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Broadband for All?

Gaps in California's Broadband Adoption and Availability

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SUMMARY

Nearly half of California households have broadband (high-speed) Internet access. Broadband is more widely available in higher-income and higher-density areas, and there are large gaps in access between the urbanized coastal regions of California and the more rural inland areas. Differences in broadband adoption rates between different racial and ethnic groups are also significant, although some of these are due to different rates of computer ownership.

The technical features of broadband, including the scale economies in providing broadband infrastructure, make some regions of California more profitable to serve than others, leading to gaps in availability. Even where broadband is available, the cost of service, as well as the cost of computer hardware, results in higher rates of adoption for some than others. However, these gaps are hard to measure. This issue of *California Economic Policy* assesses the extent of inequalities in broadband adoption and availability in California, using an innovative method to measure its availability.

All levels of government—federal, state, and local—have policies to make broadband more widely available: Policymakers hope to raise the overall level of adoption and to close the gaps between those who have access and those who do not. This report reviews the policy approaches that California and its cities are taking to raise broadband adoption and availability, including local efforts to provide municipal Wi-Fi (wireless broadband). It concludes that broadband policy in California should focus on increasing availability in rural areas and helping raise adoption rates among disadvantaged groups in urban areas.

California Economic Policy *is a series analyzing and discussing policy issues affecting the California economy.*

Introduction

California policymakers both locally and at the state level are undertaking numerous initiatives to raise the level of residential broadband Internet adoption in the state. Through regulation, subsidies, and direct provision, state and local governments seek to make broadband more widely available and, where available, to raise adoption rates among groups less likely to have access. However, in trying to overcome these gaps in availability and adoption, policymakers lack clear information about who in California has access to broadband and who can get it. In fact, the only comprehensive measure of availability widely used by policymakers is flawed and certainly overstates the level of broadband availability in the state.

This report uses an alternative measure to assess the extent of broadband availability, adoption, and the digital divide within California. It seeks to answer the following questions:

- Does California lead or lag the country in broadband adoption?[1]
- Are there inequalities in broadband availability within California?
- Are there inequalities in adoption within California and, if so, are such inequalities more pronounced for broadband adoption or computer ownership?

Why should overcoming a broadband digital divide, or raising the level of broadband adoption, be a policy goal? No one argues that government should boost ownership of other technologies such as DVD players and digital cameras. The difference is that broadband access (and Internet access generally) is believed to give social or economic benefits that are in the public interest. But does making broadband more available to residents improve health outcomes, lower unemployment, or improve job quality? Does making broadband more available to businesses encourage job growth, increase profits, or raise productivity? Does making broadband more available to public workers lower crime rates or improve emergency response? The answers to these essential questions are largely unknown, and academic research is only beginning to approach them.

Through regulation, subsidies, and direct provision, state and local governments seek to make broadband more widely available and, where available, to raise adoption rates among groups less likely to have access.

Nonetheless, there are several cogent arguments for the proposition that government should be involved in raising broadband availability and adoption and that—in the absence of government involvement—broadband use could be below a socially optimal level. On the supply side, broadband provision involves high fixed costs, especially in rural areas; if providers were to spread the fixed cost of provision among subscribers, prices would be above marginal cost and too few people would adopt. Furthermore, broadband is most efficiently provided using publicly owned resources: Digital subscriber lines (DSL) and cable lines follow existing rights-of-way, and wireless networks involve siting antennae on public property. On the demand side, there might be positive externalities in broadband adoption, so that the benefits to society of someone adopting broadband exceed individual benefit. Also, broadband adoption encourages some online behaviors, such as looking up medical information, leading to better health outcomes—something most societies consider to be a public benefit. Finally, businesses may be drawn to places where broadband is more widely available, both for better infrastructure and for a workforce that is more technologically literate, so governments consider broadband to be an economic development tool.[2]

The first section of this report reviews the different aspects of the term "digital divide." The second section explains the economics of broadband and the technical features that could lead to geographic differences in availability. The third section outlines current broadband policy at the federal, state, and local levels. The fourth explains an alternative approach to measuring broadband availability: This involves inferring availability from adoption patterns found in a particularly rich dataset, and it overcomes important shortcomings

Text Box 1. Should We Care About Closing the Digital Divide?

Some research has found positive effects of Internet use generally, although not broadband specifically, on social and economic outcomes. For example, using the Internet to get vehicle price information lowers costs to consumers by around 2 percent; furthermore, online vehicle price information eliminates the price premium that racial minorities pay offline for new cars (see Morton, Zettelmeyer, and Silva-Risso, 2001, 2003). A separate study finds that home computer adoption is greater among people whose family or friends are more likely to use computers and, specifically, email. This finding suggests that Internet use offers a positive externality, which although not a part of the public debate about broadband policy, is the kind of justification for public spending that economists find compelling (see Goolsbee and Klenow, 2002).

Other research, however, finds that the Internet does not necessarily lower consumer prices or even benefit its users. Average online book prices are no lower than in traditional bookstores, and online sellers exhibit significant dispersion associated with differentiated strategies (see Clay et al., 2002). Job searchers who use the Internet do not have shorter unemployment durations than searchers who do not (see Kuhn and Skuterud, 2004).

A companion study (Kolko, 2007) looks at how broadband adoption changes online behaviors—it has a positive and significant effect on downloading music, purchasing, visiting adult sites, and researching medications and medical conditions. Adopting broadband has no statistically significant effect, however, on visiting job or government sites—two of the many goals that governments regularly hope for when considering municipal wireless initiatives.

Some studies have attempted to measure the aggregate economic effect of higher broadband adoption, focusing on the effect of wider broadband deployment on job growth (especially in telecom industries responsible for building the infrastructure), cost savings from increased business efficiency, and the increase in consumer well-being. Estimates of the economic benefit of broadband are highly sensitive to methodology and assumptions: One study's estimates range from $32 billion to $350 billion per year in consumer surplus nationally, depending on assumptions about the shape of the demand curve (Criterion Economics, 2003).[3]

in other measures of broadband availability traditionally used in policy analysis. The fifth section presents findings about broadband availability and adoption in California. The final section draws conclusions and suggests courses of action.

Gaps in Broadband Availability and Adoption

A general definition of the digital divide is that it is "the gap separating those individuals who have access to new forms of information technology from those who do not."[4] The digital divide encompasses disparities in availability, in adoption, and in complementary skills, all of which can ultimately contribute to disparities in how much benefit individuals get from information technology. Furthermore, the digital divide can refer to a wide range of information technologies. This report focuses on the digital divide in broadband, and this section describes how availability, adoption, and complementary skills contribute to the broadband digital divide. This report also considers the digital divides in Internet access generally, of which broadband is one aspect, and computer ownership, which is for most people a prerequisite for adopting broadband.

Why should overcoming a broadband digital divide, or raising the level of broadband adoption, be a policy goal?

The first divide—that of availability—means that technologies are available for some people and not others. We discuss below why broadband could be more widely available in urban areas than in rural areas, and in richer areas than in poorer areas.

The second digital divide refers to levels of adoption, which can also differ across groups. Richer people have higher rates of broadband adoption than poorer people do. That the rich have more is not surprising, but there are two important related research questions about broadband adoption that remain to be answered. First, do race and ethnicity influence technology adoption, after differences in income and other factors are controlled for? If so, perhaps that reflects racial inequalities in technology literacy that policy could help overcome. Moreover, research suggests that disadvantaged groups can benefit disproportionately from Internet access, so targeting broadband policy to raise adoption rates among these groups could be especially desirable.[5] Second, how much does income matter for broadband adoption if computer ownership is held constant? If income affects computer ownership more than it affects broadband adoption, then making broadband less expensive and more widely available would have little effect on its adoption unless there were also efforts to raise computer ownership levels among lower-income people.

People have different levels of knowledge and comfort with technologies, and so even giving away broadband and computers would not make the benefits of information technology accessible to all.

The third digital divide concerns gaps in skills complementary to information technologies; this is often referred to as technology literacy or fluency. People have different levels of knowledge and comfort with technologies, and so even giving away broadband and computers would not make the benefits of information technology accessible to all if the recipients lack knowledge and familiarity with it. Complementary skills are not limited to technical knowledge and comfort levels with hardware. Two people equally familiar with technology might not reap the same benefits from an Internet connection if they have different abilities to filter information—one might know which sites offer reliable and trustworthy medical advice but the other, searching for the same information, might click on the first visible sponsored link and wind up in the hands of a quack. Such gaps in complementary skills might or might not manifest themselves in adoption levels. It could be that people who are less technology literate have lower demand for broadband as a consequence. Alternatively, it could be that people lacking complementary skills are no less likely to adopt broadband but benefit less from their broadband access than those with better skills.

Broadband Economics

The Internet's infrastructure consists of transmission routes, which include fiber-optic cable, coaxial cable, copper wiring, and wireless links; the infrastructure also includes connection points, where data are handed off from one route to another. An analogy with roads is useful: The Internet backbone is a network of high-capacity fiber-optic cables (like interstate highways), which connect to lower-capacity routes (like smaller highways), which in turn connect to last-mile networks (like local roads) that lead directly to residences.

The Federal Communications Commission (FCC) defines broadband as an Internet service that offers speeds of at least 200 kilobits per second (kbps) in at least one direction. Most residential broadband services today offer speeds significantly faster than this, typically in the range of 1.5 megabits per second (Mbps: A megabit equals 1,000 kbps) to 6.0 Mbps downstream (i.e., data flowing from the Internet to an end-user, like a music download). Upstream (i.e., data flowing from an end-user to the Internet, such as a sent email or a search request) speeds are typically slower, in the range of 384 kbps to 1.5 Mbps. By comparison, top downstream speeds over a dial-up modem are 56 kbps—only 1/100th as fast as the top of the range for broadband.[6]

The two primary residential broadband technologies are DSL and cable.[7] Both are last-mile technologies, which means that they connect residences to the larger Internet network.[8] Both DSL and cable rely on existing infrastructure to provide Internet services: DSL shares the copper wiring used for telephone service, and cable shares a hybrid of fiber and coaxial cable (HFC) used for cable television service. To offer broadband, DSL and cable providers must upgrade this existing infrastructure. Upgrading involves high initial fixed costs, and the technologies themselves have limitations on their deployment (described below). Because of high fixed costs and technological limitations, some cities or neighborhoods are more profitable for broadband providers to serve than others.

Upgrading infrastructures—and the effects on geographic availability—are different for DSL and cable.[9] DSL's use of existing telephone copper wiring means that it is a dedicated service—it runs directly from the residence to the service provider and is not shared with any other residences. Because DSL technology can transmit data even when the line is also in use for a telephone call, DSL provides an always-on Internet connection. To offer DSL, telephone companies must install DSLAM (digital subscriber line access multiplexer) equipment that aggregates Internet data from the service area and forwards it to the larger highways of the Internet. DSL works only within three miles of a telephone company central office. Where providers offer multiple tiers of DSL service (such as 1.5, 3.0, and 6.0 Mbps), the faster tiers might be available only to residences closer to the central office. The prevalence of telephone company central offices depends on population density. Large cities have multiple central offices and less-dense areas have far fewer per square mile; this alone makes DSL more widely available in higher-density areas. Alternatively, DSL architecture can consist of a copper connection from a residence to an intermediate node, called a street cabinet, which is connected with fiber to the central office. By installing street cabinets, telephone providers can offer DSL service to areas farther than three miles from a central office.[10] AT&T and Verizon are the main providers of DSL service in the United States, with AT&T dominant in California.

Cable infrastructure consists of a head-end, which forwards local Internet traffic to the wider Internet and serves thousands of homes, and optical nodes, which are connected to the head-end with fiber-optic cable and to residences with coaxial cable. The coaxial cable is the same infrastructure that delivers cable television service. To provide broadband, cable television providers upgrade their networks by adding nodes and moving them closer to residences, which in effect replaces some of the coaxial cable in the network with fiber. Cable companies also have to install equipment (analogous to the telephone DSLAMs) that route and switch digital data, and they install amplifiers that improve the upstream data transmission.[11] Unlike DSL, cable infrastructure is shared: The coaxial cable connects residences to the optical node in a loop, so that the bandwidth any residence receives depends in part on the number of residences sharing the node. Thus, the local fixed costs of upgrading an area's infrastructure to make cable broadband available can involve (1) moving optical nodes closer to residences, (2) building new optical nodes, (3) upgrading the upstream path, and (4) installing equipment at the head-end.[12] Comcast and Time Warner are the main providers of cable broadband service in California.

These fixed costs mean that cable and DSL are more profitable in areas where the costs can be spread over more subscribers. Areas that are higher density or higher income or both tend to be more profitable. In a higher-income neighborhood, more residents are likely to adopt broadband, so providers seeking to make broadband available in the most profitable areas first would choose higher-income areas; this effect is magnified for cable providers, since upgrading their networks offers new potential revenue from both

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broadband and digital television service. High-density neighborhoods are not only more likely to be within three miles of a telephone central office for DSL service, they also can be served at lower installation costs per subscriber.[13]

For all of these reasons, broadband availability should differ geographically according to average income and density. There might also be geographic differences in availability that are unique to a particular provider: Most areas in the United States are served by a dominant telephone provider and a dominant cable provider, and each can make different strategic decisions about when to introduce broadband service to their regions. The age and physical condition of existing telephone or cable infrastructure can also affect the cost of introducing broadband.

In addition to these two wireline technologies, two wireless broadband technologies are beginning to be used.[14] One is satellite, which although available nearly everywhere in the United States, offers a slower speed and lower reliability for a higher monthly price than either cable or DSL.[15] In practice, satellite broadband appeals to consumers only where DSL and cable are unavailable and so does not actually compete with them.[16] The other wireless broadband technology is Wi-Fi (the technical term is 802.11x), which offers high speed within a very short distance of a base station. Wi-Fi is commonly used in conjunction with DSL or cable to make broadband access available wirelessly within a home, office, café, or public space. The cost of setting up base stations and antennas to provide Wi-Fi coverage is much lower than upgrading or building wireline infrastructures such as DSL, cable, or fiber-to-the-home (FTTH). In a handful of locations, Wi-Fi offers citywide public access to the Internet and actually competes with cable and DSL. This new wave of municipal Wi-Fi initiatives is discussed below as an example of broadband policy.

Federal, state, and local governments all play a role in shaping the availability and adoption of broadband.

Current Broadband Policies—Federal, State, Local

Federal, state, and local governments all play a role in shaping the availability and adoption of broadband. The federal government, through Congress, the executive, and the Supreme Court, makes the most important regulatory decisions, whereas state and local governments play a larger role in subsidizing and in some cases directly providing broadband services.

At the federal level, the FCC regulates telecommunications. The 1996 Telecommunications Act, the 2005 Supreme Court decision in *National Cable & Telecommunications Association et al. v. Brand X Internet Services et al.*, and related FCC rulings have created the regulatory framework that exists today. Under this framework, telephone, wireless, television, and Internet providers are able to "compete in any market against any other" (FCC web site), but broadband providers are not required to give competitors wholesale access to their infrastructures so that competitors can resell services to consumers.[17] The FCC also shapes broadband policy by placing conditions on mergers between broadband providers and by allocating wireless spectrum.[18] Finally, the FCC administers the universal service requirement, which guarantees that even the most remote areas have telephone service.[19]

States and local governments are still left with important elements of broadband regulation, one being control of the physical development of infrastructure. Broadband networks typically follow public rights-of-way such as roads or rail tracks, and deploying broadband infrastructure costs providers less when it occurs in tandem with public works projects or when done simultaneously by multiple broadband providers. In California, improving rights-of-way access for broadband deployment is the most prominent element of Governor Arnold Schwarzenegger's 2006 Executive Order on "Expanding Broadband Access and Usage in California," which created a California

Text Box 2. Will New Internet Access Technologies Overcome the Digital Divide?

The economics of DSL and cable result in greater geographic differences in availability than those of dial-up access do. Will the next generation of technologies have the same effect or will they widen or narrow the digital divide?

The most promising next-wave broadband technologies are FTTH and WiMax.[20] FTTH extends fiber-optic cable—which already connects the Internet all the way to the telephone company central offices and the cable providers' optical nodes—the rest of the way to homes. Fiber would, in effect, replace the copper wiring and coaxial cable in use today. Because the capacity of fiber is far greater than that of either copper or coaxial cable, users would access much higher speeds downstream and upstream—potentially into the gigabit-per-second (gbps) range, hundreds of times faster than today's fastest cable or DSL services.[21]

Recent policy reforms at the state and federal levels have reduced some of the regulatory challenges to delivering cable television and these give telephone companies a stronger incentive to build FTTH networks.[22] Telephone companies are interested in FTTH as much for its ability to deliver television service as to deliver high-speed Internet service; this is so that they can compete fully with cable providers, who can offer television, Internet, and telephony (using voice-over-IP [Internet protocol]) over their existing networks.[23] However, current adoption in California is minimal. SureWest, a regional telecom service provider, has over 20,000 FTTH subscribers in the Sacramento area.[24] AT&T, the dominant local phone provider, has not announced plans for any major FTTH deployment.

Fiber costs more than DSL or cable, and it requires replacement of the existing connections to customers' homes, so its roll-out proceeds neighborhood by neighborhood. Multiunit dwellings, dense areas, and new developments cost less to wire with fiber than other areas, so there is a strong possibility of a future, persistent digital divide in FTTH availability; at least as important is that only some telecom companies are considering FTTH. In fact, a study prepared for San Francisco's evaluation of the feasibility of a municipally built, owned, and operated fiber-optic network argues that the city is already on the losing side of the FTTH digital divide because Verizon, the company deploying most large FTTH projects in the country, is not the dominant telephone provider in San Francisco.[25]

The other promising next-wave technology is WiMax, a wireless technology. WiMax offers Internet connectivity over a range of one to 30 miles from a transmission tower; this compares to the hundreds of feet that are Wi-Fi's limit. The downstream and upstream bandwidth of WiMax depends on the number of simultaneous users, but speeds could rival those of DSL and cable. WiMax is not yet being used for broad-based Internet access. Theoretically, the fixed costs of WiMax deployment should be much lower per subscriber than costs for wireline technologies, because the infrastructure consists of widely spaced antennas, not extensive wiring. The wide range of WiMax signals could also bring high-speed service to harder-to-reach rural areas.

Next-wave technologies are no guarantee of overcoming today's digital divide. In fact, the high fixed costs of FTTH make it likely that some areas will receive service long after others do. Furthermore, with the development of faster access technologies, expectations about adequate service ratchet upward. This is not only because the digital divide refers to relative differences, not absolute levels. It is also because online applications are designed for users' current bandwidth; as typical residential bandwidth increases, online applications incorporate more bandwidth-hungry content (such as video and interactivity), and access technologies that were once adequate cease to be so.

Broadband Task Force composed of public and private stakeholders to coordinate efforts to raise broadband adoption and identify ways to fund new technology investments.[26]

States and localities also play a large role through subsidizing and directly providing broadband. California's primary broadband subsidy program is the Teleconnect Fund, which pays half the cost of Internet access for qualified schools, libraries, community organizations, and other nonprofits. Funded from a statewide fee on telephone service, the fund's 2006–2007 fiscal year budget is $22 million.[27] In addition, the California Public Utilities Commission (CPUC) recently created the California Emerging Technology Fund, an independent nonprofit foundation to be funded with $60 million over five years from AT&T and Verizon as conditions of their respective mergers with SBC and MCI. The fund's mission is "achieving ubiquitous access to broadband and advanced services in California, particularly in underserved communities through the use of existing and emerging technologies," although specific strategies have not yet been selected.[28]

Whereas state governments have focused on subsidies to encourage adoption, more and more localities are attempting to provide broadband directly, both by themselves and in partnership with private companies. In the late 1990s, a few localities across the country built fiber-optic networks.[29] These early projects often involved public ownership of networks and were in direct response to the perceived lack of service provision by the phone and cable companies.[30] In the past couple of years, many localities have turned to Wi-Fi as a wireless standard and a way to bring broadband service at low or no cost to a wide area. In California, 58 localities have Wi-Fi initiatives under way. Service is operational in Anaheim, the San Diego County tribal nations, and several cities in Silicon Valley. Major initiatives are under negotiation for San Francisco, for the greater Sacramento region, and for a Silicon Valley–wide network; Los Angeles has also announced a citywide initiative.[31] Most of these call for low-cost or free wireless access, provided by partners such as Google, EarthLink, and MetroFi, supported by subscriptions or advertising, with little financial investment by the public sector. Of the 58 initiatives, all but four are in densely populated areas of the Bay Area, Southern California, or greater Sacramento. Text box 3 provides more detail on the justifications and challenges of municipal wireless.

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California's broadband policy can be summed up as follows: First, subsidies focus more on institutional access to broadband than residential access to broadband. Second, municipal Wi-Fi initiatives are widespread and are concentrated in the densely populated parts of the state. Third, policy is geared toward broadband access, not computer ownership.

Measuring Broadband

Trying to measure the extent of the digital divide is challenging. Publicly available household surveys on broadband adoption, Internet access, and computer ownership are inadequate for studying recent trends in California. For example, the federal *Current Population Survey* last included technology questions in 2003, and there are no plans to do so again. The Pew Internet & American Life Project surveys households about technology adoption annually or more frequently, but with only 4,000 respondents nationally, the sample is too small to draw conclusions about California.[32] A proprietary survey, the Technographics Benchmark conducted by Forrester, a technology research and consulting firm, is used for this analysis. Forrester annually surveys 60,000–100,000 households about their technology adoption and behaviors.[33]

Measuring the divide in broadband availability is more challenging than measuring broadband adoption. Broadband providers treat service avail-

Text Box 3. Local Wi-Fi Initiatives

As of early 2007, numerous localities are developing wireless broadband networks using Wi-Fi technology to serve entire regions. In contrast to earlier efforts, most municipal Wi-Fi plans and deployments today call for at least partial ownership and operation by the private sector. So phone and cable companies, after fighting earlier attempts at direct public provision, are instead partnering with local governments.[34] The best-known are in Philadelphia, where a wireless network run by EarthLink is operational, and in San Francisco, which is still negotiating with EarthLink and Google; across the country there are hundreds of others under way.[35]

Many arguments over municipal wireless rest on technical issues specific to Wi-Fi, which was not designed to provide citywide coverage but to bring it to a building, park, or other small area. Wi-Fi transmits signals over relatively short distances (up to 30 meters indoors, 450 meters outdoors) and is the technology behind public "hotspots" and home networks. Municipal networks extend the capabilities of Wi-Fi by using multiple transceiver sites that collectively cover a large area. The first technical concern about Wi-Fi is that it is unclear how far such a Wi-Fi signal can reach indoors, and users might need to install range-extending equipment. Second, new wireless standards such as WiMax that can transmit signals much farther could make Wi-Fi obsolete. Third, a citywide Wi-Fi signal could interfere with existing Wi-Fi hotspots.[36]

There is also controversy on social and economic grounds. In San Francisco, the partnership calls for EarthLink to provide paid access and for Google to provide free, advertising-supported access; Google's model, which uses tracking cookies that customize advertising, has raised privacy concerns.[37] In some cities, the business model itself is being debated: Should wireless be advertising-supported (and free), or subscription-based, or a hybrid?[38] Some are even questioning the public-private partnership model: as of May 2007, San Francisco's Board of Supervisors has delayed finalizing the agreement with EarthLink and Google to assess a city-owned and -operated alternative.

Despite these controversies, there is broad consensus that the benefits of municipal Wi-Fi include (1) narrowing the digital divide and (2) facilitating online activities that are socially desirable or economically productive. Large cities such as Philadelphia and San Francisco focus most on the digital divide among residents and on bringing free or low-cost access to everyone. Philadelphia, for instance, negotiated with EarthLink to provide broadband at a lower cost to lower-income residents.[39] Large cities also want to encourage socially desirable online behaviors related to health care, education, and employment.[40] Promoters of Silicon Valley's request for proposal for a wireless network, however, emphasize the digital divide among businesses. Some are out of reach of both DSL and cable providers, they argue, and desirable online activities include those that improve business development, government services, and public safety.[41]

Still unknown is how much demand there is among residents, businesses, and visitors for municipal Wi-Fi. Municipal Wi-Fi competes with existing fixed-wire connections in homes and workplaces; it also competes with data services offered by mobile phone providers, which offer Internet connectivity to mobile phones and to specially equipped laptops. Taipei has one of the world's most extensive wireless networks, reaching 90 percent of the city's 2.6 million people, but six months after its launch in early 2006, only 40,000 residents had subscribed.[42]

ability maps as sensitive competitive information, and regulators have not required that providers make these maps public. Although individual consumers can check availability at an individual address on most providers' web sites, anecdotal evidence suggests that this information is often inaccurate or incomplete.[43]

The only widely used data on broadband availability come from FCC surveys of broadband providers. The FCC publishes a count of the number of providers with at least one subscriber in each zip code nationally.[44] This method overstates the level of availability because broadband may be available in only some parts of a zip code. Using this measure could also understate geographic differences in broadband availability if providers make broadband available only in richer or denser portions of a zip code. Recent FCC data suggest implausibly high levels of broadband availability, rendering the data misleading for assessing the digital divide. The FCC reports that in December 2005, 99.8 percent of the U.S. population lived in a zip code where broadband was available (see Table 1). In the most sparsely populated tenth of zip codes, 96.2 percent of the population lived in zip codes where broadband was available, and in the poorest tenth of zip codes, 99.4 percent of the population lived in zip codes where broadband was available.

Rather than rely on FCC data, this analysis infers broadband availability by examining the relationship between location and broadband adoption at the individual level, controlling for numerous individual characteristics.

Nevertheless, these FCC data are the basis for most policy studies and academic work about broadband availability. In its most recent report on broadband deployment in the United States in 2004, the FCC concludes that broadband is nearly universally available in urban areas and "significant progress is being made towards ubiquitous availability of advanced services in rural areas."[45] The California Public Utilities Commission (2006) also relies on the FCC's zip code data for its maps of broadband availability, which show at least one broadband provider offering service in every zip code in California.[46] Several academic studies rely on the FCC data as well, although one notes that "the FCC count of high speed line providers within a zip code may seriously misrepresent competitive options available to the totality of residents within that zip code … [but] there is no practical alternative to using the FCC data in assessing broadband availability."[47]

Rather than rely on FCC data, this analysis infers broadband availability by examining

Table 1. U.S. Broadband Availability, FCC Measure

	Population in Zip Codes with At Least One High-Speed Subscriber[a] (%)	Population of *Lowest-Density* Zip Codes (bottom decile) in Zip Codes with At Least One High-Speed Subscriber (%)	Population of *Lowest-Income* Zip Codes (bottom-decile) in Zip Codes with At Least One High-Speed Subscriber (%)
December 2000	96.4	49.9	91.5
December 2001	97.8[b]	67.9	95.1
December 2002	99.1	80.9	97.5
December 2003	99.5	88.9	98.6
December 2004	99.6	91.8	99.0
December 2005	99.8	96.2	99.4

Source: Federal Communications Commission (2006), Tables 18 and 19.
[a]Based on FCC data and the author's calculations.
[b]Compared to an online Forrester survey in autumn 2001, in which 64 percent of online respondents reported broadband availability where they live.

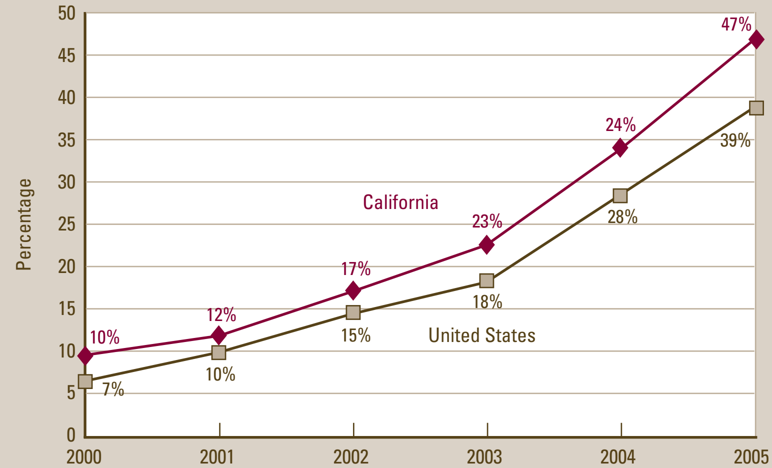
the relationship between location and broadband adoption at the individual level, controlling for numerous individual characteristics.[48] This technique, in essence, compares people who are identical in observable demographics, such as income, age, education, size of household, age of children, and so on, but who live in different types of zip codes—for example, a middle-income urban zip code and a middle-income rural zip code.[49] Because their individual demographics are the same, they are assumed to have similar underlying demand for broadband, and any difference in whether they actually have broadband is interpreted as a difference in the availability of broadband in the different types of zip codes.[50] The key location characteristics are zip code log median household income and zip code log population density.[51]

Measuring the digital divide in complementary skills presents further difficulties. Self-perceptions of skills are harder to elicit and interpret, so research on complementary skills often relies on direct observation and usability testing, which is expensive to conduct on a large scale. Furthermore, as technology changes, particular skills rise or fall in importance, making measurement and interpretation even more difficult.[52] Nor do any of the main data sources on access or availability, including Forrester, solicit detailed information on complementary skills, so this aspect of the digital divide is beyond the scope of this report.

Broadband Availability and Adoption in California

Our first research question is whether California leads or lags the nation in broadband adoption. Nationally, residential broadband adoption has grown rapidly, from 7 percent of households at the end of 2000 to 39 percent in 2005 (see Figure 1).[53] Looking just at the 68 percent of U.S. households with Internet access (broadband or dial-up) at home, more than half have broadband. During 2005, broadband adoption grew from 28 percent to 39 percent, so the

Figure 1. Broadband Adoption in the United States and California



Source: Forrester Research and author's calculations
Note: Data based on survey conducted by mail in English only.

growth in broadband adoption is not yet leveling off. Throughout this period, the level of broadband adoption in California has been above the national rate. Most recently, 47 percent of California households had broadband, eight points higher than the overall national level.

There are several possible explanations for this. One is that California residents have more favorable demographics for broadband adoption—that is, they are richer, more educated, and so on—than Americans generally, and these demographic factors influence broadband adoption. A second possibility is that broadband is more widely available in California because the density of population and income levels make it more profitable to offer broadband here than elsewhere in the country. A third possibility is that another California-specific factor—such as state policies or decisions by AT&T, the dominant local telephone provider in California—contributed to faster deployment and therefore higher adoption. These three possibilities are not mutually exclusive.

Looking just at the 68 percent of U.S. households with Internet access (broadband or dial-up) at home, more than half have broadband.

To assess the importance of each, regression analysis can identify the separate relationships of individual demographics and location characteristics such as neighborhood income and density on broadband adoption. The results of this analysis suggest that about half of the gap between broadband adoption in California and that in the rest of the nation is due to California's favorable individual demographics.[54] Location characteristics that affect providers' decisions to make broadband available—neighborhood income and population density—account for the other half of the gap.[55] Because individual demographics and location characteristics account for the entire difference between broadband adoption in California and that in the rest of the country, we infer that other factors unique to California did not collectively change the level of broadband adoption.[56]

The results of this analysis suggest that about half of the gap between broadband adoption in California and that in the rest of the nation is due to California's favorable individual demographics.

The second research question is whether there are inequalities in broadband availability within California. As noted above, this report infers availability from the relationship between location characteristics and broadband adoption. Another regression analysis reveals that broadband adoption in California is significantly higher in higher-income and denser zip codes, even after controlling for individual demographics.[57] That is, people of the same age, race, income, and so on are more likely to adopt broadband if they live in a richer or denser area.[58] The effect of location on availability means that broadband adoption differs considerably across regions within California, some of which are much richer and denser than others. Broadband adoption ranges from under 30 percent in the north of the state and in the Sierras to just over 50 percent in the Bay Area and greater Los Angeles (see Table 2).[59] The differences in Internet access (broadband and dial-up combined) and computer ownership across regions are smaller: Internet access ranges from 61 percent to 76 percent and computer ownership ranges only between 73 percent and 83 percent. More than half the differences in broadband adoption between regions remain even after controlling for individual demographics, suggesting that inequalities in broadband availability across regions account for much of the differences in broadband adoption. In contrast, the differences between regions in overall Internet access and computer ownership are due to differences in individual demographic characteristics across those regions.[60]

The third research goal is to understand the inequalities in broadband adoption in California apart from availability. Although it is obvious (as we confirm below) that broadband adoption rates are higher among richer households, two important questions about income and broadband adoption whose answers are not obvious are (1) do race and ethnicity affect broadband adoption, holding income constant, and (2) does income affect broadband adoption because income also affects computer ownership, which is essentially a prerequisite for broadband adoption?[61]

Broadband adoption, Internet adoption, and computer ownership all vary by income in California. Among households with incomes over $100,000, 68 percent have broadband, compared to 49 percent of households with incomes between $50,000 and $75,000 and compared to 24 percent of households with incomes under $25,000 (see Table 3). The gaps for Internet adoption (broadband and dial-up combined) and computer ownership across income groups are also considerable.

Looking across racial and ethnic groups, it is important to keep in mind that Forrester conducted this survey in English only. These data therefore represent people with very high English proficiency and exclude a significant share of California's Hispanic population.[62] Disparities in broadband adoption across racial and ethnic groups are less wide than across income groups but they are still apparent, with 46 percent of both non-Hispanic whites and English-proficient Hispanics having broadband, compared with 63 percent of Asian Americans and only 36 percent of African Americans.[63] Since income among non-Hispanic whites is

Table 2. Broadband, Internet, and Computer Ownership, by California Region, 2005

	Broadband (%)	Online (broadband or dial-up) (%)	Computer (%)	Number
Northern California	29	63	77	161
Northern Sacramento Valley	28	69	79	163
Greater Sacramento	44	76	83	518
San Francisco Bay Area	51	74	80	1,335
Northern San Joaquin Valley	36	67	74	241
Southern San Joaquin Valley	35	64	73	387
Central Sierra	21	61	76	54
Central Coast	48	76	80	176
Greater Los Angeles	52	76	81	1,949
Inland Empire	45	73	82	660
San Diego Border	48	72	78	722

Sources: Forrester Research and the author's calculations.
Notes: Counties in each region are listed in the web-only appendix at www.ppic.org/content/other/707JKEP_web_appendix.pdf. Data are based on a survey conducted by mail in English only.

Table 3. Broadband, Internet, and Computer Ownership in California, by Income, 2005

Household Income ($ 1,000s)	Broadband (%)	Online (broadband or dial-up) (%)	Computer (%)	Number
< 25	24	48	58	1,167
25–49	40	70	77	1,573
50–69	49	78	86	1,146
70–99	59	87	91	1,320
100+	68	89	93	1,382

Sources: Forrester Research and the author's calculations.
Note: Data are based on a survey conducted by mail in English only.

higher than income among Hispanics, and income and broadband adoption are strongly related, why do both groups have the same level of broadband adoption in California? Relative to non-Hispanic whites, Hispanics on average have larger households and are younger, both of which are positively correlated with broadband adoption.

Other research shows that Hispanics in California who prefer speaking Spanish at home have much lower broadband adoption than English-speaking Hispanics. According to the March 2007 PPIC Statewide Survey, conducted by telephone in English and Spanish, broadband adoption is 50 percent among Hispanics who speak English as much or more than Spanish at home and responded to the survey in English. Broadband adoption is only 20 percent among Hispanics who speak Spanish more than English at home or responded to the survey in Spanish. Broadband adoption among all California Hispanics is 29 percent, so looking only at His-

Broadband adoption ranges from under 30 percent in the north of the state and in the Sierras to just over 50 percent in the Bay Area and greater Los Angeles.

panics with high English proficiency overstates the level of broadband adoption among Hispanics.[64]

Holding other individual demographics constant, there is a statistically significant difference for broadband adoption among Hispanics and African Americans relative to whites. English-preferring Hispanics are 6 percent less likely to have broadband at home than non-Hispanic whites; the difference for African Americans is 10 percent.[65] Relative to California's overall broadband adoption of 47 percent, these gaps are large. Moreover, for Hispanics this is the gap between adoption among non-Hispanic whites and Hispanics with high English proficiency. The racial gaps in broadband adoption, however, cannot be explained by providers' failing to offer service in minority neighborhoods because there was no statistically significant effect of the racial composition of a zip code on broadband adoption.

Holding other individual demographics constant . . . English-preferring Hispanics are 6 percent less likely to have broadband at home than non-Hispanic whites; the difference for African Americans is 10 percent.

The other important factor about the digital divide in broadband adoption is the role of computer ownership. A home computer is for the most part a prerequisite for broadband adoption.[66] If the relationship between income and broadband adoption reflects lower computer ownership by poorer households, then making broadband more widely available at low cost might have little effect on broadband adoption. Looking across income groups, computer ownership ranges from 58 percent among households with income under $25,000 to 93 percent among households with income $100,000 and above. Regression analysis helps assess how much this gap in computer ownership contributes to the digital divide in broadband adoption. Controlling for other demographics, raising log income by one standard deviation increases the likelihood of *computer ownership* by 7 percent.[67] Then, looking only at computer owners and again controlling for other demographics, raising income by the same amount increases the likelihood of *broadband adoption* by 10 percent.[68] Both relationships are statistically significant: The effect of income on computer ownership means that there is a digital divide in computer ownership, but the effect of income on broadband among computer owners means that, even among computer owners, there is a digital divide in broadband adoption.

Conclusions and Recommendations

Within California, there are digital divides in both broadband availability and broadband adoption. Broadband is more widely available in higher-density residential areas and urban regions than in lower-density areas and rural regions; the level of neighborhood income also affects availability. These inequalities arise, in part, from the technical features and economic realities of broadband provision. The digital divide in adoption encompasses not only broadband but computer ownership as well, and income and race and ethnicity both affect broadband adoption in California.

Our findings have important implications for broadband policy. If closing gaps in broadband *availability* is a policy goal, raising availability in rural areas should be the top priority. The California Emerging Technology Fund should focus first on deployment in rural areas, and the Broadband Task Force could help identify clearly the barriers to providers' offering service in rural areas. Easing the access to rights-of-way might facilitate rural broadband deployment, but the economics of broadband make rural areas costly to serve even in the absence of any regulatory or permitting factors, so the state could consider direct subsidies to providers serving rural areas. Although broadband availability lags in lower-income areas as well, density has a greater effect on availability; furthermore, there is no evidence that broadband availability is lower in neighborhoods with higher concentrations of Hispanics and African Americans.

To close gaps in broadband *adoption*, the focus should be broadened to include racial and ethnic and income groups with lower adoption rates, including those living in neighborhoods where broadband service is already available. Improving technology literacy may also be essential. Municipal Wi-Fi initiatives will help meet these goals so long as they provide broadband at lower cost than DSL and cable providers do. Recent initiatives suggest that they will: Google's proposal to provide free, ad-supported service in San Francisco, and the prevailing rate of about $20 per month that EarthLink charges for its Wi-Fi service, are two examples. Municipalities need not resort to public ownership or operation of Wi-Fi networks to achieve these public benefits. Public involvement should be reserved for the investments that the private sector is less likely to make, such as helping raise technology literacy and improving computer access among disadvantaged residents, both of which are among the "digital inclusion" goals of San Francisco's Wi-Fi initiative.[69]

Ironically, because the Wi-Fi networks that are operational or under consideration are overwhelmingly in the urban parts of the state, they are likely to widen rather than close the gap in availability between urban and rural areas. Policymakers, therefore, should think less in terms of closing the gap between urban and rural availability, lest they hold back urban initiatives, and more in terms of raising the absolute level of rural availability. New technologies, such as FTTH, are also likely to benefit urban areas more than rural areas, so the urban-rural gap is likely to persist even if policy efforts successfully raise the level of rural broadband availability.

Two broader questions remain to be researched and answered. First, is it more desirable from a cost-benefit perspective to raise the degree of broadband adoption for those with less access than it is to overcome other inequalities that Californians face? On one hand, the economic and social benefits of broadband are unknown and are largely taken as an article of faith; on the other, the costs to the public sector of raising broadband adoption can be low if the private sector bears the cost, as is the case with most municipal Wi-Fi initiatives. Second, will the development of future Internet access technologies such as WiMax or FTTH mitigate or aggravate today's inequalities in technology access? Both of these questions should be considered—even if they cannot be answered—as California's state and local governments weigh various strategies for raising broadband adoption and closing the digital divide. ❖

If closing gaps in broadband *availability* is a policy goal, raising availability in rural areas should be the top priority. To close gaps in broadband *adoption*, the focus should be broadened to include racial and ethnic and income groups with lower adoption rates.

Notes

[1] The California Public Utilities Commission (2005) cites California's #14 ranking among states (according to the 2003 TechNet survey) as an important indicator of whether the state is "maintaining its lead in broadband usage." In the California Public Utilities Code, the main broadband policy objectives are assuring "continued affordability and widespread availability" of broadband and promoting "economic growth, job creation, and substantial social benefits." It is hard to see how the "substantial social benefits" depend on California's broadband adoption *relative* to that of other states, rather than the absolute level, but it is plausible that the relative ranking could affect economic growth and job creation if businesses consider broadband availability and adoption a factor in deciding where to open, expand, or move their operations.

[2] Only limited research has been completed on the effects of broadband. An overview of the academic literature on the effects of broadband and Internet usage is presented in Text Box 1.

[3] California Public Utilities Commission (2005) summarizes several studies on broadband and economic development.

[4] Gunkel (2003).

[5] See Morton, Zettelmeyer, and Silva-Risso (2003).

[6] Dial-up Internet access, in contrast to cable and DSL, is nearly ubiquitous in the United States and never had a long period of geographic disparities in availability. Making dial-up available does not involve a high fixed cost: Dial-up Internet service providers (ISPs) need to establish a point-of-presence (POP) in an area by making a local phone number available as a dial-in number, and although this involves adding some switching equipment in the telephone company central office, the infrastructure investment is minimal. Downes and Greenstein (2002) document that dial-up Internet service spread quickly to even the most rural counties: In 1997, 99 percent of the U.S. population lived in counties with at least one ISP, and 92 percent lived in counties with seven or more ISPs. There are scale economies in having a POP, but the costs to upgrade infrastructure for broadband service are much larger (Greenstein and Prince, 2006).

[7] DSL refers to a family of technologies, technically described as xDSL. Residential DSL is most often ADSL (asymmetric DSL), and higher-capacity variations include SDSL and VDSL.

[8] Many smaller businesses subscribe to DSL as well. Larger businesses rely on higher-bandwidth connections such as T1 and T3 lines. Cable broadband is almost exclusively a residential service.

[9] The description of Internet infrastructure and the process for upgrading networks relies on Federal Communications Commission (2000) and Corning (2001, 2005).

[10] The website www.dslreports.com/prequal/distance offers estimates of distance between a residential address and the nearest central office and maps of central office locations.

[11] Traditional cable television is a one-way communication: Video is broadcast from the cable head-end to the residence. Internet service, as well as digital cable service, is two-way communication, which requires a different "upstream" infrastructure.

[12] Cable providers might have to make additional infrastructure investments as broadband adoption rises, congestion increases, and bandwidth speeds fall.

[13] High residential density is one reason why Korea, Hong Kong, and Japan have higher broadband adoption and higher speeds of service available than the United States does.

[14] In addition to satellite and Wi-Fi, there is also WiMax, which is discussed in Text Box 2.

[15] Satellite also has a higher upfront equipment cost. HughesNet basic service costs $59.99 per month for speeds up to 700 kbps plus a $400 equipment and installation fee. See the website go.gethughesnet.com.

[16] See "With a Dish, Broadband Goes Rural" (2006).

[17] The laws and rulings that make up the federal regulation of broadband have involved the sometimes competing goals of (1) maximizing competition among broadband providers, (2) not reducing the incentives that broadband providers have to invest in infrastructure and new applications, and (3) treating DSL and cable broadband services evenly despite the fact that telephone companies as "common carriers" have traditionally been subject to much stricter federal regulation than cable companies have.

[18] In 2005, the FCC required that AT&T offer "naked DSL," under which consumers can subscribe to AT&T's DSL service without subscribing to AT&T's local telephone service, as a condition of its merger with SBC. Then, in late 2006, the FCC required specific pricing for naked DSL as a condition of its merger with BellSouth. See "AT&T to Offer 'Naked DSL' for Far Less Than Before" (2007).

[19] A short explanation of universal service is available at the FCC's website, www.fcc.gov/cgb/consumerfacts/universalservice.html. Universal service applies only to telephone, not Internet, service. However, because DSL uses the telephone network, the cost of providing DSL in remote areas is lower than if the telephone network did not cover those areas. In contrast, cable companies face no universal service requirement. As a result, DSL adoption is higher than cable broadband adoption in very low-density rural areas.

[20] Fiber-to-the-home is one technology in a class of FTTx technologies: They differ in whether the fiber network extends all the way to the individual home, or to the curb (FTTC), or to a multiunit building (FTTB). Fiber networks include those that have dedicated fiber running between the

customer and the service provider (point-to-point networks) or have shared fiber (as in a "passive optical network").

[21] Another emerging wireline technology is Broadband over Powerline (BPL), which uses the electric power network and home electrical wiring and outlets to carry Internet data. Unlike FTTH, BPL speeds are similar to those of DSL and cable (see the website www.fcc.gov/cgb/consumerfacts/highspeedinternet.html).

[22] In 2006, California passed a law creating statewide video franchises, which allow television providers to apply for a single statewide franchise rather than multiple local franchises as cable companies have traditionally had to do. Also in 2006, the FCC put time limits on the local franchise negotiation process and on franchise fees; it also curtailed unreasonable "build-out" requirements, which specify how quickly television providers are required to offer service to the entire franchise area. See the CNET.com article at http://news.com.com/FCC+adopts+relief+for+telecom+companies+planning+TV+offerings/2100-1036_3-6145184.html.

[23] Verizon's television-over-IP service is called FiOS. AT&T delivers its television service, U-Verse, by extending its fiber network closer to, but not all the way to, residences and then delivering content over the last portion of the network using a higher-capacity version of DSL. See the CNET.com article at http://news.com.com/ATT+to+ramp+up+IPTVs+expansion/2100-1037_3-6153354.html.

[24] See SureWest's 2006 Q3 financial statement, at www.surw.com/media_relations/press/releases/earnings/pdf/Q3_06financials_p6.pdf.

[25] None of San Francisco's broadband providers plan to deploy FTTH to San Francisco beyond limited trials, and these providers' future plans are "not comparable" to FTTH (Columbia Telecommunications Corporation, 2007, p. 2). Verizon, in contrast, plans to spend $20 billion over several years to make fiber-to-the-home high-speed services available to 60–70 percent of customers in its current service area, which includes some areas in California, according to "Verizon's Fios Services Build Momentum" (2006).

[26] The Executive Order designates the Business, Transportation, and Housing Agency as the lead agency for most items, highlighting the importance of infrastructure development to the goal of broadband access. On many telecom policy issues, including rate regulation, the Public Utilities Commission has responsibility.

[27] California Public Utilities Commission (2005, p. 62) has more details of the program and also of the similar federal e-Rate program.

[28] See the fund's website at www.cetfund.org.

[29] In Tacoma, Washington, the municipal power utility, City Light, built, owns, and operates a fiber-optic network that delivers Internet and television. See "Cities Deliver Broadband for Less" (2003).

[30] Gillett, Lehr, and Osorio (2004) review many of these local broadband initiatives.

[31] A full list of municipal wireless initiatives in the United States is available at www.muniwireless.org. Status of initiatives comes from the January 2007 summary.

[32] The most recent Pew report on broadband adoption is based on a survey of 4,000 adults over the period February–April 2006. See www.pewinternet.org/pdfs/PIP_Broadband_trends2006.pdf.

[33] Forrester's annual Technographics Benchmark survey is conducted by mail, in English only; the samples are selected from national market research panels to be representative of U.S. households demographically and are weighted to correct for differences in response rates. Forrester has used the TNS (formerly NFO) market research panel since 2001 and used NPD's panel in earlier years. Forrester collects data in the 48 contiguous states and the District of Columbia but not in Alaska or Hawaii. Some respondents participate in Forrester's survey in multiple years: Kolko (2007) includes some longitudinal analysis from these data. Brown and Goolsbee (2002), Goolsbee (2000), Goolsbee and Klenow (2002), and Prince (2003) use Forrester's data as well. The author was employed at Forrester from 2000 to 2005.

[34] "Companies That Fought Cities on Wi-Fi, Now Rush to Join In" (2006).

[35] A comprehensive list is available at www.muniwireless.com.

[36] "Wi-Pie in the Sky" (2006) reviews the technological and managerial challenges of citywide Wi-Fi networks.

[37] "Some Worries as San Francisco Goes Wireless" (2006).

[38] Google provides free Wi-Fi in Mountain View, California, and MetroFi offers both free and paid Wi-Fi in Cupertino, Sunnyvale, and Santa Clara, California. See "S.F. Picks Google Wi-Fi Team" (2006), and "Google Gives City Free Wi-Fi" (2006).

[39] In Philadelphia, EarthLink charges $21.95 per month generally and $9.95 per month for low-income households.

[40] See, for instance, the literature from Wireless Philadelphia, available at www.phila.gov/wireless/briefing.html; from San Francisco TechConnect, available at www.sfgov.org/site/techconnect_tf_index.asp; and from an interview with Houston's chief information officer at www.govtech.net/digitalcommunities/story.php?id=98722.

[41] "Public, Private Collaboration To Design Silicon Valley Wide Wireless Network" (2006). Silicon Valley, unlike most large cities, has a lower share of low-income residents and more geographically dispersed businesses that aren't well served by DSL or cable providers.

[42] See "What If They Built an Urban Wireless Network and Hardly Anyone Used It?" (2006). The article cites the competition from Wi-Fi connections, mobile phone data services, and fixed-wire broadband as a major reason for the lack of interest in paying for Taipei's municipal Wi-Fi service.

[43] A personal anecdote: Over a two-day period in August 2006 of checking the AT&T website and calling several customer service departments to sign up for new DSL service, the author was told by different people that (1) DSL was unavailable at the address, (2) only a slower DSL service (up to 1.5 Mbps) was available at the address, (3) all speeds of DSL service were available at the address, and (4) the address was not a valid address.

[44] These counts include both providers who own the broadband pipes (such as the dominant telephone and cable companies) and resellers. Although residential customers account for most of the dominant telephone and cable companies' subscribers, some resellers serve primarily business customers.

[45] FCC (2004), p. 38. The FCC uses "advanced services" as a synonym for broadband. Two of the five FCC commissioners dissented from the upbeat conclusions of the report, and both noted the inadequacy of using the one-subscriber-in-a-zip-code measure of availability. Still, the main concern of both dissenters was the lower level of broadband adoption in the United States relative to that in Korea, Japan, and other countries, not the inequality of broadband availability within the United States. Furthermore, not only do global broadband leaders have a higher percentage of households with broadband, average broadband speeds are also much higher.

[46] The CPUC emphasizes the inequality in the number of providers in zip codes, rather than using the data as evidence of ubiquitous access to broadband, and notes that "this representation does not depict the availability of broadband for every resident in each identified zip code area."

[47] Flamm (2006). Grubesic (2006), and Prieger (2003) also use FCC broadband data.

[48] This section of the report draws heavily on Kolko (2007). Details on the methodology for inferring broadband availability can be found there.

[49] Unlike the CPS or Pew, Forrester includes respondents' zip codes.

[50] This approach raises two methodological concerns. First, location characteristics could be capturing unobserved individual characteristics. Second, location itself could affect the demand for broadband if, for instance, people with less access to doctors or stores have greater demand for online health advice or online shopping. Kolko (2007) finds that location characteristics have a much smaller or insignificant effect on technologies other than broadband and that location characteristics strongly influence the choice of cable versus DSL, which is much more plausibly due to availability differences than to location-driven differences in underlying demand for one broadband technology versus the other. Still, it is important to keep in mind that this approach measures availability as the relationship between location characteristics and adoption, which might also be capturing some effects in addition to availability. Furthermore, this measure does not capture reasons other than zip code density and zip code income for variation in availability, such as zip-code-level topographical differences that might make some zip codes more expensive to serve.

[51] This approach implicitly captures geographic differences in broadband prices. If there is more competition among broadband providers in higher-density areas, this could result in lower prices and therefore higher adoption. The notion of "availability" used here is not just a binary measure but rather a continuous measure that captures dimensions of availability such as price and quality of service.

[52] DiMaggio et al. (2004) review the academic literature on the digital divide in complementary skills and provide more detail on the challenges researchers face in studying it.

[53] Forrester's measure of broadband refers to "high-speed Internet access" and mentions DSL and cable modem as examples. In other questions in Forrester's surveys that ask about specific technologies, broadband includes DSL, cable, fixed wireless, and satellite.

[54] That is, the coefficient on the California dummy variable in a probit regression where broadband adoption is the dependent variable falls by about half when individual demographics are included.

[55] That is, the coefficient on the California dummy variable in a probit regression where broadband adoption is the dependent variable is not significantly different from zero when individual demographics and zip code characteristics (log median income and log density) are included.

[56] Because there could be many factors unique to California that affect broadband adoption, one cannot conclude that they are irrelevant individually. For instance, if, hypothetically, AT&T had been unusually aggressive in rolling out broadband in California, but state policy made deployment more difficult than in other states, these two effects could cancel each other out. Thus, we emphasize that factors unique to California did not collectively have an effect on broadband adoption.

[57] The web-only appendix www.ppic.org/content/other/707JKEP_web_appendix.pdf presents regression results for California and also for the United States. Higher-income and higher-density zip codes have higher broadband adoption, controlling for individual characteristics, both for California and the United States. The effect of income is smaller for California than for the United States, although statistically significant in both cases. The effect of density is similar for California and the United States.

[58] These significant and positive relationships do not hold when Internet access (broadband or dial-up) is the dependent variable, or when computer ownership is the dependent variable. This is further evidence that the relationship between zip code characteristics and adoption is due to availability, since the availability of dial-up access and computer ownership do not vary geographically. Relative to the overall broadband adoption level of 47 percent, living in a zip code with a log density one standard deviation (1.72) above the mean raises the likelihood of broadband adoption by six percentage points—an amount not only statistically significant but large in magnitude as well.

[59] Table 2 shows the nine regions defined by the Economic Strategy Panel, but we have split the San Joaquin Valley into northern and southern regions, and we have split the Southern California region into Greater Los Angeles and Inland Empire. The distribution of Forrester's respondents across these regions is similar to the population distribution.

[60] That is, an F-test does not reject the hypothesis that the regional dummies all equal zero in a regression of Internet adoption (and, separately, computer ownership) on individual characteristics and regional dummies. This test does reject the hypothesis of insignificant regional dummies when broadband adoption is the dependent variable.

[61] Although this section focuses on race, ethnicity, and income, it is also a goal of California policy to consider the digital divide between people with disabilities and people without. Forrester's surveys do not ask about disability status.

[62] The Forrester Technographics survey is long, detailed, and conducted by mail, so respondents need considerable English proficiency to complete it. Furthermore, both Hispanics and African Americans are underrepresented in Forrester's survey relative to their shares in the population reported by the Census. However, the income distributions for these groups in Forrester's survey are quite close to those in the March 2005 Current Population Survey, so Forrester's sample appears to be a reasonable enough representation for us to report results.

[63] Some non-Hispanic whites, African Americans, and Asian Americans also lack English proficiency, but the English proficiency requirement should affect the representativeness of the Hispanic sample most.

[64] Because Hispanics preferring to speak Spanish are a considerable share of California's population, the overall level of broadband adoption in California rises from 55 percent among all Californians to 65 percent when these Hispanics are excluded, suggesting that the Forrester figure for English-speaking Californians would fall by up to 10 percentage points if non-English-speakers were also surveyed. These figures are higher than the Forrester figures for overall adoption in part because the PPIC survey was conducted 15 months after the Forrester survey. Also, the PPIC data, unlike Forrester data, show a gap in adoption between Hispanics preferring to speak English and whites, in part because a higher level of English proficiency would be required to complete Forrester's mail survey in English than to participate in PPIC's telephone survey in English. An earlier survey, the October 2003 *Current Population Survey*, reports that broadband adoption is 18 percent for California Hispanics who are not Spanish-only versus only 2 percent for Spanish-only Hispanics in California. Data from PPIC and the *Current Population Survey* are weighted using standard demographics to represent the population more accurately, but the figures reported here do not further adjust for demographics using a regression framework.

[65] The regression underlying this finding also controls for zip code income and density.

[66] Why might a household have broadband without a computer? Some videogame consoles, digital video recorders, and smartphones can connect directly to the Internet using cable or DSL. Households could also have broadband access for use with an employer-provided computer. In California, 80 percent of households have a computer. Among computer-owning households, 58 percent have broadband at home. Among households with broadband, 98 percent own a computer.

[67] Raising log income by one standard deviation at the mean of log income is equivalent to raising income from $48,000 to $114,000. The standard deviation of log income is .875.

[68] These results are from (1) a probit regression of computer ownership on individual characteristics and (2) a probit regression of broadband adoption on individual and zip code characteristics, conditional on computer ownership.

[69] Another strategy for increasing computer ownership is manufacturing and distributing extremely low-cost computers, which is the goal of the nonprofit One Laptop Per Child foundation, www.laptop.org. Its focus is raising computer use among children in developing countries.

Bibliography

"AT&T to Offer 'Naked DSL' for Far Less Than Before," *San Francisco Chronicle*, January 16, 2007.

Brown, Jeffery, and Austan Goolsbee, "Does the Internet Make Markets More Competitive? Evidence from the Life Insurance Industry," *Journal of Political Economy*, Vol. 110, No. 3, 2002, pp. 481–507.

California Public Utilities Commission, "Broadband Deployment in California," San Francisco, California, 2005.

California Public Utilities Commission, "Broadband Deployment in California," San Francisco, California, 2006.

"Cities Deliver Broadband for Less," *Wired News*, March 7, 2003, available at www.wired.com/news/business/0,1367,57927,00.html.

Clarke, Richard, Kevin Hassett, Zoya Ivanova, and Laurence Kotlikoff, "Assessing the Gains from Telecom Competition," NBER Working Paper #10482, Cambridge, Massachusetts, May 2004.

Clay, Karen, Ramayya Krishnan, Eric Wolff, and Danny Fernandes, "Retail Strategies on the Web: Price and Non-Price Competition in the Online Book Industry," *Journal of Industrial Economics*, Vol. 50, No. 3, 2002, pp. 351–367.

Columbia Telecommunications Corporation, "Fiber Optics for Government and Public Broadband: A Feasibility Study," prepared for the City and County of San Francisco, Columbia, Maryland, 2007.

"Companies That Fought Cities on Wi-Fi, Now Rush to Join In," *Wall Street Journal*, March 20, 2006.

Corning, Inc.,"Bridging the Last Mile: Access Network Wireline Architectures," White Paper WP 6300, Corning, New York, 2001.

Corning, Inc., "Broadband Technology Overview," White Paper WP 6321, Corning, New York, 2005.

Criterion Economics, "The Effects of Ubiquitous Broadband Adoption on Investment, Jobs, and the U.S. Economy," Washington, D.C., 2003.

DiMaggio, Paul, et al., "From Unequal Access to Differentiated Use," in Kathryn Neckerman, ed., *Social Inequality*, Russell Sage Foundation, New York, New York, 2004.

Downes, Tom, and Shane Greenstein, "Understanding Why Universal Service Obligations May Be Unnecessary: The Private Development of Local Internet Access Markets," unpublished draft, 2006.

Federal Communications Commission, *Availability of Advanced Telecommunications Capacity in the United States: Second Report to Congress*, Washington, D.C., 2000.

Federal Communications Commission, *Availability of Advanced Telecommunications Capacity in the United States: Fourth Report to Congress*, Washington, D.C., 2004.

Federal Communications Commission, *High Speed Services for Internet Access: Status as of December 31, 2005*, Washington, D.C., July 2006.

Flamm, Kenneth, "Diagnosing the Disconnected: Where and Why Is Broadband Access Unavailable in the U.S.?" unpublished draft, 2006.

Gillett, Sharon, William Lehr, and Carlos Osorio, "Local Government Broadband Initiatives," *Telecommunications Policy*, Vol. 28, 2004, pp. 537–558.

"Google Gives City Free Wi-Fi," *San Francisco Chronicle*, August 16, 2006.

Goolsbee, Austan, "In a World Without Borders: The Impact of Taxes on Internet Commerce," *Quarterly Journal of Economics*, Vol. 115, No. 2, 2000, pp. 561–576.

Goolsbee, Austan, and Peter Klenow, "Evidence on Learning and Network Externalities in the Diffusion of Home Computers," *Journal of Law and Economics*, Vol. 45, 2002, pp. 317–343.

Greenstein, Shane, and Jeff Prince, "The Diffusion of the Internet and the Geography of the Digital Divide in the United States," NBER Working Paper #12182, Cambridge, Massachusetts, 2006.

Grubesic, Tony, "A Spatial Taxonomy of Broadband Regions in the United States," *Information Economics and Policy*, Vol. 18, 2006, pp. 423–448.

Gunkel, David, "Second Thoughts: Toward a Critique of the Digital Divide," *New Media & Society*, Vol. 5, 2003, pp. 499–522.

Kolko, Jed, "Why Should Governments Support Broadband Adoption?" Public Policy Institute of California, Working Paper #2007.01, San Francisco, California, 2007.

Kuhn, Peter, and Mikal Skuterud, "Internet Job Search and Unemployment Durations," *American Economic Review*, Vol. 94, No. 1, March 2004, pp. 218–232.

Morton, Fiona Scott, Florian Zettelmeyer, and Jorge Silva-Risso, "Internet Car Retailing," *Journal of Industrial Economics*, Vol. 49, No. 4, 2001, pp. 501–519.

Morton, Fiona Scott, Florian Zettelmeyer, and Jorge Silva-Risso, "Consumer Information and Discrimination: Does the Internet Affect the Pricing of New Cars to Women and Minorities?" *Quantitative Marketing and Economics*, Vol. 1, 2003, pp. 65–92.

Prieger, James, "The Supply Side of the Digital Divide: Is There Equal Availability in the Broadband Internet Access Market?" *Economic Inquiry*, Vol. 41, No. 2, April 2003, pp. 346–363.

Prince, Jeff, "Measuring the Digital Divide: Structural Estimation of Demand for Personal Computers," unpublished manuscript, 2003.

"Public, Private Collaboration To Design Silicon Valley Wide Wireless Network," Joint Venture Silicon Valley press release, January 26, San Jose, California, 2006.

"S.F. Picks Google Wi-Fi Team," *San Francisco Chronicle*, April 6, 2006.

"Some Worries as San Francisco Goes Wireless," *New York Times*, April 10, 2006.

"Verizon's Fios Services Build Momentun," CNET, August 1, 2006, available at http://news.com.com/Verizons+Fios+services+build+momentum/2100-1034_3-6101038.html.

"What If They Built an Urban Wireless Network and Hardly Anyone Used It?" *New York Times*, June 26, 2006.

"Wi-Pie in the Sky," *The Economist*, March 9, 2006.

"With a Dish, Broadband Goes Rural," *New York Times*, November 14, 2006.

Broadband for All?

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