

# **Measuring Broadband's Economic Impact**

Final Report

Prepared for the U.S. Department of Commerce,  
Economic Development Administration

National Technical Assistance, Training, Research,  
and Evaluation Project #99-07-13829

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# Measuring the Economic Impact of Broadband Deployment



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## Executive Summary

Does broadband Internet access matter to the U.S. economy? Given how recently broadband has been adopted, little empirical research has investigated its economic impact. The analysis presented in this report represents a first attempt to measure the impact of already-deployed broadband technologies by applying controlled econometric techniques to data on broadband availability and economic performance for the entire U.S. In other words, this study differs from others in its definition of broadband as a here-and-now technology, its use of controlled statistical techniques, and its geographic scope encompassing the entire U.S. **The results support the view that broadband access does enhance economic growth and performance, and that the assumed economic impacts of broadband are real and measurable.**

We find that between 1998 and 2002, communities in which mass-market broadband was available by December 1999 experienced more rapid growth in employment, the number of businesses overall, and businesses in IT-intensive sectors, relative to comparable communities without broadband at that time. The analysis did not find a statistically significant impact of broadband on the average level of wages; however, the effects of broadband availability by 1999 can also be observed in higher property values in 2000.

These conclusions are based on a cross-sectional panel data set of communities across the United States, segmented by zip code, that we constructed and analyzed for this project. The data set matches broadband availability data from the Federal Communications Commission's Form 477 with demographic and other economic data from the U.S. Population Censuses and Business Establishment Surveys. The analysis differentiated 22,390 zip codes by their broadband availability as of December 1999, then compared economic indicators over a long enough period to see if consistent deviations from the secular trend were observable, while controlling for community-level factors known to influence broadband availability and economic activity, such as income, education levels, and urban vs. rural location.

The analysis reported in this study is necessarily preliminary; additional data and experience are needed to confirm broadband's impacts on the economy. The magnitude of impacts estimated by our models are larger than we expected, and given the many data limitations present at this early stage of the broadband transition, cautious optimism is advised in interpreting the numerical estimates. Economic development practitioners and government policy makers can contribute to the refinement of these results by participating in activities and programs designed to improve the availability of localized data on broadband usage and other economic indicators.

For most of the impacts studied here to appear, broadband had to be used, not just available. The implication for economic development professionals is that a portfolio of broadband-related policy interventions that is reasonably balanced (i.e., also pays attention to demand-side issues such as training) is more likely to lead to positive economic outcomes than a single-minded focus on availability.

The positive direction of broadband's impacts was found to be robust across the different models tested at the zip code level, including models of economically distressed areas such as the Appalachian region. Our findings thus support the conclusion that broadband positively affects economic activity in ways that are consistent with the qualitative stories told by broadband advocates. Economic development practitioners who have been spending their time or money promoting broadband have indeed been engaged in a worthwhile pursuit. Many significant programs are in place or under consideration at the federal, state, and local levels to ensure competitive availability of broadband to all U.S. citizens, stimulate ongoing investment in broadband infrastructure, and facilitate the education and training that small business and residential customers need to make effective use of broadband's capabilities. Such policies are indeed aimed at important goals. Broadband is clearly related to economic well-being and is thus a critical component of our national communications infrastructure.

## Does broadband Internet access matter to the U.S. economy, and if so, how much?

Empirical estimates of broadband’s impact are an important input to investment decisions related to economic development. Such estimates can, for example, help predict potential benefits obtainable from government investments that directly or indirectly subsidize broadband deployment or use. Examples of such investments – in place or proposed at the federal and state levels – include targeting of Universal Service Funds toward broadband; the broadband loan program of the U.S. Department of Agriculture; digital divide grants; and technology-led economic development programs. At the level of local government, an estimate of broadband’s likely impact can inform a community’s evaluation of the case for public sector investment in broadband-related programs.

The analysis presented in this report represents a first attempt to measure the impact of *already-deployed broadband technologies* by applying *controlled econometric techniques* to data on broadband availability and economic performance *for the entire U.S.* The results support the view that broadband access *does* enhance economic growth and performance, and that the assumed economic impacts of broadband are real and measurable. Economic development professionals who have been spending their time or money promoting broadband have indeed been engaged in a worthwhile pursuit.

### Results

The analysis conducted for this study found that between 1998 and 2002, communities in which mass-market broadband was available by December 1999 experienced more rapid growth in employment, the number of businesses overall, and businesses in IT-intensive sectors, relative to comparable communities without broadband at that time.

The analysis did not find a statistically significant impact of broadband on the average level of wages; however, the effects of broadband availability by 1999 can also be observed in higher property values in 2000.

Empirical estimates of the magnitude of these impacts are shown in Table 1. Broadband’s impact on the number of jobs and business establishments was particularly large relative to our expectations. While increases on the order of 1% may not appear large at first glance, in fact these figures represent increments to growth rates that are typically in the single digits. For example, in the overall sample of communities we tested, jobs grew on average by only 5.2% between 1998 and 2002. Thus even a 1% increase attributable to broadband represents a noticeably large impact.

These conclusions are based on a data set that we constructed and analyzed for this project, drawn from the sources shown in Table 2. The essence of the study’s design was to differentiate geographic areas by their availability or use of broadband, then compare economic indicators for these areas over a long enough period to see if consistent deviations from the secular trend were observable, controlling for other factors known to distinguish among the areas. As discussed further below and in Appendix IV, both state- and zip-code-level analyses were conducted, but only the zip-code-level analysis yielded meaningful results.

The remainder of this report proceeds as follows. We begin with an overview of the research challenges involved in measuring broadband’s impact at this early stage of transition to this new form of communications infrastructure. In this context we explain how broadband is defined and measured for the purposes of the analysis, and how the present study builds on and extends previous related work.

We then provide an overview of the methods we used to arrive at the results presented in Table 1. We discuss the

Table 1: Estimated Magnitude of Broadband’s Impacts<sup>1</sup>

Economic Indicator	Results
Employment (Jobs)	Broadband added about 1-1.4% to growth rate, 1998-2002
Business Establishments (Proxy for Number of Firms)	Broadband added about 0.5-1.2% to growth rate, 1998-2002
Housing Rents (Proxy for property values)	More than 6% higher in 2000 in zip codes where broadband available by 1999
Industry Mix	Broadband added about 0.3-0.6% to share of establishments in IT-intensive sectors, 1998-2002
	Broadband reduced share of small (<10 employees) establishments by about 1.3-1.6%, 1998-2002

Table 2: Data Sources

Type of Data	Description	Availability	Source
Business Activity Indicators	Used for employment, establishments, wages (payroll), industry sector and size mix. Reported at zip code level; aggregated for state-level analysis.	Collected annually; most recent data from 2002. Industry sectors coded by SIC (1994-7) and NAICS (1998-2002).	U.S. Census Bureau -ZIP Code Business Patterns (ZCBP) <sup>2</sup>
Demographic Indicators / Controls	Used for income, rent, educational attainment, and # of households. Reported at both zip code and state level. Also used to compute % of population in urban areas for state-level analysis.	Collected every 10 years; most recent data from 2000.	(1) U.S. Census Bureau - 2000 Decennial Census (2) GeoLytics – CensusCD (“1990 Long form in 2000 boundaries”) <sup>3</sup>
Geographic Controls	Used to indicate how urban or rural a zip code is, based on its population and proximity to metropolitan areas.	Computed every 10 years; most recent coding from 2003.	Economic Research Service, U.S. Department of Agriculture - Urban Influence Code (UIC) <sup>4</sup>
Broadband Metrics	Reports number of high-speed Internet providers by zip code, and number of lines in service by state.	Collected every 6 months (end of June and December) since 12/1999.	U.S. Federal Communications Commission - Form 477 databases <sup>5</sup>

hypotheses we formulated and the approaches we used for testing them statistically against the available data.

The body of the report concludes with a discussion of the implications of our results for broadband-related economic development policies.

Further details are incorporated into five appendices, the first of which provides biographical details for the authors. Appendix II provides further detail on data issues, including limitations imposed by the data sources available for use in the study. Appendix III specifies the econometric models used for the analyses. Appendix IV provides tables with all of the detailed regressions results and discusses their interpretation.

Finally, Appendix V discusses the results of applying the techniques developed in this study to the Appalachian Region, as a test of whether broadband has differential impacts in areas that are more economically distressed. This regional analysis finds positive directions of economic impact that are consistent with the nationally scoped study. In particular, the results suggest that the magnitude of broadband’s impacts on employment are even larger in distressed areas. Additional analysis is warranted to understand the sources of this difference.

### Research Challenges

Measurement of broadband’s economic impacts poses many challenges. Foremost among these is the need to define what is meant by broadband and to develop a corresponding metric for use in the analysis.

While many previous studies have been based on a forward-looking definition of broadband (e.g. access at speeds on the order of 100 Mbps), the empirical nature of the present study dictated a definition consistent with the broadband capabilities that were reasonably widely deployed in the U.S. during the years under study (1998-2002). We therefore found it appropriate to use the Federal Communications Commission’s “high-speed” classification to define broadband: any line with a speed higher than 200 Kilobits per second (Kbps) in at least one direction.

Adopting this definition allowed us to use the FCC’s Form 477 data – the richest publicly available source we are aware of – to develop broadband metrics suitable for distinguishing among communities. Ideally, we would be able to differentiate by a community’s actual use of broadband, since use is a prerequisite for most forms of economic impact. However, the FCC’s data limited our metric to broadband availability at the zip code level, because the FCC only reports lines in service (a metric easily converted to penetration) at the state level. Although we do not expect availability to serve as a perfect proxy for broadband use, this metric is the best available at the zip code level.

Other challenges arise from broadband’s relative novelty, from the general problems encountered when trying to measure impacts from any type of information technologies, and from the need for localized data. Widespread availability and use of inexpensive, always-on, faster-than-dialup access to the Internet is a relatively recent phenomenon in the U.S.

The first commercial deployments appeared only in the second half of the 1990s. About a third of U.S. households subscribed to broadband by 2004.<sup>6</sup> National economic data is only now becoming available to examine whether broadband actually does act on the economy in ways that have generally been assumed – accelerating growth, expanding productivity, and enhancing the quality of life.

Measuring the economic impact of broadband confronts the same types of measurement challenges that led to the so-called Productivity Paradox of Information Technology (IT), best articulated by economist Robert Solow’s famous quip that we see computers everywhere but in the productivity statistics. Broadband does not act on the economy by itself, but in conjunction with other IT (primarily consisting of computers and software during the period studied here) and associated organizational changes. As with computers, the effects of broadband may be strongest in service (i.e. non-farm, non-manufacturing) industries, where productivity improvements are typically less well captured by economic data.

Finally, for many of its hypothesized modes by which broadband might effect the economy, there is no available data which would allow measurement of its impact. Early studies suggested that broadband should make individuals and businesses more productive through behaviors such as online procurement and telecommuting. Data is generally not available, however, to observe these behaviors at the local level across the entire nation.

### Relation to Previous Studies of Broadband’s Economic Impact

Many of these challenges are reflected in the progression of empirical work to date. The first generation of studies appeared in 2001-2, before broadband had been significantly adopted in the United States. These studies were of necessity hypothetical and forward-looking. As a report from the U.S. Department of Commerce aptly put it at the time: “Because broadband technologies are so new (and continue to evolve), there are no definitive studies of their actual impact on regional economic growth and tech-led economic development. Of course that never prevents economists and technologists from speculating or estimating.”<sup>7</sup>

A well-known report from this period was prepared for Verizon by Criterion Economics.<sup>8</sup> It developed several forward-looking models to estimate broadband’s economic impact. The study estimated that broadband, acting through changes to consumers’ shopping, commuting, home entertainment

and health care habits, would contribute an extra \$500 billion in GDP by 2006.

Other forward-looking studies from the time include the New Millennium Research Council’s estimate of 1.2 million jobs to be created from the construction and use of a nationwide broadband network.<sup>9</sup> Similarly, a Brookings Institution report estimated that failure to improve broadband performance could *restrict* U.S. productivity growth by 1% per year or more.<sup>10</sup>

By 2003, studies started becoming available based on the experiences of individual communities. One was a case study of a municipal fiber network built in 2001 in South Dundas Ontario. It was prepared for the UK’s Department of Trade and Industry.<sup>11</sup> Similarly, a study compared Cedar Falls, Iowa, which launched a municipal broadband network in 1997, against its otherwise similar neighboring community of Waterloo.<sup>12</sup>

Each of these studies found positive economic impacts from the local government investment. More recently, Ford and Koutsky compared per capita retail sales growth in Lake County, Florida, which invested in a municipal broadband network that became operational in 2001, against ten Florida counties selected as controls based on their similar retail sales levels prior to Lake County’s broadband investment. They found that sales per capita grew almost twice as fast in Lake County compared to the control group.<sup>13</sup>

The present study builds on the foundations laid by these earlier works, but differs along several important dimensions. First, as discussed above, the present study defines broadband by the level of technical capability that was generally deployed in the U.S. during the 1998-2002 period, as measured by the FCC. Second, the study employs a nationwide sample, incorporating more potential for statistical control. Finally, within the sample, the study distinguishes among communities by the availability of any type of broadband by December 1999, regardless of who provides it (e.g. private vs. municipal), with what technology (e.g. cable modem vs. DSL vs. fiber vs. wireless), or with what level of technical capability (e.g. 200 Kbps vs. 100 Mbps).

### Hypotheses and Data Availability

Broadband does not act on the economy in isolation, but as a complement to other information technologies. In the pre-2003 period studied here, broadband typically consisted of always-on, faster-than-dialup access to the Internet, with the user’s experience typically mediated by software running



on a personal computer. Broadband is a critical enabler for the use of computer-based applications that need to communicate. Adoption of broadband-enabled IT applications can thus affect the economy by changing the behaviors and productivity of both firms and individuals.

Rappoport, Kridel and Taylor demonstrated how the convenience and responsiveness of broadband led people to use it more intensively than its narrowband (dialup) predecessor.<sup>14</sup> Forman, Goldfarb and Greenstein<sup>15</sup> are among those who have focused on changes to firm behavior, finding that these generally lie on a spectrum, with the highest payoffs in enhanced productivity appearing in the firms that commit most intensively to integration of IT into new business processes.

Forman and his colleagues distinguish between IT-using and IT-enhancing firms. The former simply adopt existing Internet applications to make current business processes more productive. The latter develop and integrate more complex e-business applications that can enable whole new business processes and models, such as automated online supply chain management and online sales into geographically distant markets. To the extent that the availability and use of broadband fosters either type of IT adoption and usage by firms, we would expect productivity improvements and other associated economic impacts to follow.

Other studies have focused on the effects of IT on individual workers. IT tends to complement workers that perform non-routine problem-solving and complex communication tasks, but substitutes for workers who perform cognitive and manual tasks that can be accomplished by following explicit rules. While both effects could be expected to increase productivity, the overall effect on employment is ambiguous and would depend on the mix of different types of jobs in the economy.<sup>16</sup>

While much of the IT productivity literature has focused on workplace usage, much of the focus of broadband policy has been on residential deployments. Broadband at home may of course be used for leisure pursuits, but it can also be expected to affect the economy both directly and indirectly.

For many knowledge workers, a residential broadband connection is a prerequisite for working at home (enabling productive use of non-traditional working hours, flexible work arrangements, or remote employment), or for establishment of a home-based business.

Less directly, expanded broadband availability at home may raise the quality of the labor force, for example through

improved access to educational opportunities via distance education programs, thus making a locale more attractive to potential employers. Similarly, home-based access may improve quality of life, for example by enabling more participation in community and civic activities, making a locale more attractive to potential residents.

Somewhat more directly, home access may enable online job hunting, thus reducing unemployment by making labor markets more efficient. It may also make workers more productive by reducing the overall time needed for them to fulfill non-work obligations, such as paying bills, shopping, telemedicine, and so forth. As with corporate use of IT, however, the overall effect of home-based broadband usage on local economic indicators is also mixed. While online banking and shopping may make local workers more productive, it is also likely to put competitive pressure on local banks and retail stores, leading to ambiguous effects on the number of local jobs.

Most of these hypothesized impacts are not measurable directly. Broadband availability varies by community, but statistics are not tallied at the community level to measure local output (GDP) or use of capabilities like e-commerce and telemedicine. To create hypotheses testable with available data, we focus instead on how broadband is likely to change other indicators that describe local economies. They include:

- Employment rate, share of high-skilled/high-wage jobs in the community, wage rates, and rate of self-employment.
- Wealth, as measured by personal income, housing values, or rents.
- Quality of the local labor force, as measured by educational attainment, dropout rates, or share of workforce in more skilled jobs.
- Community participation and quality of life as measured by voting participation, mortality rates, or local prices.

Our ability to test this list of indicators was limited by the collection frequency for different types of Census data, and geographic unit limitations for other types of data (for example, voting participation is not tallied by zip code).

For most indicators, it is reasonable to expect that broadband's impacts will be felt only after some time lag. Broadband has to be not only available, but adopted and then used. While the expected length of this process may vary depending on the particular indicator, for most indicators it is not reasonable to expect to see impacts in the most recent

decennial (2000) Census data, given that the FCC’s earliest measurement of community broadband availability was taken only at the end of 1999.

This fact limited our ability to test broadband’s impacts at the zip-code level on workforce-related indicators such as self-employment, the share of white-collar workers, educational attainment levels, and per capita expenditures on public assistance. We were, however, able to use rent in 2000 as a wealth indicator, justified because only broadband availability (not its actual use) should be sufficient to influence the value of rental housing, and the effect should be immediate.

Despite these limitations on workforce and societal impacts, the use of business Census data (for which 2002 was the most recent available during the time frame of this project) did allow testing of broadband’s impacts on five key indicators of business activity:

- Total employment.
- Wages.
- Number of business establishments (used as a rough proxy for number of firms).
- Indicators of industry mix by sector. In particular, we examine broadband’s effect on the share of business establishments in IT-intensive industry sectors. This is interesting in its own right because such jobs are about a fifth of all US jobs, but also as a proxy for the skill level of jobs in the community.
- Indicators of establishment mix by size (small vs. large).

### Methodology

We used econometric regression analysis of two separate cross-sectional/time-series data sets that we constructed for the purposes of this study. The first of these consisted of state-level data, while the second incorporated data at the zip-code level. In both cases, the essence of the approach was to compare economic outcome measurements in different areas based on when broadband became available in that area (whether state or zip code), while controlling for other factors known to affect broadband availability and levels of local economic activity.

The types of control variables used in the analysis included:

- A time-lagged version of the dependent variable (i.e. the economic outcome metric being tested), as a way to control for the secular growth trend;

- Time-lagged industry composition (the share of firms in IT-intensive industry sectors) to control for factors other than broadband that are likely to affect local economic performance;
- Variables that describe demographic and geographic characteristics of a community such as educational attainment, per capita income, and rural vs. urban (see Table 2); and
- State “dummy variables” included to account for cross-state differences in regulatory environment.

For further discussion of the dependent and control variables used in particular regressions, see Appendices II-V.

While the state-level sample provided some interesting options in selection of variables (e.g. data on penetration of broadband), it proved too coarse a geographic aggregate to produce meaningful results. We discuss the state results in Appendix IV, but our substantive conclusions and empirical estimates are based on our analysis of the zip-code data set.

The construction of the data sets proceeded by matching data on economic activity metrics and controls from the 1990s through 2002 with a broadband metric constructed from the FCC data. For the zip-code analysis, we combined Census data on business activity from the 1990s through 2002, and community demographics through 2000, with a broadband availability indicator developed from the FCC’s publicly available Form 477 data.<sup>17</sup> We identify the communities where broadband was available as those that report having broadband in the FCC’s Form 477 data for 1999 (Table 3). Since this is the first date for which the FCC

Table 3. Zip Codes with Broadband, December 1999-December 2002.

Broadband Available by Date	Number of Zip Codes	Share of Zip Codes
December-1999	17,683	54.44%
June-2000	2,725	8.39%
December-2000	1,970	6.07%
June-2001	2,026	6.24%
December-2001	910	2.80%
June-2002	957	2.95%
December-2002	894	2.75%
No Broadband by December 2002	5,316	16.37%
Total	32,481	100.00%

Source: the authors, based on data from FCC Form 477 and US Census Bureau’s Decennial Census and Zip Code Business Patterns



zip-code-level data is available, it includes communities that have had broadband for a number of years, as well as communities where broadband had become available only recently. For example, the relatively high penetration in 2000 in California, Connecticut, Massachusetts and New York (Table 4) attests to the fact that a number of communities in these states were early broadband adopters. Communities that show up in the Form 477 data in later periods are treated as non-broadband-available communities because we believe that it takes time for the impact of broadband to become available and we would not anticipate being able to see a measurable effect in the 2002 economic data.

Because there is no simple summary statistic with which to measure total economic activity (total output or GDP) by community, we examine a collection of economic variables for which we could reasonably expect to see a measurable

impact of broadband (employment, wages, rent, and industry structure or mix as discussed above). For each category of variables, we tested three regression approaches:

1. Impact of broadband at the state level. Although we found these data to be too highly aggregated, and hence, rendered the results uninformative, we discuss these in Appendix IV for completeness and to provide a point of reference with earlier research.
2. Impact of broadband using community (zip-code) level data with instrumental variables.
3. Extend the community-level analysis with a matched sample analysis as the means to control for non-broadband, unobserved effects.

The detailed rationales and methodologies behind each of these approaches are discussed fully in Appendix III.

Table 4: State Level Penetration of Broadband Lines among Residential and Small Establishments Users 2000-2002.

State	2000	2001	2002	State	2000	2001	2002
Alabama	1.60%	5.95%	10.03%	Montana	1.49%	2.67%	4.13%
Alaska	0.20%	16.18%	18.62%	Nebraska	6.70%	9.11%	14.98%
Arizona	6.21%	10.26%	15.26%	Nevada	5.87%	10.73%	15.81%
Arkansas	2.14%	5.16%	7.79%	N.Hampshire	6.87%	10.96%	16.12%
California	8.20%	13.17%	19.96%	New Jersey	6.88%	15.00%	12.91%
Colorado	4.70%	8.19%	13.86%	New Mexico	2.62%	3.46%	6.30%
Connecticut	7.04%	12.43%	20.04%	New York	6.06%	12.77%	21.77%
Delaware	0.68%	6.70%	12.55%	N. Carolina	2.26%	8.46%	14.31%
D.C.	5.03%	9.92%	13.71%	N. Dakota	1.90%	1.68%	6.18%
Florida	3.33%	10.17%	15.92%	Ohio	3.51%	7.47%	12.68%
Georgia	1.98%	9.78%	16.00%	Oklahoma	2.73%	6.64%	11.62%
Hawaii	*	*	*	Oregon	4.34%	8.59%	15.89%
Idaho	2.39%	2.39%	8.77%	Pennsylvania	1.94%	5.84%	9.73%
Illinois	3.60%	6.46%	12.19%	Rhode Island	6.29%	13.06%	17.66%
Indiana	0.88%	3.79%	6.46%	S. Carolina	2.02%	6.32%	11.00%
Iowa	4.27%	6.03%	8.75%	S. Dakota	3.20%	2.45%	4.89%
Kansas	5.40%	10.15%	15.62%	Tennessee	3.04%	8.00%	12.94%
Kentucky	0.69%	2.59%	4.35%	Texas	4.95%	8.81%	14.16%
Louisiana	2.10%	7.71%	12.53%	Utah	3.70%	7.94%	13.39%
Maine	3.67%	6.88%	9.71%	Vermont	2.27%	6.55%	9.36%
Maryland	1.67%	10.15%	14.84%	Virginia	2.68%	8.47%	13.18%
Massachusetts	9.29%	16.24%	21.10%	Washington	6.51%	11.43%	16.01%
Michigan	2.73%	8.80%	13.32%	West Virginia	0.63%	3.56%	8.38%
Minnesota	4.79%	8.32%	14.33%	Wisconsin	2.40%	6.58%	12.80%
Mississippi	0.34%	2.37%	5.96%	Wyoming	*	2.87%	5.61%
Missouri	3.12%	6.47%	9.30%	Total	3.61%	7.91%	12.46%

Source: the authors, based on data from FCC Form 477 and US Census Bureau's Decennial Census and Zip Code Business Patterns

## Conclusions

The analysis presented in this paper represents a first attempt to measure broadband's impact by applying controlled econometric techniques to national-scale data. The results support the view that broadband access *does* enhance economic growth and performance, and that the assumed (and oft-touted) economic impacts of broadband are real and measurable.

We find that between 1998 and 2002, communities in which mass-market broadband became available by December 1999 experienced more rapid growth in employment, number of businesses overall, and businesses in IT-intensive sectors. While the available data does not demonstrate statistically significant impacts on wages, the effects of broadband availability by 1999 can also be observed in higher market rates for rental housing (a proxy for property values) in 2000.

Table 1 summarizes the estimated magnitude of impacts resulting from the two analyses we conducted at the zip code level. Both of these analyses control for community-level factors known to affect both broadband availability and economic outcomes, including income, education, and urban vs. rural character.

Given broadband's novelty and associated data limitations, the analysis reported in this study is necessarily preliminary. Additional data and experience are needed to further explore the fundamental questions of how broadband affects the economy. The magnitude of impacts estimated by our models are larger than we expected. In light of the methodological challenges inherent in disentangling causality in any study of the relationships between infrastructure availability and economic development, we interpret our results cautiously. Further research is required to more fully address the causality issue. With this caveat in place, however, our finding of a positive impact of broadband is encouraging, and consistent with the qualitative stories told by broadband advocates.

The analysis presented in this study could be beneficially extended in several ways. One approach would be to use firm-level data to take a more micro-level view of broadband's impacts on the conduct of business within and between enterprises. This approach could be especially valuable for gaining a deeper understanding of broadband's impact on the size of firms and its relation to the growth of particular industry sectors.

Progression to this type of study in the case of broadband would parallel the development of studies on the so-called

productivity paradox of IT. In that literature, studies within the firm added valuable insight into factors that interacted with each other to produce economic impact from computerization. Similar results could be expected in a study of broadband's impact since, like computers in general, we do not expect broadband to act in isolation to enhance productivity, but rather to act as part of a constellation of factors including related information technologies, innovative business practices, and more flexible organizational structures. The present study is relatively crude in attempting to relate broadband availability directly to economic performance. Futures studies could examine more intervening variables and concomitant investments to better characterize the firms and individuals who adopt broadband and realize its benefits.

Ultimately, the case for broadband as a cause of positive economic outcomes will rely on the accumulated results of many studies conducted using a variety of approaches. The passage of time will make more and different forms of data available, enabling the application of additional rigorous methodological approaches to the estimation of broadband's impact. New business census data will become available annually, and data in the next decennial census (2010) will make it feasible to look at broadband's impact on workforce-related indicators such as self-employment and the share of white-collar workers. The spread of broadband (and related data collection) in more countries will make cross-national impact studies more feasible over time. In addition, recent enhancements in the broadband availability data collected by the FCC through Form 477 will eventually make it possible to test for variations in impact based on different levels of broadband (e.g. "big" broadband such as fiber-to-the-home vs. "little" broadband such as DSL) supplied in any given area.<sup>18</sup>

The present study has several clear implications for economic development practitioners. The most obvious and important implication is that broadband *does* matter to the economy. Practitioners who have been spending their time or money promoting broadband should take comfort that their efforts and investments are not in vain.

Many significant public policy reforms and programs are in place or under consideration at the federal, state, and local levels to ensure competitive availability of broadband to all U.S. citizens, stimulate ongoing investment in broadband infrastructure, and facilitate the education and training that small business and residential customers need to make effective use of broadband's capabilities. Such policies are indeed aimed at important goals. Broadband is clearly related to

economic well-being and is thus a critical component of our national communications infrastructure.

Local policymakers in particular may wish to understand whether the economic advantages conferred by broadband are temporary (i.e. growth in the early have communities came at the expense of the early have nots) or longer-lasting (i.e. broadband stimulated growth of the overall economic pie). If the advantages are temporary, then the benefits to be gained from local public investments to speed broadband availability will be muted once neighboring communities catch up.

On the other hand, if broadband affects the base growth rate of the local economy, then the benefits from getting it sooner will continue to compound into the future. Because the present study only looks at one time period, it cannot address this important question directly. The results of our study can be seen as consistent with either hypothesis. Once broadband is available to most of the country, differences in economic outcomes are likely to depend more on how broadband is used than on its basic availability.

The implication for economic development professionals is that a portfolio of broadband-related policy interventions that is reasonably balanced (i.e., also pays attention to demand-side issues such as training) is more likely to lead to positive economic outcomes than a single-minded focus on availability.

Finally, the present study highlights the fundamental role that government data plays in shaping our understanding of how communications technologies and policies relate to national economic performance. As discussed above, public data about broadband focuses primarily on the supply side (availability), especially at the local level. Economic performance, however, also depends on demand-side factors such as broadband adoption and use. Such factors are of course competitively sensitive.

Given how important broadband appears to be to the economy, however, the time has come for policy makers to engage in a dialogue with industry and develop reasonable ways to measure more of the broadband indicators that matter.

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The revised version of the academic paper originally presented at TPRC 2005 is available at [http://cfp.mit.edu/groups/broadband/docs/2005/MeasuringBB\\_EconImpact.pdf](http://cfp.mit.edu/groups/broadband/docs/2005/MeasuringBB_EconImpact.pdf).

### Endnotes

<sup>1</sup> Based on results found to be statistically significant at the 90% level or above, for the two types of controlled zip-code-level analyses described below in the Methodology section (except for the rent result, for which only one of the zip-code-level analyses proved applicable). Controls consist of community-level factors known to affect both broadband availability and economic outcomes, including income, education, and urban vs. rural character. Appendix IV lists all the regression results and discusses them in detail.

<sup>2</sup> See [http://www.census.gov/epcd/www/zbp\\_base.html](http://www.census.gov/epcd/www/zbp_base.html)

<sup>3</sup> See <http://www.census.gov/main/www/cen2000.html> for data from the US Census Bureau, and <http://www.geolytics.com/USCensus,Census-1990-Long-Form-2000-Boundaries,Products.asp> for GeoLytics data. Use of the GeoLytics CD simplified the matching and aggregation of data for changes across zip codes between 1990 and 2000.

<sup>4</sup> See <http://www.ers.usda.gov/Data/UrbanInfluenceCodes/>. The rationale for the UIC is based on growth-pole and central place theory, and the effect that an area's geographic context has on its development, as discussed in Parr (1973), North (1975), and Polenske (1988).

<sup>5</sup> These data and reports are available at <http://www.fcc.gov/wcb/iatd/comp.html>

<sup>6</sup> These estimates are based on 2004 U.S. penetration estimates from the Pew Internet Project, Nielsen/Net Ratings, eMarketer, the OECD, ITU, and FCC, and the authors' calculations based on the varying figures reported by these organizations.

<sup>7</sup> U.S. Department of Commerce (2002), *Understanding Broadband Demand: a Review of Critical Issues*, Technology Administration, Office of Technology Policy, available at [http://www.ta.doc.gov/reports/TechPolicy/Broadband\\_020921.pdf](http://www.ta.doc.gov/reports/TechPolicy/Broadband_020921.pdf).

<sup>8</sup> Crandall, R. and C. Jackson (2001), *The \$500 Billion Opportunity: The Potential Economic Benefit of Wide-spread Diffusion of Broadband Internet Access*, mimeo, Criterion Economics, Washington, DC.

<sup>9</sup> Pociask, S. (2002), *Building a Nationwide Broadband Network: Speeding Job Growth*, white paper prepared for New Millennium Research Council by TeleNomic Research, available at <http://www.newmillenniumresearch.org/event-02-25-2002/jobpaper.pdf>.

<sup>10</sup> Ferguson, C. (2002), *The United States Broadband Problem: Analysis and Recommendations*. Brookings Institution Working Paper at [http://www.brookings.edu/views/papers/ferguson/working\\_paper\\_20020531.pdf](http://www.brookings.edu/views/papers/ferguson/working_paper_20020531.pdf) last visited on September 09, 2005.

<sup>11</sup> Strategic Networks Group (2003), *Economic Impact Study of the South Dundas Township Fibre Network*, prepared for Department of Trade and Industry, UK, available at <http://www.dti.gov.uk/industries/telecoms/sdcfsi270603.pdf>.

<sup>12</sup> Kelley, D. J. (2003), *A Study of the Economic and Community Benefits of Cedar Falls, Iowa's Municipal Telecommunications Network*, available at <http://www.iprovo.net/projectInfoDocs/economicAndCommunityBenefitsStudy.pdf>. Summarized and updated in *Broadband Properties Magazine*, [www.broadbandproperties.com](http://www.broadbandproperties.com), May, 2005.

<sup>13</sup> Ford, G. and Koutsky, T., 2005. *Broadband and Economic Development: a municipal case study from Florida*. [http://www.publicpower.com/telecom\\_study/municipal\\_broadband\\_&\\_economic\\_development.pdf](http://www.publicpower.com/telecom_study/municipal_broadband_&_economic_development.pdf) last visited on August 26, 2005.

<sup>14</sup> Rappoport, P., Kridel, D. and Taylor, L. (2002), "The Demand for Broadband: Access, Content, and the Value of Time," in Crandall, Robert and James Alleman (eds.), in *Broadband: Should we regulate high-speed Internet access?*, Brookings Institution Press: Washington, DC, available at <http://www.aeibrookings.org/publications/abstract.php?pid=301>.

<sup>15</sup> Forman, C., Goldfarb, A. and Greenstein, S. (2005), "Geographic Location and the Diffusion of Internet Technology," *Electronic Commerce Research and Applications* (4):1–113.

<sup>16</sup> Autor, D., Levy, F., and Murnane, R. (2003) "The Skill Content of the Technology Change," *Quarterly Journal of Economics*, November, Vol. 118, No. 4, pp. 1279–1333.

<sup>17</sup> This data reports broadband available from all types of providers, and does not distinguish between public- vs. private-sector provision, or among broadband technologies. The data also reports the number of providers in each zip code, in a limited way: the number of broadband operators who provide service in a zip code is listed if the number is four or more, and replaced with an asterisk (\*) if the number is between one and three. Because of this limitation, this study does not use competitive information in its broadband indicator.

<sup>18</sup> In November 2004, the FCC revised the Form 477 reporting requirements and extended the data collection program for five more years. The new rules apply to data as of June 30, 2005, reported on Form 477 as of September 1, 2005. Under the new rules, all facilities-based providers will have to report their broadband deployments regardless of their reach or size, and provide more detailed information on speed and types of services

offered. By removing the 250 lines threshold that previously exempted small-scale carriers from providing information, this change will address one of the two reporting issues that led to particularly unreliable data in rural areas, as discussed above. Further information about the revised reporting requirements is available at [http://hraunfoss.fcc.gov/edocs\\_public/attachmatch/DOC-254115A1.pdf](http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-254115A1.pdf), <http://www.fcc.gov/broadband/data.html>, and <http://www.fcc.gov/formpage.html#477>.

## Appendix I: Author Biographies

This appendix provides brief biographies of the report's authors.

**WILLIAM LEHR** ([wlehr@mit.edu](mailto:wlehr@mit.edu)) is a Research Associate at the Massachusetts Institute of Technology (MIT) where he participates in the multidisciplinary research of the MIT Communications Futures Program (<http://cfp.mit.edu>). Dr. Lehr's research focuses on the economics of the Internet infrastructure industry, in particular the interrelationship between the evolution of Internet technology and industry structure, public policy, and competitive strategy. In recent years, he has focused on developments in last-mile access networks, including wired and wireless broadband. He is a frequent speaker at international conferences on telecommunications policy and business, teaches courses on eCommerce, Internet economics, and telecommunications economics and policy, and publishes regularly on matters related to his research. Over the past 15 years, he has been an active participant in the research program of the Columbia Institute of Tele-Information at Columbia University and in the Research Program on Internet and Telecoms Convergence at MIT. In addition, Dr. Lehr provides consulting services to private and government policymakers in the United States and abroad on matters related to the ICT industries. Dr. Lehr holds a PhD in Economics from Stanford (1992), an MBA from the Wharton Graduate School (1985), and MSE (1984), BS (1979) and BA (1979) degrees from the University of Pennsylvania.

**SHARON EISNER GILLET** ([sharoneg@mit.edu](mailto:sharoneg@mit.edu)) is a Principal Research Associate at the Massachusetts Institute of Technology (MIT) and co-chair of the Broadband Working Group of MIT's Communications Futures Program. Her research and industry outreach work focuses on how emerging technologies, public policies, and business imperatives interact in broadband access networks, both wired and wireless. Sharon teaches courses at MIT and Cambridge (UK) on communications policy, and has published numerous articles, most recently focusing on municipal broadband and economic impact. Her previous experience includes software development and project management in computer networking at Bolt, Beranek & Newman, Inc. and at Thinking Machines Corporation. She received her MBA and MS in Technology and Policy from MIT (1995), and her AB in Physics from Harvard (1982).

**MARVIN SIRBU** ([sirbu@cmu.edu](mailto:sirbu@cmu.edu)) is a Professor of Engineering and Public Policy, Industrial Administration, and Electrical and Computer Engineering at Carnegie Mellon University (CMU). Professor Sirbu's interests are in telecommunications and information technology, policy and management. His work is concerned with how new communications technology impacts both public regulation and corporate decision making, and conversely how public policy influences the development of new information technologies. In 1989 he founded the Information Networking Institute at CMU, which is concerned with interdisciplinary research and education at the intersection of telecommunications, computing, business and policy studies.

For more than 20 years, Professor Sirbu has conducted in-depth studies of the economics of local access technologies and their competitive impact, including cable, wireless, DSL and fiber to the user. This work has been funded variously by Verizon, Bellcore, General Instruments, and the MIT ITC consortium of companies.

Dr. Sirbu has served on the boards of the Telecommunications Policy Research Conference and two telecommunications companies, and as a member of the FCC Technological Advisory Committee where he chaired the subcommittee on local access. He has also served on numerous panels for the National Research Council and the Office of Technology Assessment.

Dr. Sirbu received an Sc.D. in Electrical Engineering (1973), an S.M. in Electrical Engineering (1968), an S.B. in Mathematics (1967), and an S.B. in Electrical Engineering (1966) from the Massachusetts Institute of Technology.

**CARLOS OSORIO** ([cosorio@mit.edu](mailto:cosorio@mit.edu)) is a Doctoral Candidate in Engineering Systems at the Massachusetts Institute of Technology (MIT) and a graduate research assistant with MIT's Communications Futures Program. His research focuses on technology and productivity, with special emphasis on broadband deployment and effects from the architectural evolution of engineering systems. He holds a M.Sc. in Technology and Policy from MIT, a Master in Public Policy from Harvard University, and a B.Sc. in Industrial Engineering and Engineer Degree from the University of Chile.



## Appendix II: Data Limitations

This appendix discusses in more detail the limitations of the data sets used for the analysis: the FCC's data on broadband deployment, and Census data on economic activity in businesses (Zip Code Business Patterns) and households (Decennial Census). We also discuss the measure of penetration used for the state-level regressions. The appendix concludes with a discussion of the issues raised by the need to match observations across these different sources of data.

### FCC Data on Broadband Deployment

A key component of our analysis is data on the availability of broadband services. Ideally, we would have liked to have had time-series data on the use of broadband, rather than just its availability. Unfortunately, the best publicly available data is from the FCC which has published data on broadband availability every six months, by zip code, starting in December 1999. This data is collected by the FCC via Form 477 and is available from the FCC's website (<http://www.fcc.gov>). After considering various options for using this data, we elected to code communities as either "having broadband" or "not having broadband" based on whether broadband was available in the community as of December 1999. There were several reasons for why we did this:

- **Timing of initial data collection:** The first available data collection reports broadband availability by December 1999. By this time, however, the FCC reported that 59% of U.S. zip codes already had at least one broadband provider. While we know that few communities had broadband before December 1996, we do not observe when broadband became available in particular communities between 1996 and 1999. Thus much of the timing variability that was present in the actual broadband rollout is not available in the data.
- **Non-monotonic broadband availability:** Given that broadband's economic impacts are likely to manifest themselves over time, it is important to be able to assume that broadband, once available, stays in place. However, we discovered several thousand zip codes in which broadband appeared to come and go over time. After discussing this issue with FCC staffers involved in the data collection, we concluded this effect was most likely noise in the data caused by oscillation above and below reporting thresholds, and by addition of new zip codes over time. We also observed that use of only December data collections produced a more stable data set, and it was therefore a reasonable approximation to assume that broadband actually stayed in place once it appeared in a December data set.

The observation that June data appeared more noisy was consistent with our discussions with FCC staffers.

In addition, several other well-known limitations of the FCC data are also relevant to our analysis. First, the sampling methods produce particular inaccuracies of uncertain overall direction in rural areas:

- **Reporting Thresholds:** Prior to the June 2005 data collection, only providers with more than 250 lines in a state were required to report to the FCC. Thus, the data used in this study may systematically underestimate broadband availability in the predominantly rural states covered by smaller independent LECs or cable franchisees, whose total subscription base could fall below this threshold.
- **Larger Zip Codes in Rural Areas:** On the other hand, the FCC's data may also systematically overstate the availability of broadband in rural areas. As long as a provider mails a bill to one customer in a zip code, the entire zip code is presumed to have broadband available. Because rural zip codes are on average larger than urban ones, the inaccuracy of this assumption is likely to be more pronounced in rural areas.

Second, penetration data is limited to the state level. At the zip code level, FCC reports only the number of providers (availability), and not number of lines (adoption). Although broadband availability might adequately explain rapid changes in economic variables like rent, penetration would be a more accurate explanatory variable for most outcomes that depend on actual use of broadband. Thus, the FCC data provides only a crude proxy for analyzing the economic effects of broadband at the zip code level.

Finally, the zip code definitions used by the FCC posed challenges. Comparison of economic outcomes in zip codes with and without broadband requires a list of zip codes of both types. However, the FCC only makes available the list of zip codes **with** broadband. Researchers working with this data are left to infer the list of zip codes **without** broadband, by comparing the FCC's list of zip codes with broadband against other sources for the list of all zip codes in the U.S. (i.e., the zip code "universe").

Prior to this study, other researchers had observed inconsistencies between the FCC's reports of the percentage of zip codes with broadband (which imply a size for the zip code universe), and the larger size of the universe of zip codes listed by the U.S. Postal Service.<sup>1</sup> Investigating this inconsistency further with the assistance of FCC staffers involved in the Form 477 data collection, we learned that the FCC's zip-code universe is based on a proprietary set of zip-code



definitions that is built into the commercial mapping software used by the FCC. These definitions are known as GDT format, after Geographic Data Technology, Inc., a firm that was later acquired by TeleAtlas.

Further consultation with the FCC confirmed that their use of GDT format also explained the inclusion of zip codes in their data that otherwise appeared anomalous. Most zip codes in the U.S. are what is called “non-unique” i.e. they represent areas of land where people live and businesses are located. “Unique” zip codes, on the other hand, typically represent a single office building or corporate campus, and may be physically enclosed within a surrounding non-unique zip code (in which case both zip codes should not be reported). Some zip codes are also assigned only to post-office boxes, and these would not be meaningful in describing whether broadband is available in a particular physical area. When we used government sources for the zip code universe, it appeared that the FCC had applied inconsistent rules regarding whether to include these special types of zip codes in their list. This apparent inconsistency arose, however, because the government sources define the type of some zip codes differently from GDT.

The construction of the zip code universe for this study is discussed further below, after discussion of the other data sources that had to be matched to create the final database for analysis.

### Zip Code Business Patterns (ZCBP)

For measurements of business activity, we used the annual Zip Code Business Patterns database provided by the U.S. Census. When this study was conducted in 2004-5, the most recent ZCBP data available was for 2002, limiting our ability to observe broadband’s impact over a longer time period.

Another limitation involved in the use of this source was its change of classification scheme for identifying industry sectors. Data prior to 1998 is classified according to Standard Industrial Classification (SIC) codes, while later data uses North American Industry Classification System (NAICS) codes. Thus, data prior to 1998 that relies on industry classification is not directly comparable to later data. Specifically, this limited the controls available for the regression analysis about the effect of broadband on IT-intensive establishments.

Finally, the ZCBP data provides counts of establishments by size category for each NAICS category included and for each zip code. This does not allow one to distinguish between firms with one establishment and firms with two or more branches. Therefore, the data does not allow one to directly

measure changes in the number of firms associated with the availability of broadband. An observation that broadband communities have a greater number of small establishments could mean that there are a larger number of small firms or more branch offices for the same number of larger firms.

### Decennial Census (DC)

The household census provided the data necessary to construct socio-economic control variables. Potentially, it could also be used to develop metrics for testing a rich set of hypotheses regarding broadband’s socio-economic impacts, such as its effects on commuting time, self-employment, or white-collar employment. However, this data is only collected every 10 years, and the most recent data collection was in 2000. Therefore, for most variables of interest, there was not enough lag time after the first reported broadband availability (1999) to expect to see impacts in these data.

Furthermore, in the selection of appropriate metrics of economic activity or controls for cross-community heterogeneity, it should be noted that many variables are correlated. Thus, communities with high per capita income also typically have high rates of educational attainment.

### Matching Across Data Sources

Creation of the database for regression analysis required matching across the three sources of data discussed above, such that each observation in the database was not missing data for any of the variables included. The bottom half of Figure A.1 illustrates the process that resulted in our sample of 22,390 U.S. zip codes overall.

The most complex aspect of this matching had to do with the zip-code universe issue. As noted above, the FCC relies on GDT zip code boundaries to define their universe. The business patterns data, in contrast, relies on the U.S. Postal Service’s apparently larger universe of zip codes, while the Census Bureau uses its own coding of areas, known as Zip Code Tabulation Areas (ZCTAs), to report the household data. ZCTAs are approximately, but not exactly, the same as USPS zip codes. Given that they are used for a household census, ZCTAs leave out areas where people don’t live, such as unique and post-office only zip codes.

After consulting with the FCC and Census Bureau, we concluded that for our analysis, the best “universe” of zip codes was provided by the ZCTA coding. First, all data for socio-economic independent and control variables from the 2000 and 1990 Decennial Census was available by ZCTAs, as aggregated by the US Census Bureau.<sup>2</sup> Second, according

Zip Code Sources	USPS 2000 Census Zip Code File N=42,198	2000 Decennial Census (ZCTAs) N=33,633	2000 Zip Code Business Patterns N=40,005	Dec 99 FCC Zip Code N=17,889
Zip Code Definition	USPS file contains original and largest zip code universe (used for control)	ZCTAs: US Census' codes matching USPS zip code boundaries	Self reported by companies (using USPS Zip Codes)	Self reported by providers, adjusted by FCC using GDT file
No. Zip Codes      %      Cumulative				
	Complete record	22,390	68.93%	68.93%
	State is missing	11	0.03%	68.97%
	Rent and/or labor data is missing	256	0.79%	69.75%
	Salary of wage is missing	2,199	6.77%	76.52%
	College Education data is missing	525	1.62%	78.14%
	IT establishment data is missing	5,431	16.72%	94.86%
	Population data is missing	747	2.30%	97.16%
	Other data (small firms, urban, etc.) is missing	922	2.84%	100.00%
	Sub Total	32,481	100.00	
	(State is DC or Puerto Rico	156 )		
	Total	32,325		

Figure A1: Process of Matching Across Data Sources

to communications with US Census officials, the differences in boundary definition between using ZCTAs and USPS zip codes were insignificant for the purpose of econometric analysis at the zip code level.

In the matching, there were a number of zip codes that were dropped for the following reasons:

- Zip Code Tabulation Areas (ZCTAs): 1,152 ZCTAs were dropped because they corresponded to places with no land (781), no population (111)<sup>3</sup>, or no match to 5-digit USPS Zip Codes (260). The last cases represented a population of 43,957 inhabitants.
- 2000 Zip Code Business Patterns: There were 7,524 zip codes that could not be matched either to ZCTA zip codes or to the FCC "broadband available" zip codes. These codes corresponded to PO Boxes and unique zip codes which could not be matched to ZCTAs.

After merging the zip code data sets, we obtained a database of 32,481 entries (See figure A1). We employed the USPS Zip Code database used by the US Census Bureau for the 2000 Decennial Census –USPS 2000 Census File- for the purpose of having a control for the universe of zip codes in 2000. In order to maintain homogeneity on the sample, we dropped an additional 156 zip codes corresponding to the District of Columbia and Puerto Rico, obtaining a final sample of 32,325 zip codes.

Finally, we dropped zip code observations with incomplete data (as shown in figure A1), resulting in a sub-sample with 22,390 observations. Table A1 compares the summary statistics of this sub-sample against the full sample for each

variable used in the zip code analysis. Because most summary statistics did not differ substantially for the full and sub-samples, we simplify the analysis by using the consistent sub-sample of zip codes throughout. One important area of difference: many of the zip codes dropped did not have broadband in 1999, so that our sub-sample has a significantly higher percentage of zip codes with broadband than the total sample (67% vs. 54%). An alternative approach would have been to run each regression with the largest sample for which all data was available for that particular regression. When we did this, the results were not significantly different from the consistent sub-sample. Reporting only on the latter simplifies interpretation of results across the various regressions.

For purposes of comparison, Table A2 reports the summary statistics for the state-level data set we constructed. As discussed in detail in Appendix IV, however, we do not base any of our substantive conclusions on the state-level analysis because it proved too coarse a level of geographic aggregation to produce meaningful results.

## Endnotes

<sup>1</sup> See Flamm, K. "The Role of Economics, Demographics, and State Policy in Broadband Competition: An Exploratory Study," Telecommunications Policy Research Conference, Arlington, VA, October 2, 2004.

<sup>2</sup> For 1990 Census data by ZCTA see GeoLytics (2002) "CensusCD. 1990 long form in 2000 boundaries" E. Brunswick, NJ

<sup>3</sup> 70 of these correspond to 3-digit+"XX" ZCTAs representing large undeveloped areas, and 41 to 3-digit+"HH" ZCTAs representing areas covered at least partially by water.

Table A1: Summary Statistics for Variables Used in Zip Code Level Analysis

Category	Variable	Full Sample		Sub-Sample (N=22,390)	Description	Source
		Obs	Mean (Std. Dev)	Mean (Std. Dev)		
Dependent Variables	InRent2K	30,659	6.167 (0.373)	6.218 (0.351)	Median Housing Rent, 2000 (Ln)	US Census, 2000 Decennial Census
	LnrSalary	27,421	0.066 (0.199)	0.068 (0.160)	Ratio of Average Salaries of 2002/1998 (Ln)	US Census, 2002 and 1998 ZCBP
	ptotIT02	27,659	0.233 (0.112)	0.226 (0.090)	Share of Establishments in IT-Intensive Sectors, 2002	US Census, 2002 ZCBP
	InrEmplo	26,877	0.047 (0.389)	0.038 (0.316)	Ratio of Employment , 2002/1998 (Ln)	US Census, 2002 and 1998 ZCBP
	psm02	31,405	0.802 (0.131)	0.790 (0.098)	Share of Establishments with less than 10 Employees, 2002	US Census, 2002 ZCBP
	InrEst	31,210	0.047 (0.273)	0.045 (0.171)	Ratio of Establishments 2002/1998 (Ln)	US Census, 2002 and 1998 ZCBP
Broadband	BB99	32,325	0.544 (0.498)	0.671 (0.470)	=1 if Zip Code had at least 1 broadband line by December 1999, =0 otherwise	FCC, Form 477 Database
Control Variables	dUrban	32,325	0.542 (0.498)	0.620 (0.485)	=1 if Zip Code in Urban Area (UIC=1,2,3), 0=otherwise	USDA, Economic Research Service
	gEmp9498	27,348	0.325 (5.525)	0.387 (6.072)	Growth Rate in the Number of Employees 1994 – 1998	US Census, 1994 and 1998 ZCBP
	grColl90s	30,359	7.986 (80.522)	8.822 (80.180)	Growth Rate in the Number of People (25+) with College Degree or Higher, 1990 – 2000	US Census, 2000 Decennial Census; GeoLytics, 1990 Decennial Census
	grEst9498	30,786	0.197 (3.119)	0.148 (1.195)	Growth Rate in the Number of Establishments, 1994 – 1998	US Census, 1994 and 1998 ZCBP
	grFinc90s	31,579	0.762 (44.808)	0.867 (53.213)	Growth Rate in Median Family Income, 1990 – 2000	US Census, 2000 Decennial Census; GeoLytics, 1990 Decennial Census
	grLabor90s	31,579	4.997 (63.978)	5.026 (66.064)	Growth of the Civilian Employed Labor Force, 1990 – 2000	US Census, 2000 Decennial Census; GeoLytics, 1990 Decennial Census
	grpIT9800	26,954	0.044 (0.273)	0.038 (0.249)	Growth Rate of Share of Establishment in IT-Intensive Sectors, 1998 – 2000	US Census, 1998 and 2000 ZCBP
	grSalary9498	26,203	0.202 (0.378)	0.191 (0.319)	Growth Rate of Average Salary, 1994 – 1998	US Census, 1994 and 1998 ZCBP
	InRent90	31,528	5.838 (0.443)	5.902 (0.414)	Median Housing Rent, 1990 (Ln)	GeoLytics, 1990 Decennial Census
	pcollege2K	31,181	18.511 (13.622)	19.697 (13.662)	Share of Population (25+) with College Degree or Higher, 2000	US Census, 2000 Decennial Census
	pIT98	27,441	0.227 (0.110)	0.219 (0.088)	Share of Establishments in IT-Intensive Sectors, 1998	US Census, 1998 ZCBP
psm98	31,436	0.804 (0.131)	0.792 (0.097)	Share of Establishments with fewer than 10 Employees, 1998	US Census, 1998 ZCBP	

Table A2: Summary Statistics for Variables Used at State Level Analysis

Category	Variable	Mean (Std. Dev)	Description	Source
Dependent Variables	LnRent00	6.315 (0.171)	Median Housing Rent, 2000 (Ln)	US Census, 2000 Decennial Census
	InrSalary	0.132 (0.018)	Ratio of Average Salaries of 2002/1998 (Ln)	US Census, 2002 and 1998 ZCBP
	ptotIT02	0.268 (0.024)	Share of Establishments in IT-Intensive Sectors, 2002	US Census, 2002 ZCBP
	psmall02	0.738 (0.021)	Share of Establishments with fewer than 10 Employees, 2002	US Census, 2002 ZCBP
	LnrEmplo	0.039 (0.037)	Ratio of Employment 2002/1998 (Ln)	US Census, 2002 and 1998 ZCBP
	InrEst	0.034 (0.032)	Ratio of # Establishments 2002/1998 (Ln)	US Census, 2002 and 1998 ZCBP
Broadband	BBAvailHU99	0.864 (0.106)	% of Housing Units located in zip codes with available broadband by December 1999	FCC, Form 477 Database; US Census, 2000 Decennial Census
	BBPen00	0.035 (0.022)	No. lines for residential and small firms, divided by total number of housing units and business establishments with fewer than 10 employees	FCC, Form 477 Database; US Census, 2000 Decennial Census, 2000 ZCBP
	SqBBPen00	0.002 (0.002)	Squared term of BBPen00	FCC, Form 477 Database; US Census, 2000 Decennial Census, 2000 ZCBP
Independent Variables	gEmp9498	0.125 (0.044)	Growth Rate in the Number of Employees 1994 – 1998	US Census, 1994 and 1998 ZCBP
	grcollege90s	0.387 (0.137)	Growth Rate in the Number of People (25+) with College Degree or Higher 1990 – 2000	US Census, 2000 Decennial Census; GeoLytics, 1990 Decennial Census
	pcollege2K	23.765 (4.347)	Share of Population (25+) with College Degree or Higher, 2000	US Census, 2000 Decennial Census
	grEst9498	0.074 (0.043)	Growth Rate in the Number of Establishments 1994 – 1998	US Census, 1994 and 1998 ZCBP
	grFamInc90s	0.401 (0.070)	Growth Rate in Median Family Income 1990 – 2000	US Census, 2000 Decennial Census; GeoLytics, 1990 Decennial Census
	grLabor90s	0.147 (0.109)	Growth of the Civilian Employed Labor Force 1990 – 2000	US Census, 2000 Decennial Census; GeoLytics, 1990 Decennial Census
	grpIT9800	0.006 (0.010)	Growth Rate of Share of Establishment in IT Intensive Sectors 1998 – 2000	US Census, 1998 and 2000 ZCBP
	grSalary9498	0.177 (0.039)	Growth Rate on Average Salary 1994 – 1998	US Census, 1994 and 1998 ZCBP
	LnRent90	6.064 (0.234)	Median Housing Rent, 1990 (Ln)	GeoLytics, 1990 Decennial Census
	psmall98	0.742 (0.021)	Share of Establishments with less than 10 Employees, 1998	US Census, 1998 ZCBP
	ptotIT98	0.258 (0.023)	Share of Establishments in IT-Intensive Sectors, 1998	US Census, 1998 ZCBP
	pUrbHousing00	0.703 (0.153)	Share of Urban Housing Units 2000	US Census, 2000 Decennial Census
	pUrbPop00	0.714 (0.149)	Share of Urban Population 2000	US Census, 2000 Decennial Census

### Appendix III: Econometric Methods

This appendix describes the estimating equations used in our regression analysis.

As noted in Appendix II: Data Issues, we expect that for broadband to show an impact on most measures of economic activity, it needs to be used. However, at the zip code level we can only observe broadband's availability, not its use.

Several earlier studies of IT's impact have looked at state-level data.<sup>1</sup> To provide a point of comparison with these studies, and because broadband penetration estimates are available at the state level, we conducted regression analysis on the state-sample database. However, we expected that state-level data would be too aggregated to meaningfully measure the local impact of broadband, because the "within-state" variation in broadband availability and adoption is greater than the "between-state" variation. The results confirmed our assumption that to be meaningful, analysis needs to be completed on a less geographically aggregated basis.

Therefore, the focus of our analysis of broadband's economic impact used zip-code level data. This analysis was implemented using two complementary econometric approaches: instrumental variables and matched-sample. In the first, we use independent control variables measuring cross-community differences other than broadband availability to explain variation in the dependent-variable measures of economic activity (e.g., controls included such things as employment growth during earlier periods or the share of firms in IT-intensive industries before the impact of broadband). In the second, we use a statistical procedure to construct a matched sample of communities with and without broadband – that is, communities that are similar with respect to the controls included. These approaches are discussed further below.

Our zip code regressions generally take the form:

$$Y(t)=a+\alpha Y(0)+X\beta+\gamma BB+e \quad (\text{Eq1})$$

where,

- $Y(\cdot)$  is the economic variable of interest, for example, the share of establishments in IT intensive industries.
- $X$  are control regressors for differences in community characteristics of the different zip codes
- $BB=1$  if community had Broadband in 1999 and 0 otherwise; and
- $e$  are error terms.

Typically,  $Y(0)$  corresponds to 1998, prior to the known availability of broadband, and  $Y(t)$  is measured in 2002, the latest year for which we have data from the Business Patterns survey.

Since we are controlling for  $Y(0)$ , we interpret  $\gamma$  as the impact of  $BB$  on the level of change in dependent variable  $Y(\cdot)$  over the interval  $[0,t]$ .

Zip codes vary widely in size, population, and other economic characteristics. Under these circumstances treating the impact of broadband as fixed additive amount may not be realistic. Treating the impact as a multiplier may make more sense, thus reducing the problem of heteroskedasticity. Accordingly, we may use  $y(\cdot) \equiv \ln Y(\cdot)$  in place of  $Y(\cdot)$ . This is consistent with the following structural model:

$$Y(t)=AY(0)^{\alpha}e^{rt} \quad (\text{Eq2})$$

where

$$r=r^*+\gamma BB+X\beta+e \quad (\text{Eq3})$$

and  $e$  are distributed log-normally and  $t$  is defined by construction so that  $t=1$  corresponds to 4 years after  $t=0$ .

Strictly speaking, if we view  $r$  as a growth rate, then we would expect  $A=1$  and  $\alpha=1$ . We can force  $\alpha=1$  by transforming our dependent variable to

$$\ln(Y(t)/Y(0))=g(t)=a+X\beta+\gamma BB+e \quad (\text{Eq4})$$

where  $a=\ln A+r^* = r^*$  if  $A=1$ .

When using equation 4,  $\gamma$  is interpreted as an increment to the growth rate of the dependent variable due to the availability of broadband.

As explained in the main text, we consider the impact of broadband on 6 different economic variables. Where the dependent variable is measured as a share (share of small establishments, share of establishments in IT-intensive industries) we use the specification in equation 1. For salaries, employment and number of establishments, we use  $g(t) = \ln(Y(t)/Y(0))$  as the dependent variable as in equation 4. For median rents, we use a specification based on equation 2. We do this because the unconstrained value of  $\alpha$  that we estimate is far from equal to 1 and so it did not seem appropriate to force it to be =1 as in equation 4.

At the state level, we have data on the actual number of broadband lines in use. We normalize this data to a penetration rate by dividing the number of residential and small business lines by the number of households and small businesses in the state. Across the states, penetration varies from near zero to as high as 22% by 2002. Because



broadband will be adopted within a state first by those who get the greatest benefit, and we expect later adopters within a state will realize a lesser benefit, we do not expect our dependent variables to be linearly related to statewide broadband penetration. Consequently, for the state level regressions, we modified our equations to incorporate both linear and quadratic terms for the impact of broadband penetration.

We know from the studies of Flamm (2004), Grubestic (2004), Prieger (2003), Gabel and Huang (2003), Gabel and Kwan (2000), and Gillett and Lehr (1999) that the decision by providers to deploy broadband is not unrelated to economic characteristics of the community, such as income and population density. As a result, if we look solely for an association between broadband availability and our economic variables, it may be hard to distinguish the direction of causality. In each equation, we introduce control variables in an attempt to separate the effects of broadband from the a priori economic characteristics of the community (zip code).

We are limited in the kinds of controls we can use by the availability of data at a zip code level over the relevant time periods. However, we have, for each equation we have estimated, identified a number of controls which improve our confidence in our estimates. We use the same controls in the regressions at the zip code level and the state level with one difference: at the zip code level we also include state dummies to account for fixed effects by state.

When analyzing data at the zip code level there is an alternative approach to the issue of controls and direction of causality when looking for the impact of broadband. Within our sample, a majority of zip codes had broadband available in 1999. These zip codes are on average in higher density, more urban areas, with greater proportions of college graduates, and higher growth rates in income and labor force. If we see differences in economic growth in communities with and without broadband, how do we know it is because of the lack of broadband, and not some other characteristic of the communities? We could try and take the (minority) set of zip codes that did not have broadband in 1999 and match them, using key economic characteristics, to a subset of the communities which did have broadband in 1999 in order to identify, insofar as possible, a “matched” sample. Then, if our dependent variable varies systematically between the two groups, we can infer that it must be due to the presence or absence of broadband.

Stata's NNMATCH function provides a method for selecting a control group to compare with a treatment group using a series of independent variables. It tries to identify a control group which has the same mean and variance across the independent variables as the treatment group—*i.e.* is statistically similar (Abadie et al. 2004). This is done by using nearest neighbor matching across these variables. In the case of our paper, we have used 1-to1 matching, which means the program has matched each control observation to the closest observation in the treatment group.<sup>2</sup> The function then estimates the average treatment effect on a dependent variable of being in one or the other group. In our analysis, we have assumed heteroskedastic standard errors, and used the robust option of `nnmatch`.

In some cases, it is not possible to find a control group which matches on all the characteristics of the treatment group. For example, if all the zip codes without broadband were rural, and only a small fraction of the zip codes with broadband were rural, it might not be possible to find a comparable number of rural zip codes among the “haves” group to match as a control with the non-broadband group. Thus, on a statistical measure such as degree of urbanness, the treatment group and the control group would not be truly similar along that dimension. Notwithstanding these difficulties, for each of our dependent variables, in addition to the regressions, we have used `nnmatch` to estimate whether broadband has a significant impact at the zip code level. Care should be taken in interpreting the results where the samples are not well matched.

## Endnotes

<sup>1</sup> See Daveri, F. and Mascotto, A. (2002), “The IT Revolution across the U.S. States.” Working Paper 226, Innocenzo Gasparini Institute for Economic Research. Daveri and Mascotto study the effect of computer diffusion at home and work on the growth rate of gross state product (GSP) per employed population. They conclude that, while there is an affect at aggregate level, most of the impact comes from states where the contribution to GSP of IT-producing and non-IT manufacturing sectors is above the US average. When these states are excluded from the sample, the authors find no evidence of an impact of IT on productivity acceleration.

<sup>2</sup> In most datasets, we find the treatment group to be smaller than the universe without the treatment, so the matching is done with respect to the smaller group. In this case, however, the set of zip codes without broadband was smaller than the group that got it by 12/99, which made the model results more complicated to interpret. Tests with NNMATCH showed no difference in results if the treatment was assigned to one group or the other. For this reason, we defined our treatment group as the one getting broadband by December of 1999 (*i.e.*, `BB99=1` forms the treatment group).



## Appendix IV: Detailed Regression Results

This appendix presents a detailed discussion of our regression results for each economic indicator tested, with the accompanying output organized into tables grouped by indicator. As noted earlier, the state-level regressions are included and discussed herein as a point of reference – but as we explain – the results are not convincing. State-level data on broadband availability is simply aggregated at too coarse a level. The principal results of our analysis rely on our zip-code level regressions and the matched-sample regressions which yielded similar results in most cases.

For each indicator, we start with the simplest regression using a dummy variable set to 1 if broadband was available in the community by December 1999, and zero otherwise. We then add regressors to control for non-broadband exogenous influences that could be expected to affect the growth of the economic variable of interest. Although we ran multiple versions of these more complex regressions, we report only what we consider the best versions of these.<sup>1</sup> All of the zip code regressions were run with robust errors to control for heteroskedasticity in our data. Finally, we ran the matched sample regressions as a final method of controlling for exogenous effects. Because broadband was first deployed (as would be expected) in more urban, denser, and richer communities where it is reasonable to believe broadband service might be more profitable to providers, the demographics of broadband "haves" (by December 1999) and "have-nots" (after December 1999 or not at all) are systematically different. The "have-nots" represent a much smaller sample of communities and are typically more rural. Thus, the matched sample results attempt to compare a sample of otherwise similar "haves" to "have not" communities (where otherwise similar is determined relative to the exogenous regressors included in the standard regressions). As one can see from examining the results (Tables A-I-3C through A-I-8C) and, as will be discussed shortly, in a number of cases, the "have nots" sample was simply too different from the "haves" to be able to generate an acceptable match. However, when it is possible to construct a well-matched sample and these results are significant, they provide additional support for our zip-code results.

Our results are generally consistent with the view that broadband enhances economic activity, helping to promote job creation both in terms of the total number of jobs and the number of establishments in communities with broadband (see Table A-I-1). The positive impact on establishment growth was higher for larger establishments and for

IT intensive sectors of the economy. We did not observe a significant impact of broadband on the average level of wages, but we do observe that residential property values (proxied by the average level of rent paid for housing) are higher in broadband-enabled communities. These results are discussed further in the following sub-sections.

Another way to see the results is to compare the sample means for communities with and without broadband ("haves" vs. "have nots") as of December 1999 (Table A-I-2). This comparison shows that the mean growth in rent, salaries, employment, number of establishments, and share of establishments in IT-intensive sectors were all higher in the communities with broadband, while only the share of small establishments declined. The regression results discussed below test this intuition further by adding additional controls to account for non-broadband influences that might account for these differences.

### Employment

Our first group of results (Table A-I-3) examines the impact of broadband availability on total employment in each community. As explained earlier, theory does not provide strong guidance *a priori* as to the expected impact of broadband on total employment. On the one hand, broadband might stimulate overall economic activity resulting in job growth; while on the other hand, broadband might facilitate capital-labor substitution, resulting in slower job growth. Furthermore, we might anticipate that broadband would have asymmetric effects by industry sector and for occupation mix. These additional share effects might result in ambiguous changes in the direction of total employment growth.

In the state-level regressions (here and in subsequent sub-sections except where noted), we use state-level data on broadband penetration as a measure of broadband use. This is appropriate in those cases where it seems reasonable to believe that it is broadband use (rather than simply its availability) that produces the economic impact. As discussed in Appendix II, because we expect a saturation effect, when we use penetration in the state-level regressions, we also include the square of penetration as an additional regressor.

In the state-level regressions for employment (Table A-I-3A), it initially looks as if broadband penetration might have a positive impact on employment growth which diminishes as penetration gets higher (thus, demonstrating the hypothesized saturation effect), but the relevant coefficients are not significant (regression 3A1). However, when additional regressors are added to control for such exogenous effects as

the growth in employment from 1994 to 1998 (gEmp9498) and a dummy variable to account for urbanization (dUrban), the signs on the broadband variables are reversed and remain insignificant (regression 3A4). This is not surprising and points to the problems with using state-level data already discussed. Simply, it offers too high a level of aggregation – combining too many separate and potentially reinforcing or countervailing forces (as suggested by the theory) – to permit us to observe a measurable impact.

However, when we turn to the zip code regressions (Table A-I-3B) and matched sample regressions (Table A-I-3C), we find a substantial positive impact for broadband availability on the growth in total employment. Progressing from simple (3B1) to more complex regressions (3B4), we observe that the magnitude of the estimated broadband effect declines. Nevertheless, it remains significant and positive. Regression 3B4 suggests that the availability of broadband added over 1 percent to the employment growth rate in the typical community (coefficient on BB99 is 0.01045). We also observe that the controls (gEmp9498 and dUrban) are significant and have positive signs as expected.

This result is also supported by the matched sample results (Table A-I-3C). The match appears reasonable and the impact of broadband on employment appears slightly higher in the results (0.014426), suggesting that broadband increased employment growth by almost 1.5 percent.

### Wages

Perhaps the most likely place to expect to see an impact of broadband would be on wages. If one believes that broadband enhances productivity in a number of ways, it is reasonable to expect that some of the benefits of these effects would be captured by workers. Additionally, perhaps the most extensive empirical literature that exists has focused on the positive effects of IT for wages and employment mix effects. Finally, one might expect that these wage effects might be observed in the economic data more quickly than shifts in employment mix (by occupation or by industry sector) or the number of firms (reflecting entry and exit into the community).

Thus, we initially approached the analyses of community wage data (measured as total payroll associated with all businesses in the community) with the hope of finding significant measurable impacts. Unfortunately, although some of the simplest regressions looked promising (4A1), as soon as we included appropriate exogenous controls, the sign of the coefficient on broadband changed signs (4A4) and became insignificant.

The coefficients on the controls have the expected signs. The growth in salary 1994 to 1998 (grSalary9498), the share of the population with college degrees in 2000 (pcollege2K), the growth of labor from 1990 to 2000 (grLabor90s), the share of establishments that are in IT intensive sectors in 1998 (pIT98), and the urbanization dummy (dUrban) all have positive and significant coefficients. After controlling for these effects, we do not observe any additional significant effect attributable to broadband.

### Rent

The third group of regressions we run look at the impact of broadband on rental rates as reported in the 2000 Census. Our measure of broadband availability only tells us whether a community has broadband by December 1999 or not, it does not tell us how long the community has had broadband. However, it seems reasonable that if broadband has an effect on rental rates, that effect ought to be observed relatively quickly. Since broadband is desirable, we would expect to see the availability of broadband resulting in higher rental rates.

The results reported in Tables A-I-5A and A-I-5B support the conclusion that rental rates were significantly higher in 2000 in communities that had broadband. The most meaningful zip-code regression shows that rental rates were almost 7 percent higher (coefficient on BB99 is 0.06557) for broadband communities (5B4). The state-level results (5A4) are consistent with the zip-code results, but for reasons already discussed, we do not place much stock in these. By contrast, the matched sample results show a significant negative impact of broadband on rents; however, in attempting to create a matched sample of zip codes with broadband in 1999 which is similar along the independent variables to the set of zip codes without broadband, we are unable to construct such a matched sample with equivalent levels of family income growth. Our attempts to find such a match reveal that otherwise comparable zip codes with broadband all had significantly higher levels of two control variables: family income growth and labor force growth. Because the matched set is not fully comparable, no conclusions should be drawn from this approach as to whether broadband availability affects rents.

### Industry Structure and Mix

The last group of results we will discuss relate to the impact of broadband on industry structure and the mix of businesses by industry sector and size. These results are reported in Tables A-I-6 through 8. Table A-I-6 looks at the growth in

the total number of establishments; Table A-I-7 looks at the growth in the share of firms that are in IT intensive sectors; and Table A-I-8 looks at the share of firms that are small (10 or fewer employees). We discuss each of these in turn.

First, looking at Table A-I-6, we see that broadband has a significant positive effect on the growth in the number of business establishments, increasing growth, by almost one-half of a percent (BB99 coefficient is 0.00483) from 1998 to 2002 in the best zip code regression (6B4). This positive effect is retained in the matched sample regressions, but is two and half times larger (Table A-I-6C), although again, labor force growth is imperfectly matched. The state-level regressions also support this result (6A4). Moreover, in the zip-code regressions, the controls have the appropriate positive sign: growth in number of establishments from 1994 to 1998 (grEst4998), urbanization dummy (dUrban), and the growth in labor force from 1990 to 2000 (grLabor90s).

Second, turning to Table A-I-7, we see that the share of firms in IT intensive sectors is higher in broadband communities. In the best of the zip code regressions, the share of establishments that are in IT intensive sectors increased by an additional one half percent between 1998 and 2002 in communities that had broadband by December 1999 (7B4). This is a large effect and it is hardly surprising since we would expect there to be a positive feedback process underlying this observation. That is, IT intensive sectors are the most likely to demand and use broadband services, and if availability is an issue, IT intensive firms are more likely to expand operations in locales with broadband. This effect complements the positive effect we observe on total employment. This result is supported by matched sample regression (7C), although the magnitude of the effect is reduced by almost half. The state-level regressions (7A4) show conflicting results that suggest that broadband's impact on the change in the share of firms in a state that are in IT intensive sectors is negative for low penetration and becomes positive only for relatively high penetration.<sup>2</sup> These results are not very interesting because almost all of the variability in the share of IT intensive firms is already explained by the share of IT intensive firms in 1998.

Third, and in some ways most interesting, our data provides some suggestive results as to the impact of broadband on firm organization and the size of business establishments. One theory is that the availability of enhanced communication services facilitates more geographically distributed types of firm organization ("death of distance"). If true, this could explain why the number of establishments in 2002, normalized by population in 2000, is higher in broadband

communities (0.030) than in communities without broadband (0.024). Additionally, broadband might lower entry barriers for new firms and may encourage the growth of self-employment. Since most of these establishments are likely to be quite small, we might expect to see faster growth in the number of small establishments in broadband enabled communities.

Table A-I-8 shows results of estimating the impact of broadband on the change in the share of firms that are small (less than 10 employees) between 1998 and 2002. The state-level results are consistent with the hypothesis explained in the previous paragraph (8A4), but are not significant, and since these are state-level regressions we do not place much stock in them in any case. When we turn to the zip-code regressions, however, we observe a significant effect that is contrary to our expectation. We observe that the share of firms that are small declined in broadband enabled communities relative to non-broadband communities by over one percent (8B4). In the overall sample, the relative size mix of establishments declined only slightly (sample means for psm98 and psm02 were 0.792 and 0.790, respectively, in Table A1 in Appendix II); however, the decline was greater in broadband communities. The matched sample results in Table A-I-8C are significant and consistent with the zip-code results.

When we tried to explore this further by looking at regressions with the number of establishments per population or using different measures of the size composition, the regressions failed to indicate a measurable impact for broadband.

Because we cannot control for the growth in the relative number of firms by different size classes (we observe only the number of establishments by industry sector and size class), our data do not really allow us to infer the impact of broadband on firm organization. To address this question, it may be more appropriate to use enterprise-level data like the data used by Greenstein, Forman et al. (2005).

## Endnotes

<sup>1</sup> For example, we do not include variables that were consistently insignificant (e.g., population density).

<sup>2</sup> That is, the coefficient on broadband penetration is -0.27606 and on broadband penetration squared is 2.61798 (Table A-I-7A4), so the overall impact of broadband is negative for any penetration level below 11 percent.

<sup>3</sup> Dependent variable is growth rate from 1998-2002, with exception of rental rates, which are 1990-2000

<sup>4</sup> First sign refers to broadband penetration, second sign to square of broadband penetration.

Table A-I-1: Broadband Impact on Growth of Selected Economic Variables<sup>3</sup> (+/-=growth higher/lower in broadband communities; \*=significant at 90% or above)

	State <sup>4</sup>	Zip	Matched Panel
Employment	-/+*	+*	+*
Wages	+/-	-	-
Rental rates	+*	+*	-*
Establishments	+/-*	+*	+*
IT-intensive share of establishments	-/+*	+*	+*

Table A-I-2: Means for Communities with (and without) Broadband by Dec99

		With Broadband by Dec 99 (N=15,020)	With No Broadband by Dec 99 (N=7,370)
Categories	Variable	Mean (Std. Dev.)	Mean (Std. Dev.)
Dependent Variables	InRent2K	6.306 (0.341)	6.039 (0.298)
	LnrSalary	0.072 (0.131)	0.059 (0.206)
	ptotIT02	0.240 (0.088)	0.195 (0.088)
	InrEmplo	0.049 (0.263)	0.015 (0.401)
	psm02	0.768 (0.087)	0.834 (0.102)
	InrEst	0.054 (0.150)	0.027 (0.204)
Independent Variables	dUrban	0.739 (0.438)	0.374 (0.483)
	URinfl03	2.882 (2.632)	5.294 (3.253)
	gEmp9498	0.434 (7.356)	0.289 (1.315)
	grColl90s	11.526 (96.28)	3.310 (24.549)
	grEst9498	0.169 (1.428)	0.104 (0.425)
	grFInc90s	1.046 (64.969)	0.501 (0.370)
	grLabor90s	6.487 (79.518)	2.046 (18.969)
	grpIT9800	0.030 (0.193)	0.053 (0.334)
	grSalary9498	0.180 (0.243)	0.212 (0.432)
	InRent90	5.995 (0.403)	5.711 (0.369)
	pcollege2K	22.387 (14.684)	14.211 (9.096)
	pEst98	0.029 (0.133)	0.024 (0.042)
	pIT98	0.232 (0.085)	0.191 (0.087)
	psm98	0.772 (0.086)	0.832 (0.102)

Employment - Table A-I-3A: Employment - State Level Regressions

	(3A1)	(3A2)	(3A3)	(3A4)
	LnrEmplo	LnrEmplo	LnrEmplo	LnrEmplo
BBPen00	0.44262	-0.39993		-0.45585
	[0.88115]	[0.79912]		[0.81443]
SqBBPen00	-0.73487	7.61773		7.43397
	[10.00182]	[8.99095]		[9.07825]
gEmp9498		0.42372	0.3912	0.41257
		[0.10915]***	[0.10807]***	[0.11250]***
pUrbPop00			0.03577	0.01914
			[0.03221]	[0.03961]
Constant	0.02467	-0.013	-0.03534	-0.02295
	[0.01621]	[0.01716]	[0.02399]	[0.02689]
Observations	48	48	48	48
R-squared	0.0531	0.2947	0.2801	0.2985

Standard errors in brackets

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-I-3B: Employment - Zip Code Regressions

	(3B1)	(3B2)	(3B3)	(3B4)
	lnrEmplo	lnrEmplo	lnrEmplo	lnrEmplo
BB99	0.03344	0.0333		0.01045
	[0.00515]***	[0.00515]***		[0.00560]*
gEmp9498		0.00094	0.00075	0.00075
		[0.00036]***	[0.00031]**	[0.00031]**
dUrban			0.0585	0.05548
			[0.00493]***	[0.00507]***
...				
Constant	0.01512	0.01485	0.04361	0.03571
	[0.00468]***	[0.00468]***	[0.03040]	[0.03070]
Observations	22390	22390	22390	22390
R-squared	0.0025	0.0028	0.0271	0.0273

Robust standard errors in brackets. State dummies are not shown in table. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-I-3C: Employment - Zip Code nmatch regressions

		Coefficient	z-statistic	P> Z	
N=22,390	BB99	.0144264	1.94	0.052	
		Treatment BB99=1		Control BB99=0	
	Variable	Mean	Std. Dev.	Mean	Std. Dev.
Dep. Variable	lnrEmplo	0.0379408	0.238360	0.0329223	0.3475896
Independent Variables	gEmp9498	0.1832633	3.193463	0.1627447	0.9055611
	URinfl03	2.74577	2.341581	2.746226	2.342017

Wage Regressions - Table A-I-4A: State Level Salary Regressions

	(4A1)	(4A2)	(4A3)	(4A4)
	lnrSalary	lnrSalary	lnrSalary	lnrSalary
BBPen00	0.34782	0.42969		0.54628
	[0.42041]	[0.44506]		[0.41635]
SqBBPen00	-0.47119	-0.85803		-2.55233
	[4.77196]	[4.84982]		[4.58457]
grSalary9498		-0.04846	-0.08287	-0.15117
		[0.08110]	[0.07780]	[0.08060]*
grcollege90s			0.07534	0.07657
			[0.04023]*	[0.03871]*
pcollege2K			0.00282	0.00243
			[0.00074]***	[0.00074]***
grLabor90s			-0.08908	-0.09298
			[0.04953]*	[0.04814]*
pUrbPop00			-0.0274	-0.04813
			[0.02390]	[0.02514]*
plTfirms98			0.06221	0.11477
			[0.16172]	[0.15833]
Constant	0.1204	0.12675	0.06724	0.07492
	[0.00773]***	[0.01318]***	[0.03122]**	[0.03042]**
Observations	48	48	48	48
R-squared	0.1389	0.1458	0.3153	0.3971

Standard errors in brackets

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-I-4B: Zip Code Salary Regressions

	(4B1)	(4B2)	(4B3)	(4B4)
	LnrSalary	LnrSalary	LnrSalary	LnrSalary
BB99	0.01328	0.00932		-0.00269
	[0.00263]***	[0.00253]***		[0.00284]
grSalary9498		-0.12272	-0.12484	-0.12504
		[0.01042]***	[0.01056]***	[0.01059]***
grColl90s			-0.00001	-0.00001
			[0.00001]	[0.00001]
pcollege2K			0.00082	0.00083
			[0.00009]***	[0.00010]***
grLabor90s			0.00003	0.00003
			[0.00001]**	[0.00001]**
dUrban			0.00429	0.00493
			[0.00252]*	[0.00259]*
plT98			0.02275	0.02443
			[0.01586]	[0.01604]
...				
Constant	0.05957	0.08564	0.08206	0.08359
	[0.00241]***	[0.00297]***	[0.01355]***	[0.01364]***
Observations	22390	22390	22390	22390
R-squared	0.0015	0.0614	0.0772	0.0773

Robust standard errors in brackets. State dummies are not shown in table. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%



Table A-I-4C: Zip Code Salary nmatch regressions

		Coefficient	z-statistic	P> Z	
N=22,390	BB99	.0003026	0.08	0.938	
		Treatment BB99=1		Control BB99=0	
	Variable	Mean	Std. Dev.	Mean	Std. Dev.
Dep. Variable	LnrSalary	0.0684275	0.1435969	0.0682071	0.1882474
Independent Variables	grSalary9498	0.1904726	0.3090776	0.1904069	0.3222383
	grColl90s	8.707712	80.1020	7.0213	49.18039
	pcollege2K	19.69874	13.62371	19.57184	13.54363
	grLabor90s	4.957307	65.87055	3.784536	29.32728
	URinfl03	3.673292	3.06596	3.683296	3.060917

Rent Regressions - Table A-I-5A: State Level Rent Regressions

	(5A1)	(5A2)	(5A3)	(5A4)
	LnRent00	LnRent00	LnRent00	LnRent00
BBAvailHU99	0.94869	0.27693		0.29616
	[0.19152]***	[0.07635]***		[0.09454]***
LnRent90		0.6333	0.70058	0.71233
		[0.03474]***	[0.04779]***	[0.04370]***
grFamInc90s			0.26186	0.25361
			[0.13617]*	[0.12408]**
grLabor9200			0.23264	0.23224
			[0.06576]***	[0.05991]***
pUrbHousing00			0.10155	-0.08143
			[0.05463]*	[0.07674]
Constant	5.49514	2.23559	1.8596	1.66449
	[0.16676]***	[0.18804]***	[0.30911]***	[0.28840]***
Observations	48	48	48	48
R-squared	0.3478	0.9222	0.9441	0.9547

Standard errors in brackets

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-I-5B: Zip Code Rent Regressions

	(5B1)	(5B2)	(5B3)	(5B4)
	lnRent2K	lnRent2K	lnRent2K	lnRent2K
BB99	0.26704	0.10341		0.06557
	[0.00445]***	[0.00507]***		[0.00390]***
lnRent90		0.57686	0.41784	0.40158
		[0.01315]***	[0.01646]***	[0.01646]***
grFInc90s			0.00007	0.00007
			[0.00002]***	[0.00002]***
grLabor90s			0.00016	0.00015
			[0.00007]**	[0.00006]**
dUrban			0.16388	0.14939
			[0.00550]***	[0.00512]***
...				
Constant	6.03934	2.7445	3.73793	3.78442
	[0.00348]***	[0.07570]***	[0.10080]***	[0.09939]***
Observations	22390	22390	22390	22390
R-squared	0.1278	0.5439	0.6165	0.6227

Robust standard errors in brackets. State dummies are not shown in table. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-I-5C: Zip Code Rent nmatch regressions

		Coefficient	z-statistic	P> Z	
N=22,390	BB99	-0.020979	-4.68	0.000	
		Treatment BB99=1		Control BB99=0	
	Variable	Mean	Std. Dev.	Mean	Std. Dev.
Dep. Variable	lnRent2K	6.227739	.3418756	6.184831	.3376517
Independent Variables	lnRent90	5.901608	.4138795	5.901871	.4118173
	grFinc90s	0.8652419	53.04271	0.4759079	.323962
	grLabor90s	4.979731	65.78181	3.964122	29.44959
	URinfl03	3.671208	3.061892	3.677066	3.059775

Total Establishments - Table A-I-6A: Total Establishments - State Level Regressions

	(6A1)	(6A2)	(6A3)	(6A4)
	InrEst	InrEst	InrEst	InrEst
BBPen00	1.12032	0.41932		0.19639
	[0.76148]	[0.40444]		[0.42569]
SqBBPen00	-8.83193	-1.20117		-0.06339
	[8.64342]	[4.58608]		[4.84344]
grEst9498		0.6161	0.51694	0.51294
		[0.05633]***	[0.11529]***	[0.11916]***
grLabor90s			0.03182	0.03725
			[0.04525]	[0.04880]
pUrbPop00			0.05317	0.03633
			[0.01648]***	[0.02019]*
Constant	0.00987	-0.02436	-0.04674	-0.04213
	[0.01401]	[0.00798]***	[0.01176]***	[0.01340]***
Observations	48	48	48	48
R-squared	0.0865	0.7376	0.7628	0.7740

Standard errors in brackets

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-I-6B: Total Establishments - Zip Code Regression

	(6B1)	(6B2)	(6B3)	(6B4)
	InrEst	InrEst	InrEst	InrEst
BB99	0.02625	0.02552		0.00483
	[0.00268]***	[0.00268]***		[0.00287]*
grEst9498		0.01122	0.00959	0.00957
		[0.00468]**	[0.00401]**	[0.00401]**
dUrban			0.04425	0.04285
			[0.00262]***	[0.00271]***
grLabor90s			0.00006	0.00006
			[0.00001]***	[0.00001]***
...				
Constant	0.02725	0.02608	0.03908	0.03542
	[0.00238]***	[0.00243]***	[0.02072]*	[0.02077]*
Observations	22390	22390	22390	22390
R-squared	0.0052	0.0114	0.0626	0.0627

Robust standard errors in brackets. State dummies are not shown in table. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-I-6C: Total Establishments - Zip Code nmatch regression

		Coefficient	z-statistic	P> Z	
N=22,390	BB99	0.0123135	3.37	0.001	
		Treatment BB99=1		Control BB99=0	
	Variable	Mean	Std. Dev.	Mean	Std. Dev.
Dep. Variable	lnrEst	0.0480704	0.1595301	0.0361407	0.1881027
Independent Variables	grEst9498	0.1381222	1.145844	0.1260622	0.6235826
	grLabor90s	4.610127	63.30446	3.935026	28.74862
	URinfl03	3.599211	3.018462	3.603401	3.014999

Table A-I-7A: Establishments in IT Intensive Sectors - State Regressions

	(7A1)	(7A2)	(7A3)	(7A4)
	ptotIT02	ptotIT02	ptotIT02	ptotIT02
BBPen00	0.68198	-0.14742		-0.27606
	[0.54717]	[0.11538]		[0.08941]***
SqBBPen00	-3.60893	0.76199		2.61798
	[6.21081]	[1.28341]		[1.01144]**
ptotIT98		1.06976	1.0274	1.03108
		[0.03346]***	[0.03715]***	[0.03414]***
grcollege90s			0.00163	0.00271
			[0.00930]	[0.00849]
pcollege2K			-0.00014	-0.00003
			[0.00017]	[0.00016]
grLabor90s			0.01454	0.0169
			[0.01142]	[0.01051]
pUrbPop00			-0.00281	-0.00043
			[0.00572]	[0.00574]
grplT9800			0.21154	0.21862
			[0.06271]***	[0.05792]***
Constant	0.25037	-0.00356	0.00476	0.004
	[0.01007]***	[0.00821]	[0.00725]	[0.00675]
Observations	48	48	48	48
R-squared	0.1299	0.9641	0.9778	0.9825

Standard errors in brackets

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%



Table A-I-7B: Establishments in IT Intensive Sectors - Zip Code Regressions

	(7B1)	(7B2)	(7B3)	(7B4)
	ptotIT02	ptotIT02	ptotIT02	ptotIT02
BB99	0.04463	0.00994		0.00594
	[0.00125]***	[0.00089]***		[0.00085]***
pIT98		0.84724	0.86345	0.85988
		[0.00541]***	[0.00598]***	[0.00609]***
grColl90s			0.00001	0.00001
			[0.00000]***	[0.00000]***
pcollege2K			0.00065	0.00062
			[0.00003]***	[0.00003]***
dUrban			0.00314	0.00174
			[0.00075]***	[0.00076]**
grpIT9800			0.0795	0.07963
			[0.00242]***	[0.00241]***
...				
Constant	0.19566	0.03319	0.01977	0.01641
	[0.00103]***	[0.00112]***	[0.00496]***	[0.00508]***
Observations	22390	22390	22390	22390
R-squared	0.0539	0.7055	0.7619	0.7626

Robust standard errors in brackets. State dummies are not shown in table. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-I-7C: Establishments in IT Intensive Sectors - Zip Code nmatch regressions

		Coefficient	z-statistic	P> Z	
N=22,390	BB99	.0028547	1.99	0.046	
		Treatment BB99=1		Control BB99=0	
	Variable	Mean	Std. Dev.	Mean	Std. Dev.
Dep. Variable	ptotIT02	0.2254862	0.0889145	0.22155	0.0898961
Independent Variables	pIT98	0.2190703	0.0874809	0.2180745	0.0862081
	grColl90s	8.685352	80.12625	6.908195	51.86047
	pcollege2K	19.69035	13.58824	19.51451	13.51298
	URinfl03	3.666503	3.05856	3.681733	3.056761
	grpIT9800	0.0381206	0.2466281	0.0360131	0.2491051

Table A-I-8A: Small Establishments - State Level Regressions

	(8A1)	(8A2)	(8A3)	(8A4)
	psmall02	psmall02	psmall02	psmall02
BBPen00	0.0625	0.24637		0.12979
	[0.51854]	[0.12967]*		[0.12543]
SqBBPen00	-0.70207	-2.73645		-1.7089
	[5.88580]	[1.47174]*		[1.40863]
psmall98		0.95164	1.00245	1.00152
		[0.03655]***	[0.03993]***	[0.04015]***
grcollege90s			0.01559	0.01374
			[0.00556]***	[0.00579]**
pcollege2K			-0.00023	-0.0002
			[0.00023]	[0.00025]
ptotIT98			0.01027	0.00199
			[0.04994]	[0.05073]
pUrbPop00			0.01172	0.01364
			[0.00724]	[0.00793]*
Constant	0.73681	0.02759	-0.01768	-0.0179
	[0.00954]***	[0.02735]	[0.03334]	[0.03353]
Observations	48	48	48	48
R-squared	0.0003	0.9349	0.9522	0.9459

Standard errors in brackets

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-I-8B: Small Establishments - Zip Code Regression

	(8B1)	(8B2)	(8B3)	(8B4)
	psm02	psm02	psm02	psm02
BB99	-0.06545	-0.01574		-0.01324
	[0.00139]***	[0.00103]***		[0.00110]***
psm98		0.81688	0.80843	0.79594
		[0.00541]***	[0.00555]***	[0.00583]***
pIT98			-0.04825	-0.04339
			[0.00605]***	[0.00601]***
grColl90s			0	0
			[0.00000]	[0.00000]
pcollege2K			-0.00001	0.00005
			[0.00003]	[0.00003]*
dUrban			-0.00952	-0.00694
			[0.00096]***	[0.00096]***
...				
Constant	0.83439	0.15403	0.15994	0.17797
	[0.00120]***	[0.00476]***	[0.00839]***	[0.00887]***
Observations	22390	22390	22390	22390
R-squared	0.0990	0.6958	0.6983	0.7013

Robust standard errors in brackets. State dummies are not shown in table. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-I-8C: Small Establishments - Zip Code nmatch regression

		Coefficient	z-statistic	P> Z	
N=22,390	BB99	-0.015714	-9.02	0.000	
		Treatment BB99=1		Control BB99=0	
	Variable	Mean	Std. Dev.	Mean	Std. Dev.
Dep. Variable	psm02	0.7875819	0.0944401	0.8049239	0.0993516
Independent Variables	psm98	0.792165	0.0957805	0.7944902	0.0954684
	pIT98	0.2191602	0.087082	0.217224	0.0848717
	grColl90s	8.698381	80.10981	6.833522	51.23653
	pcollege2K	19.70571	13.60049	19.34939	13.2098
	URinfl03	3.666324	3.058514	3.699777	3.044652

## Appendix V: Effect of Broadband in the Appalachian Region

Economically distressed areas are of particular concern to economic development practitioners. Therefore, we focused a follow-on investigation on the question of whether broadband’s impact on distressed communities looks statistically different from its impact on the nation as a whole. We used the counties listed as under the purview of the Appalachian Regional Commission (ARC) on their web site to define a list of zip codes for more focused study. We then analyzed broadband’s impact within that sample of zip codes, using two approaches.

First, we applied the same statistical techniques used in the national-scale study. The first section of this appendix presents the results of regression analysis at the zip code level across the Appalachian Region, following the same rationale used in the zip code level analysis for the United States. The regression results are consistent with the national findings, and show that broadband had a positive effect on the growth of employment, the number of business establishments, and on the rents paid for housing. In particular, the results suggest that broadband is even more potent in distressed areas at stimulating employment, suggesting that economic development practitioners are indeed pursuing important goals when they focus on stimulating broadband availability and adoption.

The second section discusses our attempt to construct and analyze a matched sample to compare economic outcomes in ARC communities that stimulated broadband against otherwise-similar ARC communities that didn’t. Unfortunately, as we explain, the lack of available data and the small size of the sample precluded statistically meaningful analysis at this time. Given the small number of cases available, future research based on qualitative methods might offer a better approach for assessing the relationship between local government broadband initiatives and economic impact.

### A-V.1. Regression Analysis

Following up from the national-scale zip-code-level analysis, this section examines broadband’s impact in economically distressed areas, by studying its socioeconomic effect across zip codes in the Appalachian Region. We followed the same rationale and performed the same regressions used in the national sample analysis. The detailed results for simple and matched sample regressions are reported in tables A-V.2 to A-V.7.

Table A-V.1 provides an “at-a-glance” summary of these results, which are consistent with our nation-wide study. Due to the smaller sample size, however, fewer statistically significant results are obtainable. The ARC regressions show that between 1998 and 2002, communities in which broadband became available by December 1999 experienced more rapid growth in (1) employment, and (2) overall number of businesses. Within the Appalachian Region, however, the available data (3) does not demonstrate statistically significant effects on wages and (4) does not show a significant effect on the share of businesses in IT-intensive sectors. The effects of broadband availability can also be observed in (5) higher market rates for rental housing. These results are discussed further in the following subsections.

Table A-V.1. Broadband Impact on Growth of Selected Economic Variables (+/- = growth higher/lower in broadband communities; \*=significant at 90% or above)

	Zip	Matched Panel
Employment	+*	+*
Wages	+	-
Rental rates	+*	+
Establishments	+*	+*
IT-intensive share of establishments	+	-

### A. Employment

Our analysis of the effect of broadband availability on employment in the Appalachian Region supports our previous finding for the nation-wide sample. The regressions in Table A-V.2A show that broadband communities had nearly a 5% higher rate of employment growth between 1998 and 2002. When we progress from the simplest (A-V.2A-1) to more complex regression (A-V.2A-4), the magnitude of the coefficient does not change very much. Furthermore, it is interesting to note that the coefficient is substantially higher than the 1.05% found for the United States (see Appendix IV, Table A-I-3B). Additional analysis is warranted to understand the sources of this difference.

The results from the matched panel regressions (Table A-V.2B) show similar results, but more robust than for the nation wide sample. Interestingly, the difference of these results with the national sample seem to be consistent with the view that broadband might have an especially important effect in smaller, more rural and economically distressed areas.

## B. Wages

As with the national analysis, we did not find a statistically significant impact of broadband availability on wages for the ARC sub-sample (Tables A-V3A.1-4). The matched sample regressions also fail to show a measurable difference. One reason for this is there are no matched samples with equivalent levels of growth of college education and labor during the 1990-2000 period. As the treatment and control samples are not comparable, no conclusions can be drawn from these results.

## C. Rent

Regression analysis (Table A-V.4A) shows that, at the zip code level, the relationship between broadband availability and market value of housing rent in the Appalachian Region is statistically significant, but of lower magnitude than for the national sample: 2.2% for the ARC as compared to 6.5% for the United States (Appendix IV, Table A-I-5B). This higher effect is consistent with an average higher valuation of broadband in urban and dense places as compared with small and rural areas, but once again, caution is advised before concluding that the observed differences in the magnitude of the coefficients is significant.

Matched sample regressions (Table A-V.4B) show better results than for the national analysis (Appendix IV, Table A-I-5C). As previously mentioned, the nation-wide results were biased because the samples were not perfectly matched in levels of growth of median family income of labor during the nineties. In the ARC case, however, while the problem persists around growth of labor in 1990-2000, there is almost a perfect match in the growth of median family income in the same period.

## D. Industry Structure and Mix

In this subsection we study the effect of broadband availability on the total number of business establishments (regressions in Table A-V.5), business establishments in IT-intensive sectors (regressions in Table A-V.6), and business establishments with less than 10 employees (regressions in Table A-V.7).

First, our regression results for the Appalachian Region are consistent with the national results which found that broadband availability has a statistically significant effect on the number of business establishments (Table A-V.5A). Again, the higher estimated coefficient for the ARC region (1.9% v. 0.05% in Table A-I-6B) is consistent with concluding that the impact of broadband is larger in small and rural areas. The matched panel regressions support these results.

Second, our results from regressions on the effect of broadband on IT-intensive establishments (Table A-V.6A) show that, while the share of firms in IT intensive sectors is higher in zip codes where broadband was available by December of 1999, this relationship is not statistically significant. The significant effect of broadband appears in the simplest regression (A-V.6A-1), but is gradually lost after adding exogenous control variables (A-V.6A-4). This result differs from the one for our national sample, and could result from an *ex ante* lower share of IT-intensive firms in the region (19.9%), as compared to the national sample (21.9%). As in the national sample, almost all the variability here is explained by the share of IT-intensive firms in 1998. Results of our matched panel regression (A-V.6B) are similar, but the sign is reversed. Because of matching problems with the growth of college graduates, and data problems mentioned in the analysis of the nation wide study, we do not regard this change in sign and lack of significance as overly important.

Third, our analysis of the effect of broadband in small establishments (Table A-V.7) shows that the results for our zip code regressions for the Appalachian Region (A-V.7A) confirm our findings for the national sample: the share of firms that are small declined in communities with broadband. This effect is significant, and the effect of broadband availability is maintained along all regressions when exogenous control variables are included. This effect, however, is lower in communities in the Appalachian Region (-0.96%, in A-V.7A-4) than for the national sample (-1.32%, in Appendix IV, Table A-I-8B4). These results are confirmed by our results of matched sample regressions (Table A-V.7B). The results in both regressions are biased due to omitted variable: we could not control for growth in the number of firms by size class, which –among other data issues- do not allow inferences about broadband’s impact in this case.

## A-V.2. Comparison of Communities vis a vis Broadband Stimulation

The previous section shows that broadband’s economic impact is hardly limited to areas where the economy is already thriving. In fact, broadband may be even more important to economically distressed areas, while at the same time less likely to be available given that many such communities are also rural. This paradoxical observation led us to investigate whether economic impacts could be observed from locally scoped initiatives intended to make broadband more available within distressed communities.

Our intention was to construct a sample of communities within the ARC region that had undertaken such initiatives,

drawing on three sources: data we already had on municipal electric utilities that offer communications services; data to be obtained from the ARC itself on locally scoped initiatives intended to stimulate broadband; and public reports of locally led<sup>1</sup> broadband wireless or fiber deployments in the region. We would then compare this sample against communities within the ARC region that had not undertaken a broadband stimulation initiative, but were otherwise similar, thus creating a matched sample for statistical analysis.

Unfortunately, meaningful statistical analysis of this sort did not prove possible due to several forms of data limitations. First, while we were able to gather reports of at least 11 locally led broadband initiatives, only one of these – the AllCoNet deployment in Allegany County, Maryland – was in operation prior to 2002, the latest year for which the U.S. Census Zip Code Business Patterns data (from which we constructed economic indicators) was available at the time of the study. Table A-V.9 reports the qualitative data we gathered about the initiatives we found. This data could form the basis of future study of the outcomes of such initiatives, possibly taking a more case-based approach given the limited number of communities available for study.

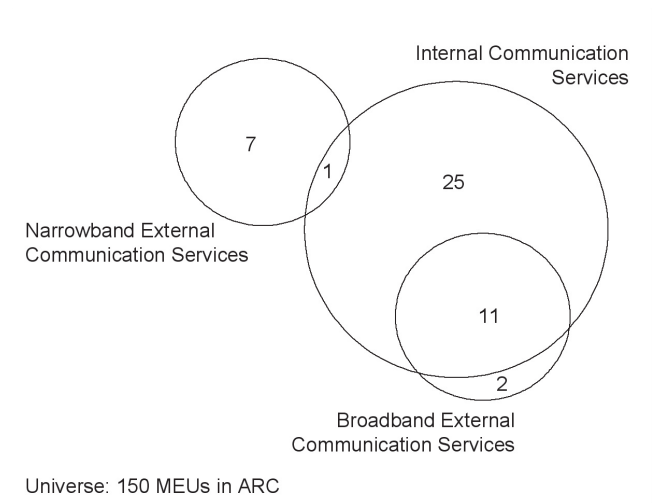
In contrast, as Table A-V.10 shows, many telecommunications-related projects funded by the ARC had longer time horizons, having begun in the 1990s. However, upon further investigation we learned that as a matter of policy, ARC projects did not involve construction of broadband infrastructure. In fact, our investigation revealed anecdotal evidence that some of the projects had in fact been limited by lack of available connectivity in remote areas, as for example would be necessary to take full advantage of telemedicine equipment. Thus, the list of ARC projects, while available to us, did not produce a list of communities where broadband infrastructure deployments had been stimulated.

We were thus left with the list of 150 Municipal Electric Utilities (MEUs) in the ARC region, of which 46 – across all 13 ARC states – offered some form of communication service in 2002 (see Table A-V.8). In lieu of regression results, which did not prove meaningful given the small number of communities involved, the remainder of this section simply provides an overview of what such utilities are doing.<sup>2</sup>

According to data from the American Public Power Association (APPA), only 13 of the 150 MEUs in the ARC region offered some form of external broadband service by 2002 (See Figure A-V.1). As an example, Barbourville Electric Utility in Knox County, Kentucky, started its Internet initiative in 1996 and –in collaboration with CommSys- serves 3,300

customers with high-speed Internet through fiber currently.<sup>3</sup> Other examples of fiber deployments are Hagerstown<sup>4</sup> in Washington County, Maryland, and Bristol in Scott County, Virginia.<sup>5</sup> In the wireless area, Tropos Networks created a wireless public safety network that covers 2 square miles in Jamestown, in Chautauqua County, New York, and a police public safety network covering 3 square miles.<sup>6</sup>

Figure A-V.1. Municipal Electric Utilities in the Appalachian Region



Source: American Public Power Association Annual Survey (2002)

An additional 8 MEUs offered external communication services, such as cable television, dial-up Internet access, and local or long distance telephony. Additionally, 37 electric utilities have deployed some form of communication service to serve internal operations or local government needs. These services are municipal data, System Control and Data Acquisition (SCADA), Automatic Meter Reading (AMR), and voice or video.

In sum, statistical approaches did not prove viable for assessing the economic impacts of broadband stimulation initiatives in the ARC region; there are simply too few of them. Such initiatives may well have an effect, but it will need to be studied by other methods, such as in-depth qualitative analysis of the relationship between local government broadband initiatives and local economic growth. Such case study research might also allow for identifying the factors that have contributed to or hindered locally led broadband deployments and their corresponding economic impacts.



## Endnotes

<sup>1</sup> This category includes initiatives led by local governments (including municipalities and counties) as well as community groups, local institutions of higher education, etc.

<sup>2</sup> For comparison purposes, we include the summary statistics for communities with and without broadband in the ARC zip codes in Table A-V.11.

<sup>3</sup> See CommSys. “On Ramp to Information Superhighway.” 4 Jun, 2001. <[http://www.commsys.com/pdf/barbourville\\_ky.pdf](http://www.commsys.com/pdf/barbourville_ky.pdf)>

<sup>4</sup> Appalachian Regional Commission Online Resource Center. “Best Practices in Telecommunications.” <<http://www.arc.gov/index.do?nodeId=977>>

<sup>5</sup> Louisa County. “Technology Assessment and Master Plan.” September 2004. <[http://top.bev.net/archive/tamp/6-Louisa/Louisa\\_TAMP.pdf](http://top.bev.net/archive/tamp/6-Louisa/Louisa_TAMP.pdf)>

<sup>6</sup> Muniwireless.com. “March 2005 Report.” <<http://www.muniwireless.com/reports/docs/March2005Report.pdf>>

Table A-V.2A Employment – Zip Code Regressions in ARC

	(A-V.2A-1)	(A-V.2A-2)	(A-V.2A-3)	(A-V.2A-4)
	lnrEmplo	lnrEmplo	lnrEmplo	lnrEmplo
BB99	0.05023	0.05019		0.0497
	[0.01579]***	[0.01581]***		[0.01576]***
gEmp9498		0.00181	0.00158	0.0017
		[0.00216]	[0.00212]	[0.00208]
dUrban			0.04352	0.03696
			[0.01415]***	[0.01397]***
...				
Constant	-0.02756	-0.02811	0.05924	0.02406
	[0.01411]*	[0.01405]**	[0.05573]	[0.05732]
Observations	2578	2578	2578	2578
R-squared	00049	0.0050	0.0216	0.0260

Robust standard errors in brackets. State dummies are not shown in table. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-V.2B Employment – Zip Code nmatch Regressions in ARC

		Coefficient	z-statistic	P> Z	
N=2578	BB99	0.052799	2.92	0.004	
		Treatment BB99=1		Control BB99=0	
	Variable	Mean	Std. Dev.	Mean	Std. Dev.
Dep. Variable	lnrEmplo	0.026087	0.307948	-0.019885	0.388651
Independent Variables	gEmp9498	0.3053506	2.28652	0.2704399	1.124838
	URinfl03	4.248697	2.902376	4.252048	2.904973

Table A-V.3A Wage – Zip Code Regressions in ARC

	(A-V.3A-1)	(A-V.3A-2)	(A-V.3A-3)	(A-V.3A-4)
	LnrSalary	LnrSalary	LnrSalary	LnrSalary
BB99	0.01522	0.01134		0.00679
	[0.00868]*	[0.00827]		[0.00870]
grSalary9498		-0.15916	-0.16064	-0.16013
		[0.02958]***	[0.02956]***	[0.02944]***
grColl90s			-0.00005	-0.00005
			[0.00005]	[0.00005]
pcollege2K			0.00094	0.00091
			[0.00048]**	[0.00049]*
grLabor90s			0.00011	0.00011
			[0.00011]	[0.00011]
dUrban			0.00794	0.00721
			[0.00740]	[0.00743]
pIT98			-0.04424	-0.04795
			[0.05382]	[0.05390]
...				
Constant	0.0443	0.07413	-0.01632	-0.02027
	[0.00791]***	[0.00849]***	[0.04072]	[0.04114]
Observations	2578	2578	2578	2578
R-squared	0.0016	0.0664	0.0780	0.0783

Robust standard errors in brackets. State dummies are not shown in table. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-V.3B Wage – Zip Code nmatch Regressions in ARC

		Coefficient	z-statistic	P> Z	
N=2578	BB99	-0.002576	-0.30	0.762	
		Treatment BB99=1		Control BB99=0	
	Variable	Mean	Std. Dev.	Mean	Std. Dev.
Dep. Variable	LnrSalary	0.054533	0.156792	0.057399	0.201902
Independent Variables	grSalary9498	0.170462	0.281923	0.169609	0.272010
	grColl90s	8.80722	60.20856	6.818312	41.74212
	pcollege2K	13.5095	8.987972	13.32141	8.981346
	grLabor90s	4.076141	28.98165	2.732311	12.75855
	URinf03	4.261443	2.899279	4.294802	2.894601

Table A-V.4A Rent – Zip Code Regressions in ARC

	(A-V.4A-1)	(A-V.4A-2)	(A-V.4A-3)	(A-V.4A-4)
	lnRent2K	lnRent2K	lnRent2K	lnRent2K
BB99	0.07734	0.04327		0.02193
	[0.00985]***	[0.00883]***		[0.00815]***
lnRent90		0.42416	0.37896	0.37323
		[0.05062]***	[0.05496]***	[0.05506]***
grFInc90s			0.12189	0.12055
			[0.03412]***	[0.03397]***
grLabor90s			0.00006	0.00004
			[0.00010]	[0.00010]
dUrban			0.0732	0.07099
			[0.01010]***	[0.01001]***
...				
Constant	5.9639	3.57121	3.81256	3.83009
	[0.00835]***	[0.28806]***	[0.31748]***	[0.31737]***
Observations	2578	2578	2578	2578
R-squared	0.0253	0.2611	0.3921	0.3940

Robust standard errors in brackets. State dummies are not shown in table. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-V.4B Rent – Zip Code nmatch Regressions in ARC

		Coefficient	z-statistic	P> Z	
N=2578	BB99	0.0058792	0.65	0.519	
		Treatment BB99=1		Control BB99=0	
	Variable	Mean	Std. Dev.	Mean	Std. Dev.
Dep. Variable	lnRent2K	6.023102	0.215061	6.012241	0.239147
Independent Variables	lnRent90	5.697824	0.244573	5.692681	0.253954
	grFInc90s	0.488176	0.408765	0.479925	0.299769
	grLabor90s	4.053074	29.04637	2.37974	12.37516
	URinfl03	4.282777	2.903095	4.27851	2.915312

Table A-V.5A Total Establishments – Zip Code Regressions in ARC

	(A-V.5A-1)	(A-V.5A-2)	(A-V.5A-3)	(A-V.5A-4)
	InrEst	InrEst	InrEst	InrEst
BB99	0.02252	0.02216		0.01904
	[0.00793]***	[0.00793]***		[0.00801]**
grEst9498		0.01292	0.00885	0.00888
		[0.00580]**	[0.00461]*	[0.00457]*
dUrban			0.02037	0.01788
			[0.00720]***	[0.00727]**
grLabor90s			0.00012	0.0001
			[0.00006]**	[0.00006]*
...				
Constant	0.00324	0.00188	0.01783	0.00434
	[0.00700]	[0.00704]	[0.03178]	[0.03228]
Observations	2578	2578	2578	2578
R-squared	0.0038	0.0067	0.0545	0.0570

Robust standard errors in brackets. State dummies are not shown in table. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-V.5B Total Establishments – Zip Code nmatch Regressions in ARC

		Coefficient	z-statistic	P> Z	
N=2578	BB99	0.0219527	2.4	0.017	
		Treatment BB99=1		Control BB99=0	
	Variable	Mean	Std. Dev.	Mean	Std. Dev.
Dep. Variable	InrEst	0.031407	0.171747	0.008261	0.190373
Independent Variables	grEst9498	0.123984	0.730279	0.116612	0.559189
	grLabor90s	4.108868	28.96746	2.834807	12.61747
	URinfl03	4.274206	2.91304	4.264524	2.91666

Table A-V.5B Total Establishments – Zip Code nmatch Regressions in ARC

	(A-V.6A-1)	(A-V.6A-2)	(A-V.6A-3)	(A-V.6A-4)
	ptotIT02	ptotIT02	ptotIT02	ptotIT02
BB99	0.01555	0.00175		0.00004
	[0.00353]***	[0.00255]		[0.00246]
plT98		0.76146	0.82015	0.82013
		[0.01844]***	[0.01895]***	[0.01929]***
grColl90s			0.00001	0.00001
			[0.00001]	[0.00001]
pcollege2K			0.00056	0.00056
			[0.00011]***	[0.00011]***
dUrban			0.00219	0.00218
			[0.00212]	[0.00212]
grpIT9800			0.065	0.065
			[0.00557]***	[0.00557]***
...				
Constant	0.19613	0.05399	0.00987	0.00985
	[0.00306]***	[0.00369]***	[0.00931]	[0.00936]
Observations	2578	2578	2578	2578
R-squared	0.0085	0.5597	0.6175	0.6175

Robust standard errors in brackets. State dummies are not shown in table. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-V.6B Establishments in IT-Intensive Sectors – Zip Code nmatch Regressions in ARC

		Coefficient	z-statistic	P> Z	
N=2578	BB99	-.0017106	-0.56	0.579	
		Treatment BB99=1		Control BB99=0	
	Variable	Mean	Std. Dev.	Mean	Std. Dev.
Dep. Variable	ptotIT02	0.205419	0.076059	0.2061657	0.082174
Independent Variables	plT98	0.198475	0.075890	0.1973134	0.074407
	grColl90s	8.83987	60.62926	6.716216	41.92712
	pcollege2K	13.50434	8.899843	13.2026	8.718149
	URinfl03	4.253685	2.878748	4.3045	2.8786
	grpIT9800	0.051238	0.280791	0.0504487	0.282351

Table A-V.7A Small Establishments– Zip Code Regressions in ARC

	(A-V.7A-1)	(A-V.7A-2)	(A-V.7A-3)	(A-V.7A-4)
	psm02	psm02	psm02	psm02
BB99	-0.03278	-0.01131		-0.0096
	[0.00431]***	[0.00302]***		[0.00310]***
psm98		0.77	0.76256	0.7588
		[0.01817]***	[0.01866]***	[0.01893]***
pIT98			-0.03758	-0.03309
			[0.01822]**	[0.01817]*
grColl90s			-0.00001	0
			[0.00001]	[0.00001]
pcollege2K			-0.00048	-0.00043
			[0.00015]***	[0.00015]***
dUrban			-0.00349	-0.00253
			[0.00261]	[0.00259]
...				
Constant	0.81276	0.18586	0.19435	0.20311
	[0.00377]***	[0.01568]***	[0.01883]***	[0.01959]***
Observations	2578	2578	2578	2578
R-squared	0.0257	0.6135	0.6159	0.6178

Robust standard errors in brackets. State dummies are not shown in table. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table A-V.7B Small Establishments– Zip Code nmatch Regressions in ARC

		Coefficient	z-statistic	P> Z	
N=2578	BB99	-0.00903	-2.35	0.019	
		Treatment BB99=1		Control BB99=0	
	Variable	Mean	Std. Dev.	Mean	Std. Dev.
Dep. Variable	psm02	0.788440	.0913369	0.799334	0.100214
Independent Variables	psm98	0.795724	0.094059	0.798230	0.095652
	pIT98	0.198535	0.075514	0.196356	0.073939
	grColl90s	8.809076	60.63085	6.536416	41.77187
	pcollege2K	13.48297	8.876144	13.08223	8.709112
	URinfl03	4.252521	2.897593	4.303336	2.874884



Table A-V.8: MEUs Providing Telecommunication Services – Appalachian Region

City	utility name	county	External Broadband Services (1)	Other External Communication Services (2)	Internal Communication Services (3)
Sylacauga, AL	Sylacauga Utilities Board	Talladega	1		1
Scottsboro, AL	Scottsboro Electric Power Board	Jackson	1		1
Cartersville, GA	Cartersville, City of	Bartow	1		1
Calhoun, GA	Calhoun, City of	Gordon	1		1
Elberton, GA	Elberton, City of	Elbert	1		1
Barbourville, KY	Barbourville, City of	Knox	1		1
Jamestown, NY	Jamestown Board of Public Utilities	Chautauqua	1		1
Convington, TN	Covington Electric System	Tipton	1		
Morristown, TN	Morristown Utility Commission	Hamblen	1		
McMinnville, TN	McMinnville Electric System	Warren	1		1
Chattanooga, TN	Chattanooga Electric Power Board	Hamilton	1		1
Bristol, VA	Bristol Virginia Utilities	City of Bristol	1		1
Radford, VA	Radford, City of	City of Radford	1		1
Florence, AL	Florence Utilities	Lauderdale		1	1
Hartselle, AL	Hartselle Utilities	Morgan		1	
Monticello, KY	Monticello Electric Plant Board	Wayne		1	
Morganton, NC	Morganton, City of	Burke		1	
Pitcairn, PA	Pitcairn Municipal Light System	Allegheny		1	
New Wilmington, PA	New Wilmington, Borough of	Lawrence		1	
Greer, SC	Greer Commission of Public Works	Greenville/ Spartanburg		1	
Philippi, WV	Philippi, City of	Barbour		1	
Muscle Shoals, AL	Muscle Shoals Electric Board	Colbert			1
Albertville, AL	Albertville Municipal Utilities Board	Marshall			1
Huntsville, AL	Huntsville Utilities	Limestone/ Madison			1
Hagerstown, MD	Hagerstown Light Department	Washington			1
Starkville, MS	Starkville Electric System	Oktibbeha			1
Endicott, NY	Endicott, Village of	Broome			1
Westfield, NY	Westfield, Village of	Chautauqua			1
Columbiana, OH	Columbiana, Village of	Mahoning/ Columbiana			1

Table A-V.8: MEUs Providing Telecommunication Services – Appalachian Region, *Continued*

City	utility name	county	External Broadband Services (1)	Other External Communication Services (2)	Internal Communication Services (3)
Dover, OH	Dover, City of	Tuscarawas			1
Leighton, PA	Leighton, Borough of	Carbon			1
Easley, SC	Easley Combined Utilities	Pickens			1
Gaffney, SC	Gaffney Board of Public Works	Cherokee			1
Seneca, SC	Seneca, City of	Oconee			1
Alcoa, TN	Alcoa, City of, Electric Department	Blount			1
Knoxville, TN	Knoxville Utilities Board	Knox			1
Lenoir City, TN	Lenoir City Utilities Board	Loudon			1
Loudon, TN	Loudon, City	Loudon			1
Cleveland, TN	Cleveland Utilities	Bradley			1
Athens, TN	Athens Utilities Board	McMinn			1
Cookeville, TN	Cookeville, City of	Putnam			1
Greeneville, TN	Greeneville Light & Power System	Greene			1
Jellico, TN	City of Jellico Electric & Water System	Campbell			1
La Follette, TN	LaFollette Utilities	Campbell			1
Harriman, TN	Harriman Utility Board	Morgan/ Roane			1
Johnson City, TN	Johnson City Power Board	Carter/Sullivan/ Washington			1
Total			13	8	37

(1): Includes Cable Modem, DSL, Fiber Leasing, wireless broadband. Some MEUs in this category also offer narrowband services

(2): Includes CATV, Dial-up Internet access, local and long distance telephony

(3): Includes municipal data, AMR, SCADA, and internal voice and data services

Table A-V.9 Appalachian Broadband Infrastructure Initiatives

Project Name	Time Frame	Project Location	State	Regional Distribution	Project Description
OptiLink <sup>1</sup>	Marketing began in Fall 2003	Dalton, in Whitfield County, GA	GA	City	Broadband data and telecom services launched by Dalton Utilities. Connectivity: High-speed Internet through the fiber optic network OptiLink. Data speeds up to 2.5 Gbps. Market served: Business and residential customers.
WMDnet <sup>2</sup>		Allegany County, Garrett County, Frostburg State University, MD	MD	2 counties, 1 university	WMDnet helped develop Internet access for the public sector in three counties. It stimulated entry of private Internet service providers into the region and has been the focal point of various computer and telecommunications projects that benefit students and improve the use of public information.
Allconet/ WMDnet <sup>3</sup>	AllCoNet currently operational. AllCoNet2 expected to be launched in Aug 2005.	Allegany County, MD	MD	County	AllCoNet is the Intranet for Allegany County, linking agencies, schools, non-profits, and colleges while providing Internet access. Connectivity: IP-based high speed Intranet, currently supporting 622 Mbps. Internet linkages via a wireless hookup. Market served: Coverage for the whole county. Agencies, businesses, schools, non-profits, and colleges.
PANGAEA <sup>4</sup>	Fund awarded in 2002 PANGAEA. In operation since 2004.	Polk County, NC	NC	County	PANGAEA is a fiber optic network deployed by e-Polk, a community-owned non-profit company serving the development interests of Polk County, NC. Connectivity: Back operates at an initial 620 Mbps; expandable to 64 Gbps. PANGAEA allows subscriber connections up to 155 Mbps. Market served: Businesses, schools and residential customers.
BalsamWest FiberNET <sup>5</sup>	Project expected to be completed by July 2005	Jackson, Macon, Swain, Clay, Cherokee, Graham counties, NC	NC	6 Counties	The BalsamWest group has built a 255-mile fiber optic ring to bring high-speed Internet access to 6 Appalachian counties in Western NC. Connectivity: Metro/regional fiber network proving dark fiber, SONET, Ethernet, high-speed Internet and other solutions. Market served: College campuses, government agencies, health services, etc.
NuNet Fiber Technologies <sup>6</sup>	Initiative reported in Jan 2004. Initial build-out the and first of four stages has begun.	Hazleton, in Luzerne County, PA	PA	City	Hazleton will soon be completely wired with a fiber-optic network that will provide high-speed bandwidth for Internet access and related technologies. Connectivity: Fiber optic network, with connections ranging from 3-5 Mbps for standard service and up to 100 Mbps for premium service. Market served: Any business or residential customers in the city.

Table A-V.9 Appalachian Broadband Infrastructure Initiatives, *Continued*

Project Name	Time Frame	Project Location	State	Regional Distribution	Project Description
Dickenson County Wireless Integrated Network (DCWIN) <sup>8</sup>	Started in Deployed in summer 2003. Expanded in 2004.	Dickenson County, VA	VA	County	DCWIN is a high-speed wireless network for Dickenson County and the surrounding region. Connectivity: Residential wireless Internet at 1540 Kbps; commercial wireless Internet at 3080 Kbps. Market served: Any commercial and residential customers.
Center for Appalachian Network Access (CANA) <sup>7</sup>	Started in 2003	Perryopolis, in Fayette County, PA	PA	City	CANA and the Fraizer School District implemented a canopy network to provide Internet connectivity to the business community. The operation and expansion of the network has been turned over to CANA's private enterprise partner American Broadband. CMU Professor Bruce Maggs and his team of student volunteers deployed Motorola wireless equipment to connect the local business community in 7 days as part of the CANA initiative. The Perryopolis network's operations and finances have been transferred to a private company. Connectivity: Wireless broadband. Market served: Businesses.
Haysi Electronic Village <sup>9</sup>	Received funding in May 2003. Became operational in May 2004.	Haysi, in Dickenson County, VA	VA	Town	Haysi Electronic Village, in Dickenson County, has deployed local access Fiber to the Premise to deliver Gigabit Ethernet to each premise. Connectivity: Fiber optic network. Subscribers may connect at any of 3 common Ethernet speeds at 10 Mbps, 100 Mbps, or 1 Gbps. Market served: Town's citizens, local businesses and medical facilities.
Center for Appalachian Network Access (CANA) <sup>10</sup>	Ongoing	McDowell County, WV	WV	County	CANA is setting up Ashland West Virginia ATV Resort with wireless broadband access. Connectivity: Wireless broadband. Market served: ATV resort.
Gilmer and Braxton County Research Zone <sup>11</sup>	Created by legislation in 2004. Ongoing activities.	Gilmer and Braxton Counties, WV	WV	2 Counties	Glennville is capable and ready to be the first site to receive a high-speed network. The Glennville wireless network will be implemented in two phases: first, school, government and nonprofit organizations; second, local business and residents. In phase one, the college, high school, and the county court house will be connected to the wireless network. In phase two, local businesses and residents will have access to the network. The project has expanded into the Gilmer and Braxton County Research Zone, the mission of which is to bring high-speed access to the two counties. Connectivity: Wireless broadband. Market served: Schools, colleges, government agencies, organizations, businesses.

<sup>1</sup> Kane County Chronicle. "Towns prove success with broadband." 29 Mar, 2004. <<http://www.tricitybroadband.com/news20.htm>>

<sup>2</sup> Appalachian Regional Commission Online Resource Center. "Best Practices in Telecommunications." <<http://www.arc.gov/index.do?nodeId=977>>

<sup>3</sup> AllCoNet.org. <<http://www.allconet.org>>

<sup>4</sup> Get Ready for PANGAEA. <<http://www.pangaea.us/index2.html>>

<sup>5</sup> BalsamWest. <<http://www.balsamwest.net>>

<sup>6</sup> NuNet Fiber Technologies. <<http://www.nunetfiber.com>>

<sup>7</sup> CANA. «CANA Projects.» <<http://canacenter.org/projects.htm>>

<sup>8</sup> DCWIN. <<http://www.dcwin.org>>

<sup>9</sup> Dickenson County. "Technology Assessment and Master Plan." Sep 2004. <[http://top.bev.net/archive/tamp/3-Dickenson/Dickenson\\_TAMP.pdf](http://top.bev.net/archive/tamp/3-Dickenson/Dickenson_TAMP.pdf)>

<sup>10</sup> Center for Appalachian Network Access (CANA). "CANA: McDowell Team." <<http://canacenter.org>>

<sup>11</sup> CANA. "Glennville Status Documentation." July 2005. <<http://canacenter.org/doc/Camp.doc>>

Table A-V.10. Telecommunications projects funded by the Appalachian Regional Commission

Project Name	Time Frame	Project Location	State	Regional Distribution	Project Description
Leatherstocking Telecommunications Consortium	Established in 1994	Multiple school districts		In the process of expanding to 9 counties	Sophisticated telecommunications providing Internet access, distance learning, telemedicine, and website setup services to local government and businesses. The consortium involved educational institutions in New York State, exposing the population to uses of high speed Internet access and helping the government build an understanding about the benefits of broadband.
Southern Tier Central Telecommunications Initiative				2 or more, but not all ARC counties	Purchasing and installing telecommunications equipment; providing relevant training. This initiative also involved a planning district in the central part of NY State. The ARC funded video conferencing equipment between the districts, and worked to raise awareness about the potential of broadband.
Acquiring mobile technology for Towns County High School	Late 1990s - 2003	Towns County, GA	GA	Towns County High School	Purchasing laptops equipped with wireless; allowing access to software, Internet, email and computer-based applications; assisting adults in completing GED, and improving computer and work skills. Wireless technology was deployed in junior-high and high school, and was used in all classes. The number of Graduate Equivalence Diplomas (GEDs) increased as a result of the project.
ChattoogaNet		Chattooga County, GA	GA	County	<p>ChattoogaNet is an ISP run by local students, teaching students operation of an Internet server and providing free Internet access to all segments of the community. The project made 20 laptops available to students, teachers, parents through a loan program, allowing access to the Internet; its students in the technology class at the high school offer outreach services, web design and technical assistance to the community.</p> <p>Based on a high school, the idea behind ChattoogaNet was to teach children about the Internet, software and the WWW. The school went online and introduced laptops into the community. In the process, the school had to become a non-profit ISP.</p> <p>Connectivity: 2 ISDN lines 2x128 Kbps Market served: High school students, community</p>
Big Sandy Telecommunications Center	Completed in early 2000	Pikeville, KY	KY	County	<p>Establishing and maintaining the community's only ISP. The ARC provided all equipment, but a third party paid for the network connectivity. The ISP at the time was Big Sandy Telecommunications Center.</p> <p>Market served: Pikeville County</p>
WMDnet		Hagerstown, Garrett County, Allegany County, MD	MD	At least 3 counties	Helping develop Internet access for the public sector; stimulating entry of private ISPs into the region; Internet linkages via a wireless hookup. The project eventually created the need for wireless connectivity among businesses.

Table A-V.10. Telecommunications projects funded by the Appalachian Regional Commission, *Continued*

Project Name	Time Frame	Project Location	State	Regional Distribution	Project Description
Golden Triangle Telecommunications Network System	Between fiscal years 1996 - 1998	Starkville, MS	MS	2 or more, but not all ARC counties	<p>Connecting 7 county governments and agencies within each county; providing training through a software package.</p> <p>The Golden Triangle is a planning district in Mississippi. The idea behind its formation was to provide service to county officials. T1 lines were deployed from county office to county office, and the ARC project involved buying laptops, software and train county officials in digital government.</p> <p>Connectivity: T1</p> <p>Market served: 7 county governments</p>
Alleghany High School Cyber Campus	Late 1990s, early 2000	Sparta, NC	NC	2 or more, but not all ARC counties	<p>Installing equipment, technology lessons, Internet courses for distance learning, an internship program, and a lab for training and public access to computers and the Internet</p> <p>The Cyber Campus is a community access center which the school uses during the day, and the community uses at other times.</p> <p>Connectivity: T1</p> <p>Market served: Community</p>
Tompkins County Collaborative Communication		Ithaca, NY	NY	County	<p>Improving the standard of county agency equipment and accessibility to improve communication, e.g. via email and the Internet; equipment purchases, training, developing websites, technical support.</p> <p>The idea behind the project was to get a sector of the community to start adopting applications that would drive the demand for many communities.</p>
Medical and Government Internet Coalition Network (MAGICnet)	Went online in Sep 1997	Athens, OH	OH	Other	<p>Providing access to message boards, email, information databases; providing separate training for physicians and government officials; helping local ISPs in widening service.</p> <p>The idea behind MAGICnet was to enable telemedicine to help doctors in hard-case diagnosis by connecting small clinics, doctors and small hospitals. The project paid for computers and software. Much of the connectivity was dialup.</p> <p>Connectivity: Dialup</p> <p>Market served: Small clinics, small hospitals, and doctors</p>
Sunday Creek Associates/ ARC Managing Information with Rural America (MIRA)		Shawnee, OH	OH	2 or more, but not all ARC counties	<p>Upgrading computers, purchase of copier machines; providing technical and project assistance to local initiatives</p>



Table A-V.10. Telecommunications projects funded by the Appalachian Regional Commission, *Continued*

Project Name	Time Frame	Project Location	State	Regional Distribution	Project Description
Susquehanna Economic Development Association-Council of Governments (SEDA-COG) Info-Structure Technology Assistance Center	Late 1990s	Lewisburg, PA	PA	2 or more, but not all ARC counties	<p>Providing basic and advanced telecommunications services, and training for access to data for daily governmental operations in a planning district in Northeast PA.</p> <p>The idea behind this project was to provide training in e-government, website building, and various ways to raise civil participation and awareness.</p> <p>Connectivity: Certain information not available. However, most government offices were struggling to get T1 in place.</p> <p>Market served: Government agencies</p>

Sources

1. Westat. "Evaluation of The Appalachian Regional Commission's Telecommunications Projects: 1994-2000." *Prepared for the Appalachian Regional Commission*, Rockville, Maryland. June 2003.
2. Appalachian Regional Commission Online Resource Center. "Examples of ARC Telecommunications Projects." 18 July 2005 <<http://www.arc.gov/index.do?nodeId=1946>>.
3. Appalachian Regional Commission Online Resource Center. "Best Practices in Telecommunications." 18 July 2005 <<http://www.arc.gov/index.do?nodeId=977>>.
4. Roesch, Harry (by telephone). Telecommunications Adviser. Appalachian Regional Commission.

Table A-V.11 Zip Code Level Summary Statistics for the Appalachian Region\*

	(1)	(2)	(3)	(4)		(5)	
	All ARC Zip Codes (N=2,578)	ARC Zip codes with BB by 1999 (N=1,723)	ARC Zip Codes with No BB by 1999 (N=830)	ARC Zip Codes with MEU BB (as of 2002) (N=39)		ARC Zip Codes with Local Gov't Broadband Initiatives (N=45)	
				BB99=1 (N=28)	BB99=0 (N=11)	BB99=1 (N=30)	BB99=0 (N=15)
Variables	Mean (Std. Dev.)	Mean (Std. Dev.)	Mean (Std. Dev.)	Mean (Std. Dev.)	Mean (Std. Dev.)	Mean (Std. Dev.)	Mean (Std. Dev.)
InRent2K	6.016 (0.229)	6.041 (0.216)	5.967 (0.244)	5.982 (0.211)	6.014 (0.164)	5.980 (0.211)	5.740 (0.271)
LnrSalary	0.054 (0.180)	0.060 (0.149)	0.044 (0.234)	0.049 (0.120)	0.060 (0.136)	0.065 (0.177)	0.044 (0.122)
ptotIT02	0.207 (0.079)	0.212 (0.073)	0.197 (0.089)	0.221 (0.070)	0.152 (0.082)	0.183 (0.060)	0.184 (0.128)
InrEmplo	0.006 (0.339)	0.023 (0.294)	-0.023 (0.410)	0.025 (0.325)	-0.217 (0.629)	0.074 (0.274)	-0.139 (0.307)
psm02	0.791 (0.096)	0.780 (0.087)	0.812 (0.111)	0.763 (0.089)	0.836 (0.053)	0.829 (0.079)	0.842 (0.089)
InrEst	0.018 (0.173)	0.026 (0.155)	0.002 (0.203)	0.006 (0.134)	0.151 (0.247)	0.028 (0.140)	-0.055 (0.250)
BB99	0.668 (0.471)	1.000 (0.000)	0.000 (0.000)	1.000 (0.000)	0.000 (0.000)	1.000 (0.000)	0.000 (0.000)
dUrban	0.508 (0.500)	0.572 (0.495)	0.387 (0.487)	0.429 (0.504)	0.182 (0.405)	0.300 (0.466)	0.067 (0.258)
gEmp9498	0.320 (2.344)	0.326 (2.759)	0.295 (1.096)	0.185 (0.428)	0.618 (1.064)	0.148 (0.380)	0.760 (1.502)
grColl90s	9.060 (60.735)	11.738 (72.345)	3.733 (23.448)	13.975 (48.246)	2.372 (4.574)	9.464 (24.590)	0.759 (1.893)
grEst9498	0.124 (0.723)	0.133 (0.810)	0.104 (0.506)	0.106 (0.232)	0.187 (0.159)	0.042 (0.151)	0.127 (0.347)
grFInc90s	0.488 (0.417)	0.498 (0.456)	0.471 (0.326)	0.414 (0.248)	0.503 (0.214)	0.553 (0.234)	0.294 (0.234)
grLabor90s	4.141 (28.991)	5.310 (34.861)	1.825 (8.918)	12.200 (51.746)	0.643 (1.433)	4.807 (12.572)	0.266 (1.475)
grpIT9800	0.052 (0.287)	0.044 (0.246)	0.071 (0.356)	0.059 (0.317)	-0.027 (0.310)	0.078 (0.247)	-0.004 (0.307)
grSalary9498	0.171 (0.289)	0.163 (0.269)	0.189 (0.327)	0.218 (0.356)	0.070 (0.236)	0.206 (0.329)	0.182 (0.292)
InRent90	5.695 (0.265)	5.721 (0.243)	5.641 (0.299)	5.728 (0.173)	5.717 (0.222)	5.595 (0.166)	5.584 (0.203)
pcollege2K	13.500 (9.064)	14.583 (9.297)	11.336 (8.185)	9.868 (4.706)	9.864 (2.891)	14.790 (9.045)	10.820 (9.312)
pIT98	0.199 (0.078)	0.205 (0.073)	0.188 (0.086)	0.215 (0.078)	0.148 (0.051)	0.187 (0.064)	0.167 (0.062)
psm98	0.796 (0.097)	0.786 (0.087)	0.814 (0.112)	0.767 (0.072)	0.843 (0.114)	0.827 (0.069)	0.807 (0.090)

\* Includes only the sub-sample of entries with available data for all variables. Standard errors in parenthesis.

## Bibliography

- Allen Consulting Group (2003), "True Broadband: Exploring the Economic Impacts (an Ericsson contribution to public policy debate)." Available at [http://www.citynet.nl/upload/ERN01\\_Final\\_Report\\_2\\_Broadbandproductivity\\_1.pdf](http://www.citynet.nl/upload/ERN01_Final_Report_2_Broadbandproductivity_1.pdf).
- Aron, D. J. and Burnstein, D. E. (2003), "Broadband Adoption in the United States: An Empirical Analysis." 31st Research Conference on Communication, Information and Internet Policy, Arlington, VA. Available at [http://intel.si.umich.edu/tprc/papers/2003/180/aron-burnstein\\_broadband\\_adoption\\_paper.pdf](http://intel.si.umich.edu/tprc/papers/2003/180/aron-burnstein_broadband_adoption_paper.pdf).
- Autor, D., Levy, F., and Murnane, R. (2003), "The Skill Content of the Technology Change." *Quarterly Journal of Economics*, November, Vol. 118, No. 4, pp. 1279–1333.
- Barua, A., Pinnell, J., Shutter, J., and Whinston, A. (1999), "Measuring the Internet Economy: An Exploratory Study." Center for Research in Electronic Commerce, Graduate School of Business, University of Texas at Austin. Available at [http://cism.bus.utexas.edu/works/articles/internet\\_economy.pdf](http://cism.bus.utexas.edu/works/articles/internet_economy.pdf).
- Burton, M.L. and Hicks, M.J. (2005), "The Residential and Commercial Benefits of Rural Broadband: Evidence from Central Appalachia." Center for Business and Economic Research, Marshall University. Available at: <http://www.marshall.edu/cber/research/broadband/Final%20Rural%20Broadband%20July%202005.pdf>.
- Brough, W. (2003), "State Economies Can Benefit from Broadband Deployment." CSE Freedom Works Foundation Issue Analysis, Washington, DC. Available at [http://www.cse.org/reports/Broadband\\_Study.pdf](http://www.cse.org/reports/Broadband_Study.pdf).
- Brynjolfsson, E. and Hitt, L. (1996), "Paradox Lost? Firm-level Evidence on the Returns to Information Systems Spending." *Management Science*, April. Reprinted in Willcocks, L. and Lester, S., eds., (1998), *Beyond The IT Productivity Paradox: Assessment Issues*. McGraw Hill, Maidenhead.
- Computer Science and Telecommunications Board (CSTB) of the National Research Council, (2002), *Broadband: bringing home the bits*, National Academy Press.
- Crandall, R. and Jackson, C. (2001), "The \$500 Billion Opportunity: The Potential Economic Benefit of Wide-spread Diffusion of Broadband Internet Access." *Criterion Economics*, Washington, DC. Available at <http://www.ntia.doc.gov/ntiahome/broadband/comments/verizon/ExhibitA.pdf>.
- Daveri, F. and Mascotto, A. (2002), "The IT Revolution across the U.S. States." Working Paper 226, Innocenzo Gasparini Institute for Economic Research. Available at [http://www.igier.uni-bocconi.it/folder.php?vedi=851&tbn=albero&id\\_folder=182](http://www.igier.uni-bocconi.it/folder.php?vedi=851&tbn=albero&id_folder=182).
- De Castro, E.A., and Jensen-Butler, C. (2003), "Demand for information and communication technology-based services and regional economic development." *Papers in Regional Science*, Vol 82, No. 1, pp. 27–50.
- Dutton, W. H., Gillett, S.E., McKnight, L. and Peltu, M. (2004), "Bridging Broadband Internet Divides: Reconfiguring Access to Enhance Communicative Power." *Journal of Information Technology* 19, March. Available at <http://itc.mit.edu/itel/docs/2003/Bill-Dutton-Oxford.pdf>.
- Ferguson, C. (2002), "The United States Broadband Problem: Analysis and Recommendations," Brookings Institution Working Paper. Available at [http://www.brookings.edu/views/papers/ferguson/working\\_paper\\_20020531.pdf](http://www.brookings.edu/views/papers/ferguson/working_paper_20020531.pdf).
- Flamm, K. (2004), "The Role of Economics, Demographics, and State Policy in Broadband Competition: An Exploratory Study." 32nd Research Conference on Communication, Information and Internet Policy, Arlington, VA. Available at <http://web.si.umich.edu/tprc/papers/2004/397/flammtprcrev2.pdf>.
- Ford, G. and Koutsky, T. (2005), "Broadband and Economic Development: a municipal case study from Florida." Available at [http://www.publicpower.com/telecom\\_study/municipal\\_broadband\\_&\\_economic\\_development.pdf](http://www.publicpower.com/telecom_study/municipal_broadband_&_economic_development.pdf).
- Forman, C. (2005), "The Corporate Digital Divide: Determinants of Internet Adoption." *Management Science*, Vol 51, No. 4, pp. 641–654.
- Forman, C., Goldfarb, A. and Greenstein, S. (2005), "Geographic Location and the Diffusion of Internet Technology." *Electronic Commerce Research and Applications* (4):1–113.
- Gillett, S. E. and Lehr, W.H. (1999), "Availability of Broadband Internet Access: Empirical Evidence." 27th Annual Telecommunications Policy Research Conference, available at [http://itc.mit.edu/itel/docs/MISC/LehrGillettTPRC99\\_0523.doc](http://itc.mit.edu/itel/docs/MISC/LehrGillettTPRC99_0523.doc).
- Gillett, S. E., Lehr, W.H. and Osorio, C. (2004), "Local Government Broadband Initiatives," *Telecommunications Policy* 28, August/September, pp. 537–558.
- Gillett, S.E., Lehr, W.H., and Osorio, C. (2006), "Municipal Electric Utilities' Role in Telecommunications Services," *Telecommunications Policy*, forthcoming.

- Horrigan, J. B. (2003), "Broadband Adoption at Home: A Pew Internet Project Data Memo." Available at [http://www.pewinternet.org/reports/pdfs/PIP\\_Broadband\\_adoption.pdf](http://www.pewinternet.org/reports/pdfs/PIP_Broadband_adoption.pdf).
- Horrigan, J. B. and Rainie, L. (2002), "The Broadband Difference." Pew Project on Internet and American Life. Available at [http://www.pewinternet.org/reports/pdfs/PIP\\_Broadband\\_Report.pdf](http://www.pewinternet.org/reports/pdfs/PIP_Broadband_Report.pdf).
- Jackson, M., Lookabaugh, T., Savage, S., Sicker, D.C. and Waldman, D. (2002), "Broadband Demand Study Final Report." Telecommunications Research Group, University of Colorado, Boulder. Available at [http://newsroom.cisco.com/dlls/Broadband\\_Demand.pdf](http://newsroom.cisco.com/dlls/Broadband_Demand.pdf).
- Jorgenson, D. W. (2001), "Information Technology and the U.S. Economy." *American Economic Review*, 91(1), March, 2001, pp. 1–32.
- Kelley, D. J. (2003), "A Study of the Economic and Community Benefits of Cedar Falls, Iowa's Municipal Telecommunications Network." Available at <http://www.iprovo.net/projectInfoDocs/economicAndCommunityBenefitsStudy.pdf>; updated summary available in Broadband Properties Magazine, [www.broadbandproperties.com](http://www.broadbandproperties.com), May, 2005.
- Lehr, W. H., Sirbu, M. and Gillett, S.E. (2006), "Wireless is Changing the Policy Calculus for Municipal Broadband." *Government Information Quarterly*, Vol. 23, No. 3.
- Lentz, R.G. and Oden, M.D. (2001), "From Digital Divide to Digital Opportunity? Telecommunications and Socioeconomic Development in the Lower Mississippi Delta Region in the U.S." *Telecommunications Policy* 25(5), pp. 291–313.
- Lichtenberg, F. and Lehr, W. (1998), "Computer Use and Productivity Growth in Federal Government Agencies, 1987–92." *Journal of Industrial Economics*, 46(2), pp. 257–279.
- Lichtenberg, F. and Lehr, W. (1999), "Information Technology and Its Impact on Productivity: Firm-level Evidence from Government and Private Data Sources, 1977–1993." *Canadian Journal of Economics* 32 (2), pp. 335–362.
- Litan, R. (2005), "Great Expectations: Potential Economic Benefits to the Nation from Accelerated Broadband Deployment to Older Americans and Americans with Disabilities." New Millennium Research Council. Available at [http://www.newmillenniumresearch.org/archive/Litan\\_FINAL\\_120805.pdf](http://www.newmillenniumresearch.org/archive/Litan_FINAL_120805.pdf).
- Malecki, Edward (2003), "Digital development in rural areas: potentials and pitfalls." *Journal of Rural Studies* 19, pp. 201–214.
- Organization for Economic Cooperation and Development (2003), *ICT and Economic Growth: Evidence from OECD Countries, Industries, and Firms*, OECD, Paris.
- Oliner, S. D. and Sichel, D.E. (2000), "The resurgence of Growth in the Late 1990s: Is Information Technology the Story?" *Journal of Economic Perspectives* 14:4, Fall, pp. 3–22.
- Osorio Urzua, C. A. (2004), "Bits of Power: The Involvement of Municipal Electric Utilities in Broadband Services." MS Thesis, Technology and Policy, Massachusetts Institute of Technology. Available at <http://itc.mit.edu/itel/theses.html#2004>.
- Pociask, S. (2002), "Building a Nationwide Broadband Network: Speeding Job Growth." White paper prepared for New Millennium Research Council by TeleNomic Research. Available at <http://www.newmillenniumresearch.org/event-02-25-2002/jobspaper.pdf>.
- Rappoport, P., Kridel, D. and Taylor, L. (2002), "The Demand for Broadband: Access, Content, and the Value of Time." in Crandall, R. and Alleman, J. (eds.), *Broadband: Should we regulate high-speed Internet access?*, Brookings Institution Press: Washington, DC. Available at <http://www.aeibrookings.org/publications/abstract.php?pid=301>.
- Sirbu, M. A., Lehr, W.H., and Gillett, S.E. (2006), "Evolving Wireless Access Technologies for Municipal Broadband." *Government Information Quarterly*, Vol. 23, No. 3.
- Strategic Networks Group (2003), "Economic Impact Study of the South Dundas Township Fibre Network." Prepared for Department of Trade and Industry, UK. Available at <http://www.dti.gov.uk/industries/telecoms/sdcsfi270603.pdf>.
- Telecommunications Industry Association (2003), "The Economic and Social Benefits of Broadband Deployment." Available at <http://www.tiaonline.org/policy/broadband/Broadbandpaperoct03.pdf>.
- U.S. Department of Commerce (2002), "Understanding Broadband Demand: a Review of Critical Issues." Technology Administration, Office of Technology Policy. Available at [http://www.ta.doc.gov/reports/TechPolicy/Broadband\\_020921.pdf](http://www.ta.doc.gov/reports/TechPolicy/Broadband_020921.pdf).
- U.S. Federal Communications Commission (1999–2005), "High-Speed Services for Internet Access." Reports from December 1999 to December 2005. Available at <http://www.fcc.gov/wcb/iatd/comp.html>.