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Does Broadband Boost Local Economic Development?

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Summary

"Broadband" refers to high-speed Internet service that—unlike dial-up modem service—is always "on." This technology has become widely available throughout the United States. It is essential for businesses, and well over half of American households have broadband access at home.

In recognition of its importance, public investment in broadband is surging. The American Recovery and Reinvestment Act (ARRA) of 2009 allocated $7.2 billion for broadband investment and commissioned a National Broadband Plan to promote universal access, foster economic development, and achieve additional potential benefits through this technology. Several California programs also support the expansion of broadband access, especially in areas where availability is lagging.

This report assesses whether policies to raise broadband availability will contribute, as hoped, to local economic development. Our analysis relies on the fact that broadband technology has diffused unevenly throughout the United States, thus allowing us to compare economic indicators between areas with greater and less growth in broadband availability. Using broadband data from the Federal Communications Commission and economic data from several government and proprietary sources, we examine broadband availability and economic activity throughout the nation between 1999 and 2006.

Our analysis indicates a positive relationship between broadband expansion and economic growth. This relationship is stronger in industries that rely more on information technology and in areas with lower population densities. Although the evidence leans in the direction of a causal relationship, the data and methods do not definitively indicate that broadband caused this economic growth.

The economic benefits to residents appear to be limited. Our analysis indicates that broadband expansion is also associated with population growth and that both the average wage and the employment rate—the share of working-age adults that is employed—are unaffected by broadband expansion. The economic benefits to households are thus more ambiguous than they would be if employment growth also led to an increase in wages or the employment rate. We also found that expanding broadband availability does not change the prevalence of telecommuting or other home-based work. Of course, local employment growth might still raise property values and the local tax base, but in the absence of more direct benefits for residents in the form of higher wages or improved access to jobs, we can only say that the local economic development benefits of broadband are mixed.

Broadband expansion may of course offer other social or economic benefits, such as improved health care delivery. Although our study does not examine such effects, we briefly review the limited evidence of other benefits in the conclusion of the report.

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All technical appendices to this paper are available on the PPIC website:
http://www.ppic.org/content/pubs/other/110JKR_appendix.pdf

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Introduction

Since the mid-1990s, when businesses and households began to use the Internet, observers have been trying to predict—and more recently to assess—the effects of this relatively new mode of communication. Some of the early predictions about the Internet and related technologies, such as causing the "death of cities," have clearly not materialized.[1] But we still know very little about the economic effects of these technologies.

The Internet has transformed many areas of life, providing individuals and businesses with easy and instant access to communication, information, and entertainment. But it may take years before the Internet—like many other new technologies—exerts a quantifiable effect on business productivity. It takes considerable time to develop applications and adjust business processes and organizations to take full advantage of new technologies.[2]

Nonetheless, governments need to assess whether new technologies are likely to offer benefits in the public interest and whether the private sector will make the technology available and affordable enough to support public policy goals. Occasionally, governments will deem a new technology essential for achieving these goals and will support universal access, even in areas that are expensive to serve.

The federal government and the state of California, as well as other state and local governments, have made universal access to broadband service a public policy goal—the specific objective is to close the digital divide in broadband availability.[3] The phrase "digital divide" can refer to geographic inequalities in availability or to gaps in broadband adoption owing to income, race/ethnicity, education, or other inequalities in access or skills that affect the ability of individuals or businesses to take advantage of broadband's capabilities.[4] To help promote the goal of universal access, the federal government allocated $7.2 billion for broadband investment and also commissioned a National Broadband Plan as part of its 2009 American Recovery and Reinvestment Act (ARRA). These federal "stimulus" funds provided a large addition to existing state and local efforts to support broadband access.

The federal and state broadband initiatives presume multiple economic and social benefits will accrue from increasing broadband access. Local economic development ranks high among these benefits. Other benefits include improvements in health care delivery, access to education, energy efficiency, civic participation, and public safety. To date, the evidence on the extent to which broadband provides any of these benefits has been quite limited.

In this report, we are particularly interested in the relationship between broadband and economic development. Previous research has not assessed whether broadband expansion causes economic development, nor has it examined who benefits from increased economic activity; there has been little research on the effect of broadband on outcomes other than employment, output, and income. Our analysis relies on the fact that broadband technology has diffused unevenly throughout the United States, thus enabling us to compare economic indicators between areas with greater and less growth in broadband availability. In this report, we examine broadband availability throughout the nation between 1999 and 2006. Our parameters are partly determined by our

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[1] George Gilder, *Forbes ASAP*, February 27, 1995. Quoted in Mitchell Moss, "Technology and Cities," *Cityscape* 3:3.
[2] "The Broadband Myth," *The Economist*, May 23, 2008.
[3] While broadband can include satellite and high-speed mobile data services, the vast majority of households and businesses that subscribe to broadband receive their service over cable, digital subscriber line (DSL), or other technologies that use physical wires or cables to connect end-users to the Internet. Discussions about broadband availability usually refer to wireline technologies.
[4] "Digital divide" can refer to inequalities in the availability or adoption of other technologies as well. See Gunkel (2003).

data: Federal Communications Commission (FCC) data on broadband are available beginning in 1999, and our source for detailed employment data ends in 2006. We answer four questions:

1. Does employment grow faster in areas with greater broadband expansion?
2. Does the relationship between broadband and employment differ by industry or across places? For example, is it stronger for industries that are more reliant on technology or that use workers who are more technically knowledgeable? Is it stronger in places that are more isolated or in those with more amenities?
3. If there is a positive relationship between broadband and employment growth? Does broadband expansion *cause* employment growth?
4. If broadband does boost employment, who benefits? Is employment growth accompanied by a greater likelihood of employment, higher pay, increased income, or greater flexibility to be able to work from home?

Although other studies have examined broadband and economic growth, this report offers more definitive answers by using richer data and more-refined methods. We also examine questions left unanswered in previous work, such as whether broadband actually *causes* economic growth, who benefits from this growth, and whether broadband increases telecommuting and other forms of home-based work. Of course, economic development is only one of many policy concerns that must be considered when targeting broadband investments, and in our concluding chapter we briefly review the limited evidence available on other potential benefits of this technology, including improved health care delivery and overall consumer welfare.

We begin our discussion in the next chapter with a description of the national and California policies designed to increase broadband availability. We then describe the extent of broadband availability, explain why some places have better broadband access than others, and discuss the limitations of the available data. We then present our research questions, the methods we use to answer them, and the main findings of our study. We conclude with a discussion of the policy implications of our findings and then briefly review other possible effects of broadband that are outside the scope of our analysis. A technical appendix offers further details about related research and our data, methods, and results.

Broadband Policies and Goals

Broadband policy at both the national level and in California is designed to achieve multiple goals, most prominently economic development. The federal government, through Congress, the executive branch, and the Supreme Court, has shaped broadband policy through important regulatory decisions.[5] And today, federal public investment in broadband is surging. ARRA, the $787 billion economic stimulus package passed in 2009, allocated $7.2 billion to broadband investments, with a particular focus on increasing broadband availability in targeted areas to improve economic development.[6] ARRA also requires the development of a National Broadband Plan to guide broadband policy beyond the federal stimulus funds. This plan is supposed to be wide-ranging, covering numerous technologies, policy options, and goals.

Well before the current federal investment in broadband, state and local governments have subsidized and in some cases directly provided broadband services. California has several programs in place that subsidize the demand and supply of broadband. The stated goals of these policies—described in detail below—include job creation and economic growth, civic participation, public safety, education, health care, and access to government services. Like federal policies, some California initiatives are more narrowly targeted toward underserved areas and economic development goals, while other programs are focused on a wider set of concerns, such as health care and education.

In sum, broadband policy at the federal level and in California aims to achieve a wide range of goals, with a particular emphasis—especially in the federal broadband stimulus—on raising broadband availability in unserved and underserved communities in an effort to create jobs and stimulate economic growth.

The Federal Economic Stimulus and the National Broadband Plan

Signed into law in February 2009, ARRA directs two federal agencies, the Department of Agriculture's Rural Utilities Service (RUS) and the Department of Commerce's National Telecommunications and Infrastructure Administration (NTIA), to grant or lend $7.2 billion for broadband deployment and other broadband projects.[7]

ARRA directs both agencies to consider the effect on economic development when awarding funds. RUS will offer grants, loans, and loan guarantees worth $2.5 billion for broadband infrastructure projects in rural areas that lack "sufficient access to high speed broadband service to facilitate rural economic development."[8] NTIA will award grants worth $4.7 billion to states, non-profits, and broadband providers for a wider set of broadband projects—not just infrastructure projects and not just in rural areas. While economic growth and job creation are explicit goals of NTIA's funds, as is raising broadband access in unserved and underserved areas, so is improved broadband access for schools, medical facilities, other community institutions, and

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[5] 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 helped create the national regulatory framework in effect today. Under this framework, telephone, wireless, television, and Internet providers are able to compete in any market against each other, but broadband providers are not required to give competitors wholesale access to their infrastructures that would enable competitors to resell services to consumers.
[6] Of the $4 billion to be allocated in the first round of funding, 75 percent has been targeted toward infrastructure projects.
[7] Applications for broadband stimulus funds are being accepted and reviewed in multiple rounds. First round applications were due in August 2009; up to $2.4 billion of the RUS funds and $1.6 billion of NTIA funds will be awarded in this round. Subsequent rounds will award the remainder of the $7.2 billion by September 2010. Stimulus funds will be allocated by RUS through the Broadband Initiatives Program (BIP) and by NTIA through the Broadband Technology Opportunities Program (BTOP).
[8] ARRA, (H.R. 1) Title I, p. 4.

public safety agencies. Together, these two components illustrate the prominence of economic development and job creation as goals for the broadband stimulus funds, among other goals.

ARRA also requires the FCC, the national telecommunications regulator, to present a National Broadband Plan to Congress in February 2010 to guide future broadband policy. The Plan is supposed to "seek to ensure that all people of the United States have access to broadband capability" and is an acknowledgement that the broadband stimulus funds alone are "insufficient to support national broadband deployment."[9] The Plan should recommend goals and benchmarks for a national broadband strategy and for achieving eleven enumerated policy goals, including job creation and economic growth, entrepreneurial activity, and other specific targets such as consumer welfare, civic participation, public safety, education, and health care delivery.[10] The plan will thus cover a wider range of interests and technologies than the broadband stimulus funds, which are geared toward infrastructure, technology mapping, and related activities.

Broadband Policy in California

Well before the passage of ARRA, states and localities—including the state of California and some of its cities and counties—have made broadband investments through subsidies and direct provision.[11] As with federal broadband initiatives, California's broadband policy is focused on numerous goals, with economic development prominent among them.[12]

For many years, the state's primary broadband subsidy program has been the Teleconnect Fund, established in 1996, which pays half the cost of Internet access for qualified schools, libraries, community organizations, and other nonprofits, funded through a statewide fee on telephone service. The program has grown from $33 million in FY 2008–2009 to $47 million (proposed) in FY 2009–2010 and $67 million (proposed) in FY 2010–2011.[13]

Two newer programs have expanded the state's involvement in broadband infrastructure deployment. In 2006, the California Public Utilities Commission (CPUC) created the California Emerging Technology Fund (CETF), an independent nonprofit foundation. CETF has received funding for its first five years through a $60 million contribution from AT&T and Verizon, a condition of their respective mergers with telecommunications companies SBC and MCI. CETF's mission is to achieve "ubiquitous access to broadband and advanced services in California, particularly in underserved communities." The foundation seeks to promote broadband availability in rural areas, affordability and adoption in urban poor and other disadvantaged areas, and accessible technology for people with disabilities. CETF hopes to disburse $240 million over five years, supplementing its own seed money with matching funds. As of December 2008, it had awarded $20 million in grants. The largest award helped support the California Telehealth Network (CTN), which electronically connects hundreds of clinics and hospitals—primarily in rural areas and tribal lands—to medical centers. CETF's support also helped CTN win a larger grant from the FCC's Rural Health Care Pilot Program.

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[9] ARRA (H.R. 1), Section 6001 (k)(2), p. 402; FCC Notice of Inquiry 09-31, 2009, paragraph 6.
[10] The FCC's Notice of Inquiry reviews these and other current FCC activities that relate to broadband.
[11] Although the major current initiatives are sponsored at the federal and state levels, some localities in recent years have provided broadband directly through public municipal Wi-Fi (wireless) networks, fiber-optic networks, or other broadband technologies. Kolko (2007) discusses local initiatives in California.
[12] In addition to the subsidy and investment programs described in this section, California has set broadband policies through the final report of the California Broadband Task Force, created by Executive Order S-23-06 in 2006, and the 2006 Digital Video and Infrastructure Competition Act (AB 2987), which created statewide video franchises and established the CPUC's responsibility for collecting and mapping broadband data.
[13] Actual and proposed budgets are available at the CTF website, www.cpuc.ca.gov/PUC/Telco/Public+Programs/CTF/CTFList.htm.

The second new state program is the California Advanced Services Fund (CASF), which is providing $100 million over two years to subsidize broadband deployment in unserved and underserved areas; successful applicants are awarded 40 percent of total project costs for broadband infrastructure in these areas. CASF was authorized by the CPUC in 2007 and implemented in 2008 under SB 1193 (Padilla); the first projects were funded in November 2008. Whereas CETF has a broad strategy that includes infrastructure availability, adoption, applications, and technology literacy, CASF is more narrowly focused on promoting infrastructure availability in the largely rural parts of the state that lack adequate broadband. Thus, the main goal of CASF is quite similar to the objectives of the portion of the broadband stimulus funds targeted toward broadband availability in rural areas.

The funds currently available through state programs—the Teleconnect Fund, CETF, and CASF—are small relative to the sums California might expect to receive under the federal broadband stimulus program. While the state programs have budgets or plans to disburse tens of millions of dollars annually, California's share of the federal broadband funds would be over $900 million.[14] Thus, an essential element in California's current broadband strategy is to win federal broadband stimulus funds. Numerous cities, counties, nonprofits, and companies in California were among the first-round applicants for federal funds: Their grant and loan requests totaled $1.4 billion.[15] CPUC was a winner in the first round of the separate broadband mapping funds competition, receiving a $2.3 million grant in October 2009.[16]

California's expectations, like those of the federal government, are that broadband will contribute to economic development. The final report of the California Broadband Task Force, for example, lists "economic and community development" first among the ways that broadband is likely to affect California, citing the potential effect of broadband on job creation in high-tech and other industries as well as on employment in rural areas.[17] The state also expects broadband to lead to increased telecommuting and environmental benefits. In establishing its definition for "underserved" areas for CASF grant eligibility, the CPUC chose the minimum speed that would support telecommuting.[18] In turn, the California Air Resources Board cites telecommuting as one way the state government can encourage its own employees to "decrease their individual carbon impact."[19]

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[14] CETF's "Summary of ARRA Proposals" estimates California's "fair share" to be 13 percent of the federal total, proportional to the state's share of the national population.

[15] These applications have been submitted for the first round of $4 billion in federal funds, of which California's 13 percent "fair share" would be $520 million—roughly one-third of the amount that California-based organizations have applied for. Applicants are listed at www.ntia.doc.gov/broadbandgrants/applications/search.cfm (viewed on October 12, 2009). The total request in California-based applications was reported in CETF's "Summary of ARRA Proposals."

[16] The NTIA grant comes through the State Broadband Data and Development Grant Program, the program authorized by the 2008 Broadband Data Improvement Act and funded with up to $350 million from ARRA.

[17] California Broadband Task Force, "The State of Connectivity," 2008. Viewed on October 14, 2008, at www.calink.ca.gov/pdf/CBTF_FINAL_Report.pdf . Governor Schwarzenegger's official response to the request for comments on the broadband stimulus also notes the importance of economic development: "… without any broadband service, [an area's] residents are excluded from the economic development and social-economic benefits of broadband, including tele-education, telemedicine, access to health care information, access to government services and benefits, and more." See California response to BIP/BTOP request for comment, www.recovery.ca.gov/Content/Documents/California_Response_to_NTIA_on_BB_Stimulus_Grants_4-13-09.pdf, p. 12.

[18] CASF chose minimum speeds of 3 megabits per second downstream and 1 megabit per second upstream, arguing that at these speeds telecommuting becomes feasible, and lacking rapid enough connections to work from home qualified an area as "underserved." See Table 1 and California's response to BIP/BTOP request for comment, www.recovery.ca.gov/Content/Documents/California_Response_to_NTIA_on_BB_Stimulus_Grants_4-13-09.pdf.

[19] California Air Resources Board, *Climate Change Draft Scoping Plan*, June 2008, page 12.

Broadband Availability and the Digital Divide

California and federal policies seek to close the digital divide in broadband availability, placing a particular emphasis on unserved and underserved areas. ARRA and CASF define unserved and underserved in terms of whether broadband service is available and, if so, at what speed. CETF also mentions "ubiquitous access" and supporting "underserved communities" in its mission statement.

Targeting "unserved" and "underserved" areas requires defining these terms and identifying which areas qualify. Recent improvements in data collection, and planned improvements funded by ARRA, will provide policymakers with much better information on broadband availability. However, for analyzing past trends in broadband availability and the relationship between broadband and local economic development, we must rely on the less detailed data collected historically by the FCC.

Unserved and Underserved Areas

"Unserved" and "underserved," as defined for the federal stimulus funds, are an important policy statement about what constitutes adequate broadband availability. "Unserved" areas lack broadband service offering downstream speeds of at least 768 kilobits per second (kbps) and upstream speeds of 200 kbps.[20] These minimum speeds are lower than typical digital subscriber line (DSL) and cable broadband service today, which often advertise top downstream speeds of 1.5 to 6 megabits per second (mbps) and top upstream speeds of at least 768 kbps (Table 1). "Underserved" areas have either only partial service coverage at those speeds, no service at a higher speed threshold of 3 mbps downstream and 1 mbps upstream, or low adoption rates.[21]

To assess the extent of the digital divide and to help identify unserved and underserved areas, the FCC recently improved its data collection efforts, and ARRA is allocating funds for additional mapping and surveying efforts. Since December 2008, broadband providers have been required to report subscribership levels by Census tract at different speeds of service through the FCC's "Form 477" data collection process. (Form 477 data is about subscribership, and availability is inferred, based on the location of subscribers. This could result in an undercount of availability in areas where a provider has infrastructure allowing it to provide broadband service, but no subscribers.) As noted above, ARRA also seeks to provide information on unserved and underserved areas. It provides funding for the development of maps showing broadband availability and calls for the development of "a comprehensive nationwide inventory map of existing broadband service capability and availability" by February 2011. Finally, the 2008 Broadband Data Improvement Act requires the FCC to conduct consumer surveys on pricing, speed, adoption, and online behaviors, and to collect international data on broadband speeds and prices.

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[20] "Downstream" refers to data sent "down" from the Internet to an end-user, such as a downloaded file or a received email. "Upstream" refers to data sent "up" to the Internet from an end-user, such as an uploaded file or a sent email.

[21] Unserved areas consist of contiguous Census blocks where at least 90 percent of households lack access to terrestrial (i.e., not satellite or mobile phone) broadband service offering speeds of at least 768 kbps downstream and 200 kbps upstream. Underserved areas consist of contiguous Census blocks where either (1) 50 percent of households or fewer have access to terrestrial broadband service of at least 768 kbps downstream and 200 kbps upstream; (2) no broadband service offers speeds of at least 3 mbps downstream and 1 mbps upstream; or (3) 40 percent of households or fewer subscribe to broadband. Note that the standard of 3 mbps downstream / 1 mbps upstream is the level that CASF believes is necessary to support telecommuting, as mentioned in the previous section.

TABLE 1
Broadband speed illustration

Downstream speed	Relevance	Approximate time to download 3 megabyte pop song
56 kilobits/second (kbps)	Top speed of dial-up modem service	7 minutes
200 kbps	Minimum speed to qualify as "high-speed" (broadband) under historical FCC definition	2 minutes
768 kbps	Minimum speed for an area not to be "unserved" according to ARRA	30 seconds
1.5 megabits/second (mbps)	Lower speed tier advertised for many broadband (DSL or cable) services	15 seconds
3 mbps	Minimum speed for an area not to be "underserved" according to ARRA, and minimum speed CASF considers necessary for telecommuting	8 seconds
6 mbps	Upper speed tier advertised for many broadband (DSL or cable) services	4 seconds
10 mbps	Speed of advanced services available in some areas, including much of metropolitan southern California	2 seconds
100 mbps	Speed of advanced services available in very limited areas, including parts of metropolitan Sacramento	¼ second

NOTE: 1 byte equals 8 bits.

Some states, including California, have already undertaken their own mapping initiatives. Based on infrastructure data collected from providers, California publishes maps of broadband availability throughout the state, disaggregated into several speed tiers.[22] Maps dated August 10, 2009, show large rural and mountainous areas in the state without broadband access. The fastest service—more than 100 mbps—is available in parts of the Sacramento metropolitan area; service at speeds of 10–100 mbps is available throughout much of urban southern California, as well as Bakersfield and Napa and Solano Counties; and speeds of 5–10 mbps are offered in most of the Bay Area, including Silicon Valley (Figure 1). These differences demonstrate that even among places with broadband availability, speeds can vary considerably. And much of the state appears to have no service at speeds of at least 500 kbps, thus meeting the definition of unserved or underserved.[23]

[22] See maps at www.cpuc.ca.gov/PUC/Telco/Information+for+providing+service/Broadband+Availability+Maps.htm.
[23] The speed categories presented in the CPUC map (Figure 1) do not accord with the speeds that define unserved and underserved areas (Table 1), making it difficult to determine which areas qualify for federal stimulus funds based on the map.

FIGURE 1
Broadband Availability in California, August 2009

SOURCE: California Public Utilities Commission, Communications Division, Video Franchising and Broadband Deployment Group.

NOTE: Map used with permission of CPUC.

Limitations of Available Broadband Data

FCC data collected prior to the December 2008 improvements represent the best public historical information on broadband availability, and policymakers and academics have relied on these data to analyze the extent of broadband deployment and the relationship between broadband and economic and social outcomes.[24] These historical data consist of the number of subscribers at the state level, disaggregated by advertised speed of service and type of technology (cable, DSL, etc.), as well as a list of ZIP codes where the provider has at least one subscriber to "high-speed Internet service," defined as at least 200 kbps in at least one direction. Thus, the only sub-state information was the number of providers in a ZIP code with at least one subscriber, which has been published in semiannual reports back to 1999.[25]

Some caution must be exercised in interpreting these data, because many ZIP codes cover large geographic areas, and providers with a subscriber in a ZIP code might not offer service throughout the entire ZIP code. That said, these ZIP code provider-count data have two strengths for assessing policies designed to raise broadband availability. First, broadband policies are often enabled by adding providers to an area—sometimes directly through public provision and sometimes indirectly through subsidization or regulation; thus, using the number of providers as a proxy for broadband availability is meaningful in a policy context. Second, there is a reliable relationship between the number of providers in a ZIP code and the estimated extent of residential broadband availability, even though the data are imperfect. As explained in the technical appendix, the publicly available FCC data do not distinguish between providers that own the wires and cables that constitute broadband's infrastructure and those that lease and resell space on these lines to offer service; nor do FCC data indicate how much of the ZIP code each provider serves, nor at what speed. Nevertheless, related research has shown that estimated broadband availability in a ZIP code does increase when the number of providers increases, especially when the ZIP code has fewer providers to begin with.[26]

What We Know about Broadband Availability

Broadband is widely available. By December 2006, essentially all ZIP Code Tabulation Areas (ZCTAs) in the United States, including those in rural areas, had at least one provider offering service (Table 2).[27] This simple metric overstates broadband availability because providers do not always offer service throughout an entire ZIP code. Using an improved methodology that infers availability based on adoption patterns and FCC provider counts, we estimate that broadband was available to 85 percent of U.S. households and 92 percent of California households in December 2005 (Kolko, forthcoming). Looking at the number of providers, broadband availability continued to increase between 1999 and 2006, relative to its level in 1999. The average number of providers per

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[24] National broadband data collected prior to December 2008 cannot show which areas qualify as unserved or underserved, as defined for ARRA. Historically, the FCC has reported the number of providers in a ZIP code with service at speeds of at least 200 kbps in at least one direction, whereas an area qualifies as unserved if it lacks service of 768 kbps downstream and 200 kbps upstream. Thus, areas with "high-speed access" according to the historical FCC definition could still be unserved or underserved according to definitions for current broadband programs.

[25] These semiannual reports and provider count lists are available at www.fcc.gov/wcb/iatd/comp.html. Two reporting changes occurred starting in December 2005: First, providers with fewer than 250 high-speed connections were required to submit data through Form 477, whereas previously they were exempt; second, providers had to start reporting state-level subscribership by technology (GAO, 2009).

[26] Kolko (forthcoming) demonstrates the relationship between provider count and availability. This relationship suggests that the logarithm of the number of providers better approximates availability than either a linear measure or an assumption that availability reaches a maximum with one or a few providers. The appendix of this report discusses other shortcomings with FCC Form 477 data in more detail, as does GAO (2006).

[27] ZCTAs are U.S. Census Bureau approximations of U.S. Postal Service ZIP codes. ZCTAs are better suited to data analysis than ZIP codes. See the appendix for more detail about how ZCTAs and ZIP codes compare and how we converted ZIP code data to ZCTAs. "Rural" means outside a metropolitan area and accounts for roughly 20 percent of the U.S. population.

ZIP code in the nation grew from 3.4 in 1999 to 11.2 in 2006, weighted by employment. The comparable figures for California were slightly higher (5.0) in 1999 and similar (11.5) in 2006.

TABLE 2
Number of broadband providers by ZCTA

	All areas		Rural only	
	U.S.	California	U.S.	California
1999				
Average broadband provider count	1.6	2.9*	0.8	0.9
Average broadband provider count (employment-weighted)	3.4	5.0*	1.7	1.6
Percent of ZCTAs with one or more providers	63%	77%*	42%	43%
Percent of ZCTAs with one or more providers (employment-weighted)	96%	98%*	83%	81%
2006				
Average broadband provider count	6.9	8.6*	5.0	4.9
Average broadband provider count (employment-weighted)	11.2	11.5	8.3	7.4*
Percent of ZCTAs with one or more providers	99.6%	99.93%*	99.4%	99.5%
Percent of ZCTAs with one or more providers (employment-weighted)	99.97%	>99.99%*	99.94%	99.99%

NOTES: Asterisks indicate California value is different from rest of U.S. at 5% statistical significance level. "Rural" means not in a metropolitan area. See technical appendix for further definitions and details.

Since broadband appears, by these data, to be widespread, we may ask why federal and California broadband policy is focused on unserved and underserved areas. The answer is that ARRA, CASF, and other current initiatives use higher speed thresholds than the historical FCC definition of high-speed access (see Table 1). It is very likely that many areas are unserved or underserved relative to these thresholds, even if they have one or more broadband providers according to the historical FCC definition.

Thus, even though historical data on broadband availability do not show which areas qualify as unserved or underserved for the purposes of current broadband initiatives, they do reveal that broadband became available at different times throughout the country. These historical data allow us to identify areas with more and less broadband availability and whether broadband expansion was associated with economic development outcomes.

Why There Is a Digital Divide in Broadband Availability

Why might broadband be more widely available in some places than others? The primary reason is that the costs and benefits of providing broadband depend on local factors. Broadband provision requires fixed costs to extend service to an area: Much of the cost to install or upgrade telecommunications infrastructure is required "up front," regardless of the number of eventual subscribers served by that infrastructure. Thus, in order to spread the fixed costs across more subscribers, providers are more likely to serve areas with high demand for broadband. In addition, infrastructure is more expensive to deploy in some areas, such as those with steep terrain or fewer roads, as broadband lines often follow existing transportation rights-of-way. Finally, broadband availability can vary because most areas in the United States are served by a dominant telephone provider and a dominant cable television provider, and each can make different strategic decisions

about when to introduce broadband service to their regions. State policies about regulating or subsidizing broadband could also affect the level of availability.[28]

As expected, ZCTAs with higher population density, higher income, and flatter terrain had more broadband providers in 2006, holding other factors constant (Technical Appendix Table A1). Roughly half of the difference between the number of providers in California and the nation in 1999 (see Table 2) was due to differences in density, income, education, and terrain; the remainder was due to unmeasured factors, which could include state policies or the particular broadband strategies of the telephone and cable companies serving California. By 2006, the gap in availability between California and the United States had closed to a statistically insignificant difference.

The extent and reasons for the digital divide in Internet availability also depend on technology. Compared with today's main broadband technologies, cable and DSL dial-up Internet service involves lower fixed costs and did not lead to persistent geographic disparities in availability. Fiber-to-the-home, which offers speeds much faster that DSL or cable, has high fixed costs of deployment and is therefore likely to lead to a more persistent digital divide than cable and DSL (Kolko, 2007). Even if today's broadband technologies become available everywhere, digital divides in future technologies will probably appear, and "closing the digital divide" will remain a policy goal.

[28] We do not attempt to measure the effect of state policies on broadband availability because telecommunications regulations are difficult to quantify in a consistent way across states.

Research Questions and Approach

In this chapter we first discuss the questions this report addresses, explaining the underlying hypotheses and why the questions are important. We then present the empirical strategy that we use in answering these questions. We conclude the chapter with a discussion of other important questions about broadband's effects that lie beyond both the scope of our analysis and the main concerns of current federal and state policy initiatives.

Questions Addressed in This Report

Our analysis answers four questions about broadband expansion and economic growth:

1. Does employment grow faster in areas with greater broadband expansion?
2. Does the relationship between broadband and employment differ by industry or across places? For instance, is it stronger for industries that are more reliant on technology or that use workers who are more technically knowledgeable? Is it stronger in places that are more isolated or that have higher amenities?
3. If there is a positive relationship between broadband expansion and employment growth, does broadband expansion *cause* this growth?
4. If broadband does boost employment growth, who benefits? Is employment growth accompanied by a greater likelihood of employment, higher income, or greater flexibility to be able to work from home?

To answer our first question—whether the availability of broadband is associated with local employment growth—it is helpful to consider why broadband might contribute to this type of local economic development. Obviously, broadband and other information and communications technologies lower the cost of sending and receiving many forms of data, including documents and audio and video content. According to standard economic theory, lowering the cost of one input to a profit-maximizing firm has two possible effects: First, the firm raises its output; second, the firm shifts its mix of inputs toward the input whose cost went down. When the spread of broadband lowers the cost of communication, the net result of these two effects on hiring is theoretically ambiguous. The first effect—raising output—would lead most businesses to hire more labor. But the second effect—shifting toward the inputs that just got cheaper—could cause businesses to use new technology in lieu of labor for some tasks.

Our second question explores how the relationship between broadband and employment varies across industries, types of workers, and places. Again, it is useful to think about why there might be differences. Turning to industries first: Businesses reliant on information technology might increase their employment of workers skilled in using new technology and possibly even reduce their employment of others—shifting, in other words, toward labor that is "complementary" with broadband technology. Broadband would therefore have a larger positive effect on employment in industries whose workers are more skilled in using information technology. Furthermore, even if broadband expansion caused individual firms to reduce employment, economic activity could shift to locations where broadband is more widely available, raising aggregate employment there relative to other areas. Locational shifts in economic activity would be more pronounced in more "footloose" industries—those whose location is not tied to local markets or inputs.

The relationship between broadband expansion and economic growth could also vary across places. Broadband might offer greater benefit for places that are smaller or more isolated, helping local businesses or households to connect with larger markets: This line of thinking lies behind predictions that rural areas might benefit disproportionately from Internet technology. Other examples include areas that have access to a more highly educated labor market (if the more educated workers are better able to use advanced information technologies) and areas with more favorable climates and recreational opportunities (if broadband access allows firms to move further away from suppliers and customers toward locations appealing to employers and workers). [29]

At the same time, broadband expansion could lead to declines in both employment and economic output in local businesses that begin to face competition from online businesses located elsewhere. For example, broadband expansion might encourage households to purchase goods online instead of in local stores, or to download movies rather than visit their local theaters. As with the other possible links between broadband and local economic activity, the effects will vary by industry: Those businesses most dependent upon local demand, such as retailers or entertainment, are more likely to be hurt by broadband expansion, depending on how easily their customers can switch from local businesses to their online counterparts.

Turning to our third question, it is important to acknowledge that a positive empirical relationship between broadband expansion and economic growth does not, in itself, mean that broadband expansion *causes* economic growth. The reverse might actually be true if broadband providers choose to offer or expand service in areas that are growing faster. Alternatively, population growth could cause both broadband expansion and employment growth. Broadband expansion might follow population growth since more than 60 percent of broadband subscribers are households, according to the most recent FCC broadband report. Once again, this effect could vary by industry: Population growth would lead to employment growth in industries whose customers are local residents. Assessing causality is, of course, essential for predicting whether broadband policies will lead to economic development. Looking at broadband expansion and employment growth in individual industries might help clarify the relationship between broadband expansion and overall employment growth.

Our final question asks who benefits if, indeed, broadband expansion does cause economic growth. The answer depends, in part, on what happens to the population. If population growth accompanies employment growth because people follow jobs, then the likelihood of residents being employed—the employment rate—might not rise much. The effect on average pay and household incomes is unclear as well: Increased labor demand might raise wages, but if labor supply also increases, this would push wages down. Employment growth that raises the employment rate, average pay, or household incomes benefits residents; employment growth that does not might still contribute to property owners' land values or local governments' tax base, benefitting some residents but not others.[30]

It is quite plausible that targeting unserved and underserved areas for broadband expansion could raise local employment yet offer ambiguous economic returns for residents. Economists are often skeptical about "place-based" policies, which provide geographically targeted infrastructure investments; the broadband

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[29] "Why Wall Street Is Losing Out To 40 Acres and a Modem," *New York Times,* December 27, 1998, highlights the relocation of some financial operations to idyllic recreation areas like Jackson Hole and Nantucket.

[30] We do not assess the relationship between broadband expansion and property values because the time period we study (1999–2006) coincides with the large and varying house price bubbles in many local housing markets. The geographic variation in price changes during this time is probably too noisy to be a reliable measure of the geographic variation in the capitalization into land values of potential local productivity enhancements such as broadband expansion.

stimulus funds are an example of such policies. According to Louis Winnick (1966), an economist and urban development expert, "Federal programs to change the geography of output are a kind of welfare device to redistribute personal income. But at best it is a clumsy, expensive, and often inequitable device. Not only are the gains to one locality offset by losses to another, but even in the locality of gain the added income frequently goes to the wrong people. … A disproportionately large share of the increased purchasing power goes to the owners of immobile resources [e.g. property owners] other than labor."[31] Furthermore, place-based policies may end up encouraging economic activity in places where that activity might not otherwise be economically sustainable: Many of the places that are unserved and underserved by broadband are so because terrain, remoteness, or low population density raises the cost of broadband provision.[32] Yet, in defense of place-based policies, not all people can or want to leave disadvantaged places, and governments are committed to offering basic services to residents in all places.

Research Strategy

The relationship between broadband and economic outcomes at the local level is relevant for assessing policy that targets specific locations for broadband investments. As described above, broadband availability has varied across the nation, and this report takes advantage of these geographic differences to assess how the expansion of local broadband availability relates to changes in many economic outcomes.

Several other studies have also looked at the relationship between broadband and economic development. They have generally found a positive relationship between broadband expansion and employment growth and a mixed relationship between broadband expansion and income (or wage) growth. By using richer data, better measurement, and a wider range of methods, this report offers more definitive answers about the relationship between broadband and economic growth, which are generally consistent with previous work.[33] This report also examines questions left unanswered in previous work, such as causality, the effect on population, and the effect on telecommuting and other forms of home-based work.

Our research strategy consists of comparing changes in several economic outcomes with the extent of broadband expansion. To measure the expansion of broadband availability, we use the FCC's Form 477 data on the number of broadband providers in a ZIP code, as described in the previous section and the technical appendix. We match these data with economic outcomes from several other data sources:

- The change in employment provided in the National Establishment Time-Series (NETS) database, which reports employment for nearly all businesses in the United States from 1992 to 2006 and includes detailed industry and geographic information. The NETS is based on the Dun & Bradstreet business register.
- The change in employed residents, total and working-age population, average pay, and median household income, all at the county level, from the U.S. Census and other government data sources.
- The change in the likelihood of telecommuting, bringing work home, and operating a home-based business, as reported in surveys conducted by Forrester Research, a technology consultancy. Forrester surveys households annually about technology adoption and related behaviors.

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[31] Ladd (1994), in a review of research on enterprise zones, also notes that the benefits of place-based policies to non-landowning local residents are uncertain.
[32] One prominent urban economist (Edward Glaeser) argues that disaster-struck New Orleans (Glaeser, 2005) and economically depressed Buffalo (Glaeser, 2007) should be allowed to shrink, with support given directly to residents rather than to places.
[33] The appendix offers more detail on related academic and policy research.

The FCC, NETS, and Forrester all report information at the ZIP code level. ZIP code areas are small relative to counties and offer rich detail on local broadband availability and economic outcomes. But official ZIP codes, as defined by the U.S. Postal Service (USPS), change frequently over time and do not accord precisely with county boundaries, Census tracts, or other areas for which data are typically available. Furthermore, while the NETS and Forrester report actual USPS ZIP codes for businesses and households, respectively, the FCC uses its own approximation of ZIP codes. And the Census uses its own ZIP code approximation, the ZCTA (ZIP code tabulation area), for reporting selected demographic and economic measures. We converted data from all these sources to the Census ZCTA definitions to create consistent geographic boundaries across datasets and over time. Most previous research has examined the relationship between broadband and employment growth at larger geographic levels (e.g., counties or states). However, using smaller units of geography is more desirable because broadband availability can vary block-by-block. ZIP codes are the smallest geographic area for which both broadband and employment data are publicly available.[34]

We focus on broadband expansion and outcomes between 1999 and 2006. Although broadband diffusion began earlier, most growth in the number of providers occurred during this period (the FCC began reporting provider count data in 1999). These years are also most relevant as a guide to what future broadband expansion—through ARRA or other programs—might mean for economic development. The relationship between broadband (or any technology) and economic outcomes might change over the course of the technology's diffusion.[35] Policies designed to bring broadband to still-underserved areas are at the end of the broadband diffusion process (at current broadband speeds, anyway), so more recent experience is a better guide than earlier experience to what might happen in the future.[36] To further refine these insights, our analysis highlights the relationship over the period 1999–2006 in ZCTAs with the least broadband provision in 1999. Although data do not yet exist to assess whether the locations that lagged in 1999 are the same locations that remain unserved or underserved by today's policy definitions, this analysis may offer guidance for the effects of policies targeting today's unserved and underserved areas.

The first step, then, is to assess the overall relationship between broadband expansion and employment growth. We then look at whether the relationship varies by industry or type of place. Next, we try to assess causality by examining the industry-specific effects and by also using an "instrumental variable" strategy.[37] And finally, we examine other outcomes: population growth, changes in the likelihood of being employed, average pay, and household income, as well as the changing prevalence of three types of home-based work: telecommuting, bringing work home occasionally, and operating a home-based business. These additional outcomes reveal how broadband expansion relates to outcomes that households experience.

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[34] To assess the relationship between broadband expansion and employment growth, the ideal level of geography would be the exact street address because a business can have broadband access only if it is available at its exact location. The ZCTA is the smallest geography for which data are available and is therefore the level of analysis we use for employment growth. In contrast, counties are more appropriate than ZCTAs for examining household labor market outcomes because counties better approximate the size of labor markets and broadband could affect households that are in the same labor market as businesses that adopt broadband.

[35] It is ambiguous whether the economic effects, theoretically, might be larger earlier or later in the diffusion process. Early users, by taking advantage of a technology first, might grow to a scale that later users would find difficult to compete with. However, the cost of adopting a new technology can fall over time with technological improvements and knowledge from lessons learned by earlier users, which might increase the economic benefits for later users.

[36] Focusing on the 1999–2006 period also allows us to adjust for earlier trends in employment growth, because the NETS data start in 1992. Adjusting for prior trends is important because it accounts for the possibility that earlier employment growth encouraged later broadband expansion, and later employment growth might simply be the continuation of the earlier growth trend rather than the effect of broadband expansion.

[37] The instrumental variable strategy identifies a factor – in this case, slope of terrain – that affects broadband expansion without independently affecting employment growth, holding other factors constant. The relationship between employment growth and the variation in broadband expansion that is predicted by slope identifies the causal portion of the effect of broadband on growth, at least for the areas in which slope is a good predictor of broadband expansion. The appendix offers detail on this approach and the results.

Although our analysis focuses on the 1999–2006 period, there is also some value in looking at the 1992–1999 period, when broadband first became available in some areas.[38] The relationship between broadband expansion and economic growth in this earlier period may offer guidance on how policies aimed at hastening the diffusion of early-stage technologies affect local economic development, assuming that next-generation technologies that fundamentally change business processes will have the same relationship to economic activity as did current broadband technology.

Questions This Report Does Not Address

Because federal and state broadband policies are particularly focused on unserved and underserved areas, this report looks at how local broadband expansion relates to local economic outcomes. The methods used in this report and in related research examine the relationship between broadband expansion and local activity *relative to other areas*. Even if broadband had no net effect on employment growth nationally, we could still see a positive relationship between broadband expansion and local employment growth if broadband expansion shifted economic activity from some locations to others, resulting in no net gains in jobs or output. If equity is an important public policy goal, governments could still favor broadband investments that redistribute economic activity toward underserved areas.

Yet broadband policies could also affect economic activity nationally. Numerous countries have set goals not only to close the digital divide by making a minimum broadband service available to all residents, but also to support higher-speed broadband services to keep high-tech industries globally competitive (Li and Losey, 2009). In its own evaluation of broadband deployment in the United States, the FCC considers both the extent and evenness of broadband access among Americans—the digital divide—as well as comparisons with other countries, though there is disagreement about which measures accurately reflect international differences in broadband availability and, accordingly, disagreement about the international ranking of the United States.[39] It is thus challenging to estimate the net national benefits of broadband, and attempting to do so requires different methods. Although this subject lies beyond the scope of our report, we do return to the question of national benefits briefly in the conclusion, as measured by consumer willingness to pay for broadband.

Broadband may also offer benefits not fully captured in measures of output, employment, or growth. People use broadband for a wide range of activities, including many—such as sharing pictures with friends or downloading music—that might not fulfill a public policy goal, even though people value these activities. Other benefits—for example, access to news, remote medical services, or distance learning—might be public policy goals but might not be reflected in standard economic indicators such as employment, output, or income. Thus, looking at the relationship between broadband and economic outcomes might exclude some benefits of broadband that do achieve public policy goals and others that do not. Although our analysis in this report focuses on local economic development measures, we also review the limited recent research on other outcomes in our final chapter.

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[38] As the appendix explains, a methodological disadvantage of looking at the 1992–1999 period is that we have to assume that no ZIP code had any broadband providers in 1992, so the level of providers that the FCC reported in 1999 equals the change between 1992 and 1999. Another disadvantage of looking at the 1992–1999 period is that we cannot adjust for prior trends in employment because the NETS data start in 1992.
[39] FCC 08-88, Fifth Report on broadband deployment, as required by Section 706 of the 1996 Telecommunications Act, June 2008.

Research Findings

Broadband and Local Overall Employment Growth

The overall relationship between broadband expansion and employment growth, as measured by the NETS, is positive. Moving from no broadband providers to 1–3 providers (the FCC groups one, two, and three providers together in its reporting) is associated with employment growth that is higher by 6.4 percentage points over the seven-year period from 1999 to 2006 (Table 3).[40] The size of this relationship is large relative to the overall national employment growth rate, but employment growth at the ZCTA level shows wide variation, and broadband expansion accounts for relatively little of the variation in growth rates across ZCTAs.[41] The relationship between broadband expansion and employment growth is similar when looking only at areas with few or no broadband providers in 1999. As explained above, these less-well-served ZCTAs in 1999 are the best guide to the relationship between future broadband expansion and employment growth in the areas targeted today by federal and state programs to raise broadband availability. Broadband expansion is associated with a smaller but still statistically significant increase in employment growth of 3.5 percentage points in the 1992–1999 period. (Many of the results discussed in this section are shown in the technical appendix tables.)

TABLE 3
Broadband and economic outcomes, 1999–2006

	Percentage point change associated with increase in broadband availability
Employment growth (ZCTA)	6.4*
Working age population (county)	2.4*
Employed residents / working age population rate (county)	-1.2
Average pay per employee (county)	1.1
Median household income (county)	-2.4*

NOTES: Percentage changes reflect the coefficient of the change in the dependent variable, in log form, for a shift from 0 to 1–3 providers or from 1–3 to 4 providers, or equivalent changes in the log of the number of providers. Asterisks denote significance at the 5% level. Employment growth is from the NETS; remaining variables are from Census and BLS. See technical appendix for detailed explanation and complete results.

[40] Our regression analysis uses the change in broadband providers in logarithmic form, so adding more providers has a less-than-proportional additional effect on employment and other outcomes. See appendix for details.

[41] The cumulative national employment growth rate in 1999–2006, according to the NETS, was 0.1 percent, which is well below Census estimates based on business surveys (6.2%) and household surveys (7.5%). The NETS is known to undercount some employment in the most recent years, though local employment growth across counties is highly correlated between the NETS and Census business surveys, especially when looking over multiyear employment changes rather than one-year changes. See Kolko and Neumark (2007) for discussion of the NETS and its comparison to other data sources. The standardized beta of the relationship is .08, meaning that a one standard-deviation increase in broadband availability is associated with a .08 standard deviation increase in employment growth. See appendix for details.

Broadband and Employment Growth across Industries and Places

The relationship between broadband expansion and employment growth varies across industries. The positive relationship is especially large for utilities; information; finance and insurance; professional, scientific, and technical services; management of companies and enterprises; and administrative and business support services. The relationship in these sectors is much larger than the relationship for overall employment (Table 4) and is positive and statistically significant for all but two sectors: mining and public administration.

TABLE 4
Broadband and industry employment growth, 1999–2006

Employment growth	Percentage point employment change associated with increase in broadband availability	Highest share of technology inputs	Highest share in computer occupations	Employment location most tied to population
Management of companies and enterprises (55)	40.8***	X	X	
Utilities (22)	16.7***		X	
Professional, scientific, and technical services (54)	16.4***	X	X	
Finance and insurance (52)	14.8***		X	
Administrative and business support services (56)	14.1***	X		
Information (51)	12.0***	X	X	
Construction (23)	11.8***			X
Agricultural, forestry, fishing, and hunting (11)	11.6***			
Real estate and rental and leasing (53)	10.2***			X
Accommodation and food services (72)	9.9***			
Transportation and warehousing (48-49)	8.6***			
Health care and social assistance (62)	7.4***			
Wholesale trade (42)	7.1***			
Other services (81)	7.1***			X
Mining (21)	6.6			
Retail trade (44-45)	6.5***			X
Manufacturing (31-33)	6.3**			
Educational services (61)	6.1***	X		X
Arts, entertainment, and recreation (71)	5.7**			
Public administration (92)	0.5			

NOTES: Numbers in parentheses are the NAICS codes for the industry sector. Industries are ranked by the employment change associated with increased broadband availability. Percentage changes reflect the coefficient of the change in the dependent variable, in log form, for a shift from 0 to 1–3 providers or from 1–3 to 4 providers, or equivalent changes in the log of the number of providers. Asterisks denote significance at the 5% level. Employment growth is from the NETS. See technical appendix for detailed explanation and complete results.

The relationship between broadband and employment tends to be stronger in industries where information technology (IT) services (Internet publishing, telecommunications services, data processing, and related services) represent a larger share of an industry's inputs. These industries include: information; professional, scientific, and technical services; management; administrative services; and educational services. Of these, all but educational services are among the industries whose employment growth shows the strongest relationship with broadband expansion. In addition, industries with a larger share of employees in computer specialist occupations tend to show a stronger relationship between broadband expansion and employment growth. Utilities; information; finance and insurance; professional, scientific, and technical services; and management had a higher share of employees in these occupations, and all five of these industries are among those showing the strongest relationship between broadband expansion and employment growth.[42] In sum, industries that rely more on technology inputs and on workers in computer specialist occupations—the industries that should benefit more from broadband—are those in which broadband expansion is associated with stronger employment growth.

A possibility raised above is that some businesses could be hurt by broadband expansion if online services compete with traditional businesses. Retail is one example, if people with broadband access choose to shop online instead of at local retailers. Another could be the arts, entertainment, and recreation industry, which could see less local demand for live or on-site events if broadband makes online substitutes available. Both of these industries show weaker relationships between broadband expansion and employment growth, relative to other industries.

The relationship between broadband and employment growth is also stronger in some places than others. For example, the relationship is stronger for ZCTAs with lower population density (and, conversely, weaker for those with higher density)—consistent with the theory that smaller or more isolated areas may benefit more from high-speed connections, giving businesses in these areas access to larger markets. However, even for most high density areas, the relationship between broadband and growth remains positive on balance, just not as large as for lower-density areas. None of the other place characteristics—such as having a more educated workforce, having a better climate, or being a vacation destination—affects the relationship between broadband expansion and employment growth (Technical Appendix Table A4).

Does Broadband Expansion Cause Employment Growth?

A crucial question for broadband policy is whether broadband expansion *causes* employment growth: If so, then policies to make broadband available should result in local growth. Conceivably, a positive relationship between broadband expansion and employment growth could arise for other reasons. For example, if broadband providers expand in locations where they anticipate future growth, then the positive relationship would in part or entirely reflect this strategic decision of providers rather than a causal effect of broadband on growth. Alternatively, population growth could cause both broadband expansion and employment growth: Broadband providers could invest in areas where population (and therefore demand for broadband) is growing, while at the same time population growth could cause employment growth in industries (such as retail, restaurants, and personal services) that serve local populations.

[42] The appendix explains these two industry-level measures of technology intensity. "Inputs" are based on the Bureau of Economic Analysis's input-output tables, which describe the types of inputs– including IT services–each industry uses in producing its output. Occupational data, by industry, are from the Bureau of Labor Statistics.

Our results seem to rule out the idea that broadband providers are explicitly targeting areas where they expect higher economic growth: Later employment growth does not predict earlier broadband growth. The evidence also indicates that population growth is not the main driver. Adjusting the analysis for population growth changes the relationship between broadband expansion and employment growth only minimally: The boost to employment growth falls from 6.4 to 5.0 percentage points but remains statistically significant (Technical Appendix Table A2). Furthermore, the sectors whose employment is most tied to population are not those that show the strongest relationship between broadband expansion and employment growth.[43] Jobs tend to locate where people do in industries such as construction, real estate rental and leasing, education, retail trade, and other personal services; these industries are not among those in which employment grows most where broadband expands (see Table 3).

A more technical assessment of causality uses the instrumental variable approach described above, in which slope of terrain in a ZCTA is used as proxy for broadband expansion that should not have any independent relationship with employment growth.[44] Using this approach, the relationship between broadband expansion and employment growth remains positive and statistically significant, suggesting a causal relationship. However, using this approach, the size of the relationship appears implausibly large and is quite sensitive to how the regression model is specified, which makes us less confident in this result (Technical Appendix Table A5). This approach, therefore, is only modestly suggestive that broadband expansion causes employment growth.

These different approaches, though not definitive, generally point in the direction of a causal relationship and suggest that broadband expansion leads to large increase in local employment growth.

Broadband and Household Outcomes

To assess how the employment growth associated with broadband expansion benefits households, we consider key labor market outcomes. First, we look at the employment rate: the percentage of working-age residents that are employed. Other important outcomes are average pay per employee and median household income, which could change with employment growth because of changes in labor demand, labor supply, or the composition of the workforce.[45] Finally, we consider whether broadband availability facilitates working from home.

Broadband expansion has no statistically significant relationship with the employment rate. As discussed above, it does not appear that population growth causes both broadband expansion and employment growth. Rather, people may be following jobs: The employment growth associated with broadband expansion could encourage people to move to areas where employment opportunities are expanding. Furthermore, although most people work in their county of residence, some people commute across county lines. In counties where many employees live elsewhere or where many residents work elsewhere, broadband expansion is associated with an increase in employment but not in the number of employed

[43] The appendix explains this industry-level measure of whether employment is tied to population, which is based on the similarity between the geographic distribution of employment in an industry and the geographic distribution of population.
[44] As the appendix explains, the regression includes variables such as road density that, if omitted, could lead slope and employment growth to have a direct relationship and would invalidate this approach.
[45] The analyses of household outcomes look at the county, rather than the ZCTA, level. Although businesses should be directly affected by broadband expansion only at their exact address, increased demand for employment could benefit workers throughout a labor market, and counties—which are almost always larger than ZCTAs—are a better approximation of labor markets than ZCTAs.

residents. In other words, some new jobs associated with broadband expansion aren't filled by local residents: Employment opportunities attract people who are willing to move or commute. [46]

Broadband expansion is associated with no change in average pay per employee and a decrease in median household income. The results for counties with less broadband availability in 1999—the group which may be most comparable to the places that current broadband policy targets—are similar: There is no relationship between broadband expansion and either the employment rate or average pay per employee. In sum, whatever positive effects broadband may have on employment growth, it did not result in either higher employment rates or higher pay for residents in areas where broadband expanded during the period 1999–2006 period. As described above, these residents may benefit indirectly from employment growth in their county if that growth raises the local tax base or property values, but they do not benefit directly in terms of greater likelihood of being employed or higher earnings or income. Residents who rent, and therefore might have to pay more for housing when property values rise, could possibly become worse off economically from employment growth that raises neither the employment rate nor average pay per employee.

The household outcomes reveal a difference between the earlier and later time periods of broadband's diffusion. In contrast to the later period, broadband expansion from 1992 to 1999 showed positive and statistically significant relationships with average pay per employee, median household income, and the employment rate (Technical Appendix Table A6). One possible explanation is that businesses that adopted broadband earlier faced a labor market where computer skills were less widespread than in later years; these early adopters might also have had to hire workers with more advanced skills if they had to develop more applications in-house to integrate a nascent and fundamentally new technology into their business processes. Later adopters could rely more on off-the-shelf mass-market applications that workers with more modest technology skills could use.[47] If the supply of workers with the appropriate technology skills were more limited in the earlier period, that could result in both higher increases in the employment rate and in average pay per employee in areas with greater broadband expansion.

Finally, we examine the link between expanded broadband availability and the likelihood of working at home. At-home work could benefit households by giving them (and their employers, in the case of telecommuting) more flexibility. We find no relationship between broadband expansion and all three types of home-based work: (i) having a formal relationship with an employer to work at home at least one day a week (which the survey refers to explicitly as "telecommuting"); (ii) bringing work home to do outside of normal work hours; and (iii) operating a business from home (Technical Appendix Table A7). Even for the types of people whose jobs or skills might lend themselves more easily to home-based work—people with college degrees or in managerial or professional occupations—there was no relationship between broadband expansion and changes in doing home-based work.

The absence of a relationship between broadband expansion and home-based work may seem surprising, yet recent experience shows that telecommuting—even in places where technology makes telecommuting possible—is rarer than some have expected. One reason for this might be that communication with remote workers through "telepresence" or other video communications often involves expensive hardware and

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[46] Note that the number of employed residents and the employment rate (reported by the Census) are based on whether residents of a county are employed, regardless of where their employer is located. In contrast, employment growth (reported by the NETS) is based on where businesses are located, regardless of where their employees live. See appendix for further discussion.

[47] The NETS data provide information on the number of employees in a business but no information about their education or skill level. Data on the characteristics of workers in firms adopting broadband technology at different stages of broadband diffusion would help assess these conjectural explanations.

much faster broadband connections than the minimum speeds that qualify as "broadband." Recall that the speed necessary for telecommuting according to the CPUC—3 mbps downstream—is fifteen times faster than what qualifies as broadband in the historical FCC definition. Another plausible explanation is that corporate culture can deter telecommuting, even if all of the requisite technology is available: Telecommuters often feel invisible to their employers, and managers often feel a loss of control and uncertainty about the output of remote workers.[48] The relationship between broadband and telecommuting could change, however, with the development of low-cost, high-quality video technology and management styles more conducive to remote work.

[48] "Home Warriors: Telecommuters Need More Than E-mail and a Broadband Connection," *The Economist*, July 25, 2008. "Top 10 Myths About Mobile Work," Sun Microsystems Open Work Services Group White Paper, 2008.

Implications and Conclusion

What the Results Mean for Broadband as Local Economic Development Policy

The findings indicate a positive relationship between broadband expansion and employment growth (Table 5). The evidence suggests that broadband may have a causal effect on employment growth: The relationship is strongest in more technology-reliant industries, and population growth does not appear to be the trigger, which was the most plausible alternative explanation to a causal relationship because most broadband subscribers are households, not businesses.

TABLE 5
Summary of findings

Economic outcome	Relationship with broadband	Possible reason
Employment	Positive and big	Broadband expansion causes existing businesses to expand or redistributes economic activity toward the area
Working-age population	Positive	People are mobile and move to where employment opportunities are expanding
Employment rate (employed residents / working-age population)	None	Because people are mobile or willing to commute, labor supply grows along with labor demand, and businesses need not pay a large premium for basic technology skills
Average pay per employee	None	
Median household income	Negative	
Telecommuting	None	Home-based work requires faster speeds than the minimum that qualifies as broadband, and many corporate cultures are not well-suited to telecommuting
Bringing work home	None	
Having home-based business	None	

NOTE: Employment data are from NETS; population, employed residents, employment rate, average pay, and median household income data are from Census/BLS; telecommuting, bringing work home, and having home-based business data are from Forrester.

However, the large increase in employment growth associated with broadband expansion does not necessarily benefit local residents. Areas with faster broadband expansion between 1999 and 2006 experienced no greater increases in either the employment rate—employment as a share of the working-age population—or in average pay per employee, relative to other areas, and median household income declined. One possible explanation for this is that broadband does indeed lead to employment growth, which encourages people to move or commute to areas where employment opportunities have expanded, and this increase in the local labor supply prevents the increased demand for labor from raising either the employment rate or average pay. Employment growth might still raise local property values and tax bases, but in the absence of more direct benefits for residents, the economic development benefits of broadband are ambiguous. As discussed above, place-based policies—for example, targeted broadband infrastructure investments—often involve uncertain economic benefits for residents.

This debate surrounding place-based policies such as broadband infrastructure investment, along with our finding that broadband expansion raises neither the employment rate nor the average pay of residents, begs the question of whether public money designated for broadband infrastructure might have a larger effect on

economic or social outcomes if the funds were allocated instead toward subsidizing broadband adoption or other needs of disadvantaged households, regardless of where they live. There is no easy answer; but it depends to some extent on the contribution of other potential benefits of broadband, which we discuss below, and how much society values investment in disadvantaged places.

One caution with regard to our findings is that the best publicly available data on broadband's diffusion—the FCC's count of providers in a ZIP code—is an imperfect measure of availability. Although the provider count measure we use in our study is a good proxy for availability and an improvement over previous studies, it does not take broadband speed into account, which can vary considerably across different locations. This limitation may be especially relevant for our finding of no association between broadband expansion and any of three types of home-based work, including telecommuting. While broadband service that meets the minimum speed in FCC's historical definition of broadband may not raise the prevalence of telecommuting, future broadband services that support videoconferencing and other "telepresence" applications might do so. Better broadband data will make the relationship between broadband speed and economic outcomes clearer in future research.

Improving Data for Measuring and Evaluating Broadband

The federal stimulus includes significant funds for broadband mapping and data collection, and the National Broadband Plan has the potential to propose additional forms of broadband research. We recommend two research directions to further the understanding of broadband and its effects. First, we should not only measure the availability, adoption, and use of broadband but also identify potential benefits of broadband and assess whether broadband diffusion is meeting those goals. ARRA is focused on measuring access to broadband but not its effects. Second, although the FCC has already begun to collect better data on broadband availability since December 2008, earlier data on broadband availability—including the data we use in this report—could be much improved with better geographic specificity and information about speeds. To the extent that the FCC or other agencies have collected these data in the past but have not made them publicly available, they should do so. With a better understanding of where exactly and at what speeds broadband became available, researchers can more accurately assess the relationship between broadband and economic development and other outcomes—and offer better guidance to policymakers about how to maximize the benefits of future broadband policies.

Other Possible Benefits of Broadband

Although economic development is a primary goal of ARRA and other initiatives seeking to raise broadband availability, ARRA, in the National Broadband Plan, directs the FCC to consider other possible benefits of broadband, including consumer welfare, health care, education, civic participation, government services, energy independence and efficiency, and public safety. [49] Very few studies have examined the effect of broadband on these other outcomes.[50] The most compelling research in these areas either estimates the consumer welfare of broadband based on demonstrated willingness to pay for service or considers how switching from dial-up to broadband Internet access changes online behaviors.

The research on consumer welfare tries to place a dollar value on broadband access, based on what consumers are willing to pay. Yet estimates vary wildly because of different assumptions about how many residents value their home broadband connections well above the $30–50 per month that many households pay, and how much these people would actually be willing to pay. The estimates of the consumer benefit of broadband range from a few billion dollars per year to hundreds of billions per year, with little way to assess which assumptions about consumer willingness to pay are more accurate.[51] Yet even if it were possible to pin this number down, people might value broadband for activities without any clear public benefit, such as downloading music, rather than for activities often believed to be in the public interest, such as increasing civic participation. To answer the policy question of why government should support broadband, the fact that consumers want broadband is not enough; consumers value many goods and services, such as cars and cable television, which governments do not subsidize. The case for government support of broadband depends on what consumers use broadband for and what effects broadband has.

Recent research shows that people switching from dial-up to broadband spend more time using the Internet but that only some online behaviors change (Kolko, 2009).[52] Switching to broadband increases the likelihood and intensity of several activities that do not fall under goals promoted by broadband policy: downloading music, purchasing products online, and visiting adult entertainment sites. Among "socially desirable" online activities that do fall under these goals, the only activity that increases is researching health information. There is no change in visits to job or career websites or government websites, including civic participation activities such as getting information about public hearings or contacting elected officials. Changing online behaviors will not necessarily lead to better social outcomes. For example, researching health information online will not necessarily enable people to live longer or healthier lives. But it is difficult to see how broadband will come to affect policy goals such as civic participation without changing online behaviors.

Other research has identified improved health care as a realistic benefit of broadband. One study estimates that broadband will save $30 billion per year in reduced medical costs and reduced institutionalization due to electronic medical records, remote monitoring of health indicators, and other health applications that depend on broadband (Litan, 2005). Policies have already begun to reflect these possible benefits of

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[49] The FCC's Notice of Inquiry asks whether broadband could contribute to energy independence and efficiency through teleworking, a "smart" electricity grid, or "intelligent" highways that monitor traffic. Fuhr and Pociask (2007) suggest numerous ways that broadband and other information technologies could achieve environmental and energy goals, including better supply-chain management, fewer printed materials, and reductions in driving and business travel.

[50] Some research has looked at the relationship between Internet access in general and outcomes such as community participation and social ties, racial discrimination in retail transactions, book prices, and other outcomes, but not at broadband specifically. Since dial-up access has long been available throughout the United States, the relevant question for policy is the effect of having broadband access relative to having dial-up access. Studies looking at the effect of Internet access generally do not help us understand the marginal effect of broadband.

[51] See the appendix for more detail on willingness-to-pay estimates by Crandall, Jackson, and Singer (2003) and Greenstein and McDevitt (2009).

[52] Other studies, including Anderson (2008) and Hitt and Tambe (2007), also found that broadband adopters increase their time online, but the researchers' methodology did not allow them to identify effects on specific online activities.

broadband on health. CETF's largest award to date has been to the California Telehealth Network (CTN), connecting clinics, hospitals, and medical centers throughout the state. At the federal level, the FCC's Rural Health Care Pilot Program began in 2007 to allocate over $400 million for broadband infrastructure and design for health care purposes; this program also supports CTN.

Although we point to health care as a potential area of benefit, the evidence so far is based primarily on online behaviors. Further studies are needed to assess the relationship between broadband availability and social outcomes, even if these effects are too long-term to be immediately measurable: health outcomes could include illness incidence or mortality rates; education outcomes could include attainment of a high school diploma or college degree.

If future studies show evidence of broadband's benefit for health or other social outcomes, broadband policies could consider weighing multiple criteria in determining which geographic areas might benefit the most from closing the digital divide. For instance, policies could explicitly take into account not only which areas have the least broadband availability, but also which areas have the most pressing need for improvements in health care or another outcome that future research discovers is improved by increasing access to broadband.

Broadband: The Next Generation

Federal and state broadband policies seek to invest in broadband in underserved areas to close the digital divide. Yet closing the digital divide is not the only broadband policy that could affect economic development outcomes; and policies that support and hasten early-stage rollout of next-generation technologies, such as extremely fast fiber-to-the-home or new technologies that affect business processes, could have different economic development outcomes than those we report.

What does appear certain is that even if the United States achieves the policy goal of ubiquitous broadband availability at current speeds, and the current broadband digital divide closes, new digital divides will open. Fiber-to-the-home, for example, is likely to promote even more extreme geographic disparity in availability than current broadband because the fixed costs of provision are so high (Kolko, 2007). Recent maps of broadband availability in California already show disparities across the state in available speeds. As average speeds increase, new applications develop that take advantage of—and require—these higher speeds, making what may have been an adequate broadband connection in the past inadequate for applications deemed in the future to be important for participating in the economy or society. Federal and state governments might again consider policies to increase the availability of new technologies in less-well-served areas, expecting specific economic or social benefits from the expansion of the new technology. Our research on recent broadband expansion shows that technologies that contribute to local employment growth might not, in fact, benefit local residents; and we must carefully consider who would ultimately benefit from public investments in next-generation broadband and other new technologies.

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