%	44	41.5	39	20.4%	24
Average for 44 MSAs	56.4%		\$50.4		25.1%	
Standard Deviation	6.8%		\$10.5		9.4%	

Sources: AGS/ACN, Scarborough Research

TABLE 3.6
Internet Penetration Rates and Age-Profile of Residents

MSA	2000		Median Age	Rank	Percent Age	
	Penetration Rate	Rank			55+ (2000)	Rank
1 San Jose, CA	73.6%	1	32.7	15	17.9%	11
2 Washington, DC	73.0%	2	33.5	20	17.4%	6
3 Seattle-Bellevue-Everett, WA	68.1%	3	34.3	28	18.8%	15
4 San Francisco, CA	65.0%	4	36.8	40	23.3%	36
5 Oakland, CA	63.8%	5	34.3	27	19.0%	16
6 Minneapolis-St. Paul, MN	63.7%	6	32.4	12	17.7%	10
7 Orange County, CA	63.4%	7	32.3	11	17.6%	8
8 Denver, CO	61.3%	8	33.6	21	18.5%	14
9 Bergen-Passaic, NJ	61.2%	9	37.2	41	24.3%	40
10 Portland-Vancouver, OR	61.2%	10	34.7	30	19.2%	17
11 Atlanta, GA	60.7%	11	32.3	10	15.4%	2
12 Houston, TX	60.5%	12	31.0	4	15.3%	1
13 Norfolk-Virginia Beach-Newport News, VA	60.0%	13	30.9	3	18.4%	13
14 Boston-Worcester-Lawrence, MA	59.9%	14	34.8	31	22.2%	33
15 San Diego, CA	59.8%	15	31.7	9	19.3%	18
16 Nassau-Suffolk, NY	59.6%	16	36.1	39	23.4%	37
17 Salt Lake City-Ogden, UT	59.3%	17	27.6	1	15.4%	3
18 Fort Worth-Arlington, TX	58.1%	18	31.6	8	17.3%	5
19 Columbus, OH	57.9%	19	32.5	13	18.3%	12
20 Dallas, TX	57.4%	20	31.3	5	15.6%	4
21 Indianapolis, IN	56.6%	21	33.5	19	19.9%	22
22 Kansas City, MO	56.4%	22	33.9	24	20.1%	23
23 Baltimore, MD	55.3%	23	34.5	29	21.0%	27
24 Phoenix-Mesa, AZ	55.3%	24	32.9	16	20.6%	25
25 Hartford, CT	55.2%	25	35.2	33	22.9%	35
26 Newark, NJ	55.1%	26	35.6	37	21.6%	29
27 Los Angeles-Long Beach, CA	54.0%	27	31.4	7	17.7%	9
28 Chicago, IL	53.5%	28	33.2	17	19.6%	21
29 Philadelphia, PA	53.2%	29	34.9	32	22.9%	34
30 Charlotte-Gastonia-Rock Hill, NC	53.1%	30	33.7	22	19.6%	20
31 Riverside-San Bernardino, CA	52.6%	31	30.8	2	17.6%	7
32 Fort Lauderdale, FL	52.1%	32	38.8	43	25.6%	41
33 Cincinnati, OH	51.0%	33	33.3	18	20.9%	26
34 Milwaukee-Waukesha, WI	49.9%	34	33.8	23	21.6%	30
35 New Orleans, LA	49.9%	35	32.6	14	20.4%	24
36 San Antonio, TX	49.5%	36	31.3	6	19.4%	19
37 New York, NY	49.0%	37	35.2	34	22.0%	32
38 Buffalo-Niagara Falls, NY	48.6%	38	35.9	38	25.8%	42
39 St. Louis, MO	48.5%	39	34.1	26	21.9%	31
40 Tampa-St. Petersburg-Clearwater, FL	48.3%	40	39.6	44	29.8%	44
41 Cleveland-Lorain-Elyria, OH	47.7%	41	35.5	35	24.0%	39
42 Detroit, MI	47.2%	42	34.1	25	21.4%	28
43 Pittsburgh, PA	46.6%	43	37.7	42	27.9%	43
44 Miami, FL	45.4%	44	35.5	36	23.9%	38
Average for 44 MSAs	56.4%		33.8		20.5%	
Standard Deviation	6.8%		2.3		3.3%	

Sources: AGS/ACN, Scarborough Research

TABLE 3.7
Internet Penetration Rates and Demographic Characteristics

MSA	2000 Penetration Rate	Rank	Percentage White (2000)	Percent African- American (2000)	Percent Hispanic- American (2000)	Percent Asian- American (2000)	Percent Female (2000)
1 San Jose, CA	73.6%	1	63.4%	3.8%	27.5%	23.5%	49.7%
2 Washington, DC	73.0%	2	65.9%	24.7%	7.3%	6.8%	51.2%
3 Seattle-Bellevue-Everett, WA	68.1%	3	84.3%	4.5%	4.5%	9.1%	50.4%
4 San Francisco, CA	65.0%	4	59.5%	7.7%	19.9%	27.6%	50.7%
5 Oakland, CA	63.8%	5	60.8%	14.8%	18.9%	17.9%	51.0%
6 Minneapolis-St. Paul, MN	63.7%	6	90.1%	4.4%	2.1%	4.0%	50.9%
7 Orange County, CA	63.4%	7	74.9%	2.0%	32.0%	14.0%	49.7%
8 Denver, CO	61.3%	8	85.9%	6.1%	15.6%	3.2%	50.9%
9 Bergen-Passaic, NJ	61.2%	9	76.8%	9.8%	16.3%	8.3%	51.9%
10 Portland-Vancouver, OR	61.2%	10	89.9%	2.9%	5.5%	4.9%	50.7%
11 Atlanta, GA	60.7%	11	71.0%	25.4%	3.3%	2.6%	51.1%
12 Houston, TX	60.5%	12	66.2%	17.7%	27.0%	5.1%	50.3%
13 Norfolk-Virginia Beach-Newport News, VA	60.0%	13	66.8%	28.6%	3.4%	3.5%	51.6%
14 Boston-Worcester-Lawrence, MA	59.9%	14	84.7%	7.8%	5.9%	5.0%	52.0%
15 San Diego, CA	59.8%	15	71.0%	6.9%	28.3%	11.3%	50.3%
16 Nassau-Suffolk, NY	59.6%	16	85.2%	8.9%	8.4%	4.0%	51.3%
17 Salt Lake City-Ogden, UT	59.3%	17	92.5%	1.0%	8.6%	3.5%	50.3%
18 Fort Worth-Arlington, TX	58.1%	18	76.8%	12.0%	18.8%	3.4%	50.5%
19 Columbus, OH	57.9%	19	84.0%	13.1%	1.1%	2.5%	51.1%
20 Dallas, TX	57.4%	20	72.2%	15.2%	20.5%	3.7%	50.7%
21 Indianapolis, IN	56.6%	21	85.5%	12.8%	1.3%	1.2%	51.7%
22 Kansas City, MO	56.4%	22	83.5%	13.0%	3.8%	1.7%	51.6%
23 Baltimore, MD	55.3%	23	70.0%	26.8%	1.9%	2.6%	51.6%
24 Phoenix-Mesa, AZ	55.3%	24	83.5%	3.9%	22.3%	2.4%	50.5%
25 Hartford, CT	55.2%	25	83.9%	9.7%	9.1%	2.5%	51.5%
26 Newark, NJ	55.1%	26	69.0%	22.9%	13.9%	4.5%	51.8%
27 Los Angeles-Long Beach, CA	54.0%	27	54.5%	11.4%	46.9%	14.0%	50.5%
28 Chicago, IL	53.5%	28	69.3%	19.2%	15.0%	5.0%	51.3%
29 Philadelphia, PA	53.2%	29	75.1%	19.2%	4.8%	3.5%	52.2%
30 Charlotte-Gastonia-Rock Hill, NC	53.1%	30	77.1%	20.6%	1.7%	1.5%	51.6%
31 Riverside-San Bernardino, CA	52.6%	31	72.2%	7.4%	35.5%	5.8%	49.7%
32 Fort Lauderdale, FL	52.1%	32	80.3%	16.2%	12.2%	2.0%	51.6%
33 Cincinnati, OH	51.0%	33	86.0%	12.6%	0.7%	1.2%	51.8%
34 Milwaukee-Waukesha, WI	49.9%	34	80.5%	15.1%	4.6%	2.1%	51.7%
35 New Orleans, LA	49.9%	35	60.4%	35.6%	5.0%	2.5%	52.4%
36 San Antonio, TX	49.5%	36	76.1%	7.5%	52.2%	1.9%	51.8%
37 New York, NY	49.0%	37	51.0%	29.4%	27.1%	9.7%	52.9%
38 Buffalo-Niagara Falls, NY	48.6%	38	84.5%	11.8%	3.2%	1.8%	52.0%
39 St. Louis, MO	48.5%	39	81.1%	16.9%	1.5%	1.5%	51.9%
40 Tampa-St. Petersburg-Clearwater, FL	48.3%	40	87.0%	9.8%	10.0%	1.6%	52.0%
41 Cleveland-Lorain-Elyria, OH	47.7%	41	78.9%	18.3%	2.7%	1.6%	52.3%
42 Detroit, MI	47.2%	42	73.4%	23.5%	2.5%	2.1%	51.9%
43 Pittsburgh, PA	46.6%	43	90.3%	8.3%	0.9%	1.2%	52.6%
44 Miami, FL	45.4%	44	76.2%	17.5%	63.1%	1.6%	52.4%
Average for 44 MSAs	56.4%		76.2%	13.8%	14.0%	5.4%	51.3%
Standard Deviation	6.8%		10.1%	8.2%	14.7%	5.9%	0.8%

Sources: AGS/CAN, Scarborough Research

TABLE 3.8
Internet Penetration Rates and Occupational Mix

MSA	Penetration Rate		Percent Workforce		Percent Executive/ Professional	
	2000	Rank	White Collar	Rank	Professional	Rank
1 San Jose, CA	73.6%	1	50.6%	6	18.9%	2
2 Washington, DC	73.0%	2	55.3%	1	21.1%	1
3 Seattle-Bellevue-Everett, WA	68.1%	3	47.6%	15	16.7%	7
4 San Francisco, CA	65.0%	4	51.7%	3	18.6%	4
5 Oakland, CA	63.8%	5	50.4%	7	16.8%	5
6 Minneapolis-St. Paul, MN	63.7%	6	46.6%	18	15.7%	13
7 Orange County, CA	63.4%	7	47.6%	14	16.7%	8
8 Denver, CO	61.3%	8	49.1%	11	16.8%	6
9 Bergen-Passaic, NJ	61.2%	9	51.0%	5	16.3%	9
10 Portland-Vancouver, OR	61.2%	10	43.3%	36	13.9%	22
11 Atlanta, GA	60.7%	11	46.1%	20	14.9%	16
12 Houston, TX	60.5%	12	44.2%	27	13.9%	23
13 Norfolk-Virginia Beach-Newport News, VA	60.0%	13	41.9%	41	12.1%	38
14 Boston-Worcester-Lawrence, MA	59.9%	14	52.8%	2	18.8%	3
15 San Diego, CA	59.8%	15	45.5%	23	13.9%	21
16 Nassau-Suffolk, NY	59.6%	16	50.0%	8	16.1%	11
17 Salt Lake City-Ogden, UT	59.3%	17	45.6%	22	13.1%	30
18 Fort Worth-Arlington, TX	58.1%	18	43.9%	30	13.5%	26
19 Columbus, OH	57.9%	19	47.6%	16	14.5%	17
20 Dallas, TX	57.4%	20	46.3%	19	15.0%	15
21 Indianapolis, IN	56.6%	21	43.5%	34	13.4%	27
22 Kansas City, MO	56.4%	22	45.8%	21	13.8%	24
23 Baltimore, MD	55.3%	23	48.4%	12	15.7%	12
24 Phoenix-Mesa, AZ	55.3%	24	44.2%	29	13.0%	31
25 Hartford, CT	55.2%	25	49.1%	10	16.3%	10
26 Newark, NJ	55.1%	26	49.9%	9	15.5%	14
27 Los Angeles-Long Beach, CA	54.0%	27	44.9%	24	13.2%	28
28 Chicago, IL	53.5%	28	47.2%	17	14.0%	20
29 Philadelphia, PA	53.2%	29	48.3%	13	14.3%	19
30 Charlotte-Gastonia-Rock Hill, NC	53.1%	30	39.7%	43	12.4%	35
31 Riverside-San Bernardino, CA	52.6%	31	39.1%	44	9.8%	44
32 Fort Lauderdale, FL	52.1%	32	42.6%	38	12.2%	37
33 Cincinnati, OH	51.0%	33	43.9%	31	12.9%	32
34 Milwaukee-Waukesha, WI	49.9%	34	44.2%	28	13.6%	25
35 New Orleans, LA	49.9%	35	44.5%	25	12.2%	36
36 San Antonio, TX	49.5%	36	42.6%	37	11.2%	43
37 New York, NY	49.0%	37	51.1%	4	14.5%	18
38 Buffalo-Niagara Falls, NY	48.6%	38	42.3%	39	12.0%	39
39 St. Louis, MO	48.5%	39	44.5%	26	13.1%	29
40 Tampa-St. Petersburg-Clearwater, FL	48.3%	40	41.9%	42	11.2%	42
41 Cleveland-Lorain-Elyria, OH	47.7%	41	43.5%	33	12.4%	33
42 Detroit, MI	47.2%	42	43.3%	35	12.4%	34
43 Pittsburgh, PA	46.6%	43	43.5%	32	11.9%	40
44 Miami, FL	45.4%	44	42.1%	40	11.5%	41
Average for 44 MSAs	56.4%		46.1%		14.3%	
Standard Deviation	6.8%		3.6%		2.4%	

Sources: AGS/ACN, Scarborough Research

TABLE 3.9
MSAs Ranked According to Basic Model Variables

MSA	Rank according to PEN2000	Rank according to COLLEGE	Rank according to HITECH	Rank according to MEDHHINC	Rank according to POPGR	Rank according to MEDAGE
San Jose PMSA	1	7	1	2	24	15
Washington SMSA	2	2	6	6	18	19
Seattle-Bellevue-Everett PMSA	3	4	2	16	14	27
San Francisco PMSA	4	1	17	7	30	40
Oakland PMSA	5	3	7	10	17	28
Minneapolis-St. Paul MSA	6	8	28	15	16	12
Orange County PMSA	7	20	8	4	13	10
Denver PMSA	8	5	9	22	6	21
Bergen-Passaic PMSA	9	14	14	3	8	30
Portland-Vancouver PMSA	10	19	24	34	29	41
Atlanta MSA	11	16	11	17	2	11
Houston PMSA	12	34	26	30	9	4
Norfolk-Va. Beach-Newport News MSA	13	13	40	37	25	3
Boston-Worcester-Lawrence NECMA	14	12	4	8	39	31
San Diego MSA	15	24	10	20	15	9
Nassau-Suffolk PMSA	16	15	19	1	33	39
Salt Lake City-Ogden MSA	17	22	25	36	11	1
Fort Worth-Arlington PMSA	18	31	20	35	10	8
Columbus MSA	19	21	30	33	22	13
Dallas PMSA	20	11	3	25	4	5
Indianapolis MSA	21	26	15	26	20	20
Kansas City MSA	22	28	16	29	21	24
Baltimore PMSA	23	9	5	12	1	16
Phoenix-Mesa MSA	24	36	38	38	31	29
Hartford NECMA	25	6	31	9	43	33
Newark PMSA	26	10	13	5	35	37
Los Angeles-Long Beach PMSA	27	33	12	11	28	7
Chicago PMSA	28	18	21	14	26	17
Philadelphia PMSA	29	25	18	13	40	32
Charlotte-Gastonia-Rock Hill MSA	30	30	34	24	5	22
Riverside-San Bernardino PMSA	31	44	43	23	3	2
Fort Lauderdale PMSA	32	37	29	28	7	43
Cincinnati PMSA	33	17	35	31	27	18
Milwaukee-Waukesha PMSA	34	35	37	21	37	14
New Orleans MSA	35	38	44	44	38	23
San Antonio MSA	36	42	22	43	12	6
New York PMSA	37	23	27	18	36	34
Buffalo-Niagara Falls MSA	38	29	41	40	44	38
St. Louis MSA	39	41	23	27	34	25
Tampa-St. Petersburg-Clearwater MSA	40	43	33	42	23	44
Cleveland-Lorain-Elyria PMSA	41	27	39	32	41	35
Detroit PMSA	42	40	36	19	32	26
Pittsburgh MSA	43	32	32	41	42	42
Miami PMSA	44	39	42	39	19	36

Sources: Scarborough Research, U.S. Census Bureau, Milken Institute, AGS/ACN

TABLE 3.10
Top 20 MSAs Ranked According to Internet Penetration Rates

Home			Work		
	2000	1999		2000	1999
1 San Jose PMSA	61.4	56.7	Washington PMSA	50.2	48.2
2 Seattle-Bellevue-Everett PMSA	59.9	54.4	Austin-San Marcos MSA	43.7	39.6
3 Washington PMSA	59.4	57.4	San Jose PMSA	42.5	36.2
4 Ventura PMSA	59.0	49.7	Minneapolis-St. Paul MSA	39.2	36.4
5 Austin-San Marcos MSA	58.6	51.4	Raleigh Durham-Chapel Hill MSA	38.8	35.9
6 Monmouth-Ocean PMSA	58.5	49.7	Seattle-Bellevue-Everett PMSA	38.7	35.0
7 San Francisco PMSA	56.3	54.6	San Francisco PMSA	38.0	33.3
8 Oakland PMSA	55.1	51.9	Oakland PMSA	37.5	34.5
9 Orange County PMSA	54.7	53.6	Orange County PMSA	36.0	34.4
10 Middlesex-Somerset-Hunterdon PMSA	53.8	48.0	Ventura PMSA	35.7	27.7
11 Tacoma PMSA	53.7	47.9	Dallas PMSA	35.5	31.0
12 Atlanta MSA	53.4	45.4	Houston PMSA	35.1	29.6
13 Bergen-Passaic PMSA	52.8	43.4	Atlanta MSA	34.5	29.1
14 Nassau-Suffolk PMSA	52.7	46.2	Denver PMSA	34.2	33.3
15 San Diego MSA	51.6	44.8	Portland-Vancouver PMSA	34.2	32.6
16 Portland-Vancouver PMSA	51.5	47.3	Columbus MSA	33.5	26.7
17 Ft.Lauderdale PMSA	51.1	44.4	Indianapolis MSA	33.2	23.9
18 Raleigh Durham-Chapel Hill MSA	51.0	46.9	Albuquerque MSA	32.7	27.5
19 Boston-Worcester-Lawrence NECMA	50.9	44.9	Lexington MSA	32.7	26.9
20 Denver PMSA	50.4	47.0	San Diego MSA	32.6	28.1

Source: Scarborough Research

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Prior to joining the PEW Internet and American Life Project, Horigan was a staff officer for the Board on Science, Technology, and Economic Policy at the National Research Council. He has also served as a consultant to the World Resources Institute and as a legislative assistant and press secretary to U.S. Congressman Jake Pickle. His past research has focused on technology and telecommunications policy, including work on universal telephone services, state and local telecom policy, and U.S. R&D policy. Horigan received his Ph.D. in public policy from the University of Texas at Austin and his B.A. in government and economics from the University of Virginia.

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