Measuring Broadband's Economic Impact

From 1999 to 2002, American communities with broadband access did significantly better than those without

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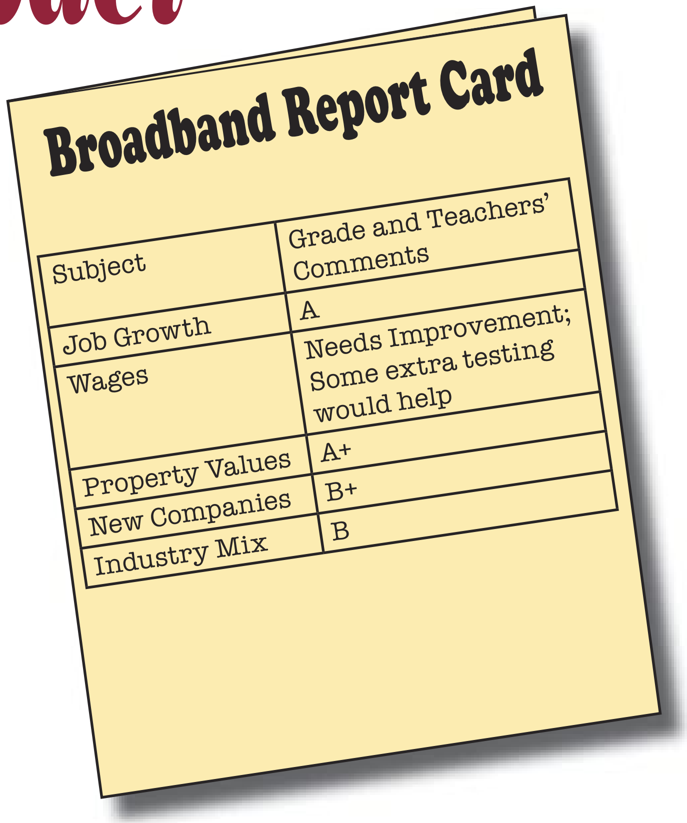
" . . . broadband access does matter to the economy, just as common sense would say it should . . ."

" . . . 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 . . ."

" . . . the mean growth in rent . . . employment, number of establishments, and share of establishments in IT-intensive sectors were all higher in the communities with broadband . . ."

" . . . we find a substantial positive impact for broadband availability on the growth in total employment."

" . . . broadband has a significant positive effect on the growth in the number of business establishments . . . "



" . . .broadband access does enhance economic growth and performance, and . . . the assumed (and oft-touted) economic impacts of broadband are real and measurable.

"The present study has several clear implications for policy-makers. The most obvious and important implication is that broadband does matter to the economy."

"Broadband is clearly related to economic well-being and is thus a critical component of our national communications infrastructure."

Table 1: 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)
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")
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)
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

For the first time, we can say unequivocally that broadband access does matter to the economy, just as common sense suggests it should. We estimate 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. In addition, the effect of broadband availability by 1999 can be observed in higher market rates for rental housing in 2000.

Now that we've said it, however, we feel compelled to explain how we think we know all this. After all, your company or your taxpayers may be investing a lot of money based on our findings.

There are indeed practical limits on what research can tell us at this early point in the broadband revolution. 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.[1]

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.

Estimates of broadband's economic impact are an essential input to the development of broadband-related public policies. They can, for instance, 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 – 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; and municipal broadband networks.

Corporate officials certainly understand the financial impact of public policies such as the Supreme Court's *Brand X* decision (described in detail in *Broadband Properties*, January, February and July 2005), the FCC's order making DSL an information service, state prohibitions on municipal networking, and debates over video franchising for next-generation networks such as Verizon's FiOS.

To the general public, however, such issues can easily seem inscrutable. By defining the stakes involved for the economy as a whole, an estimate of broadband's impact helps inform the public, government officials, and investors.

A Short History

The challenges inherent in developing reliable estimates of broadband's value 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 thus somewhat hypothetical and forward-looking. As a report from the U.S. Department of Commerce 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.[2]

A well-known report from this period was prepared for Verizon by Criterion Economics.[3] 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

Table 2: Number and share of ZIP Codes with broadband, December 1999 - December 2002

Date	ZIP Codes added with Broadband	Cumulative %	
Up to December 99	17,683	54.44%	
Jun-00	2,725	8.39%	
Dec-00	1,970	6.07%	
Jun-01	2,026	6.24%	
Dec-01	910	2.80%	
Jun-02	957	2.95%	
Dec-02	894	2.75%	
No Broadband by Dec 2002	5,316	16.37%	
Total	32481	100.00%	

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

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.[4] There was also a Brookings Institution report estimating that failure to improve broadband performance could *reduce* U.S. productivity growth by 1% per year or more. [5]

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.[6] There was also a study comparing Cedar Falls, Iowa, which launched a municipal broadband network in 1997, against its otherwise similar neighboring community of Waterloo.[7]

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.[8]

Given the passage of time, increased availability and adoption of broadband in the U.S., and newer data from the biennial (2002) business Census, it is now possible to begin looking for broadband's economic impacts more generally and at a larger geographic scale. To do that, we compared various economic outcome measurements in different communities based on when broadband became available in the community. We controlled for other factors known to affect broadband availability and levels of local economic activity.

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.[9]

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 non-farm, non-manufacturing industries, where productivity improvements are typically less well captured by economic data.

A particular challenge for this study is that data to distinguish localities by their actual use of broadband – which would seem to be a pre-requisite for most types of economic impact – is not generally available. For example, the FCC's Form 477 data only distinguishes among communities by their broadband availability, and provides no metrics of broadband adoption or use below the state level.

These early prospective studies suggest that broadband should make individuals and businesses more productive through behaviors such as online procurement and telecommuting, but national data is generally not available to observe these behaviors at the local level. We will discuss these measurement and data availability challenges in more detail.

Study Design

The essence of our study's design is to differentiate geographic areas by their availability and use of broadband, then look at economic indicators for these areas over a long enough period to see if consistent deviations from the secular trend are observable, controlling for other factors known to distinguish among the areas.

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

Table 3. Penetration of broadband in residential and small business

State	2000	2001	2002
New York	6.06%	12.77%	21.77%
Massachusetts	9.29%	16.24%	21.10%
Connecticut	7.04%	12.43%	20.04%
California	8.20%	13.17%	19.96%
Alaska	0.20%	16.18%	18.62%
Rhode Island	6.29%	13.06%	17.66%
N.Hampshire	6.87%	10.96%	16.12%
Washington	6.51%	11.43%	16.01%
Georgia	1.98%	9.78%	16.00%
Florida	3.33%	10.17%	15.92%
Oregon	4.34%	8.59%	15.89%
Nevada	5.87%	10.73%	15.81%
Kansas	5.40%	10.15%	15.62%
Arizona	6.21%	10.26%	15.26%
Nebraska	6.70%	9.11%	14.98%
Maryland	1.67%	10.15%	14.84%
Minnesota	4.79%	8.32%	14.33%
North Carolina	2.26%	8.46%	14.31%
Texas	4.95%	8.81%	14.16%
Colorado	4.70%	8.19%	13.86%
D.C.	5.03%	9.92%	13.71%
Utah	3.70%	7.94%	13.39%
Michigan	2.73%	8.80%	13.32%
Virginia	2.68%	8.47%	13.18%
Tennessee	3.04%	8.00%	12.94%
New Jersey	6.88%	15.00%	12.91%
Wisconsin	2.40%	6.58%	12.80%
Ohio	3.51%	7.47%	12.68%
Delaware	0.68%	6.70%	12.55%
Louisiana	2.10%	7.71%	12.53%
Illinois	3.60%	6.46%	12.19%
Oklahoma	2.73%	6.64%	11.62%
South Carolina	2.02%	6.32%	11.00%
Alabama	1.60%	5.95%	10.03%
Pennsylvania	1.94%	5.84%	9.73%
Maine	3.67%	6.88%	9.71%
Vermont	2.27%	6.55%	9.36%
Missouri	3.12%	6.47%	9.30%
Idaho	2.39%	2.39%	8.77%

State	2000	2001	2002
Iowa	4.27%	6.03%	8.75%
West Virginia	0.63%	3.56%	8.38%
Arkansas	2.14%	5.16%	7.79%
Indiana	0.88%	3.79%	6.46%
New Mexico	2.62%	3.46%	6.30%
North Dakota	1.90%	1.68%	6.18%
Mississippi	0.34%	2.37%	5.96%
Wyoming	*	2.87%	5.61%
South Dakota	3.20%	2.45%	4.89%
Kentucky	0.69%	2.59%	4.35%
Montana	1.49%	2.67%	4.13%
Hawaii	*	*	*
Total	3.61%	7.91%	12.46%

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 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.[10] Forman, Goldfarb and Greenstein,[11] and others, 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 cog-

Table 4: broadband impact on growth of selected economic variables

Variable	State	ZIP	Matched Panel
Employment	Mixed impact because within-state circumstances vary widely. But relationship between broadband and employment was stronger in states showing positive relationship; in no states were negative relationships significant.	Positive relationship*	Positive relationship*
Wages	Mixed but never statistically strong link	Weakly negative, not significant at 90%	Weakly negative, not significant at 90%
Rental rates	Positive relationship*	Positive relationship*	Weakly positive; not significant at 90%
Establishment growth	Mixed impact; states with negative relationship more signficant	Positive relationship*	Weakly positive; not significant at 90%
IT-intensive share of establishments	Mixed impact; states with positive impact more significant	Positive relationship*	Weakly negative; not significant

(=significant at 90% or above)*

Table 5: Mean percentage change for communities with (and without) broadband by December 99

Variable	With Broadband by Dec 99 (N=15,020)	With No Broadband by Dec 99 (N=7,370)	
	Mean (Std. Dev.)	Mean (Std. Dev.)	
Dependent Variables			**Sources**
Median Housing Rent, 2000	6.306 (0.341)	6.039 (0.298)	US Census, 2000 Decennial
Ratio of Average Salaries of 2002/1998	0.072 (0.131)	0.059 (0.206)	(Ln) US Census, 2002 and 1998 ZCBP
Share of Establishments in IT-Intensive Sectors	0.240 (0.088)	0.195 (0.088)	2002 US Census, 2002 ZCBP
Ratio of Employment 2002/1998	0.049 (0.263)	0.015 (0.401)	US Census, 2002 and 1998 ZCBP
Share of Establishments with fewer than 10 Employees	0.768 (0.087)	0.834 (0.102)	2002 US Census, 2002 ZCBP
Ratio of # Establishments 2002/1998	0.054 (0.150)	0.027 (0.204)	US Census, 2002 and 1998 ZCBP
Independent Variables			Sources
"dUrban" variable	0.739 (0.438)	0.374 (0.483)	Degree of urbanization, from USDA data
URinfl03 - Urban Influence Code 2003*	2.882 (2.632)	5.294 (3.253)	US Dept. of Agriculture 2003
Growth Rate in the Number of Employees 1994 -- 1998	0.434 (7.356)	0.289 (1.315)	US Census 1994 and 1998 ZCBP
Growth Rate in the Number of People (25+) with College Degree or Higher 1990 – 2000	11.526 (96.28)	3.310 (24.549)	US Census, 2000 Decennial Census; GeoLytics, 1990 Decennial Census
Growth Rate in the Number of Establishments 1994 - 1998	0.169 (1.428)	0.104 (0.425)	US Census, 1994 and 1998 ZCBP
Growth Rate in Median Family Income 1990 – 2000	1.046 (64.969)	0.501 (0.370)	US Census, 2000 Decennial Census; GeoLytics, 1990 Decennial Census
Growth of the Civilian Employed Labor Force 1990 – 2000	6.487 (79.518)	2.046 (18.969)	US Census, 2000 Decennial Census; GeoLytics, 1990 Decennial Census
Growth Rate of Share of Establishment in IT Intensive Sectors 1998 – 2000	0.030 (0.193)	0.053 (0.334)	US Census, 1998 and 2000 ZCBP
Growth Rate on Average Salary 1994 –1998	0.180 (0.243)	0.212 (0.432)	US Census, 1994 and 1998 ZCBP
Median Housing Rent, 1990 (Ln)	5.995 (0.403)	5.711 (0.369)	GeoLytics, 1990 Decennial Census
Share of Population (25+) with College Degree or Higher, 2000	22.387 (14.684)	14.211 (9.096)	US Census, 2000 Decennial
Share of Establishments, 1998	0.029 (0.133)	0.024 (0.042)	US Census, 1998 ZCBP
Share of Establishments in IT-Intensive Sectors, 1998	0.232 (0.085)	0.191 (0.087)	US Census, 1998 ZCBP
Share of Establishments with less than 10 Employees, 1998	0.772 (0.086)	0.832 (0.102)	US Census, 1998 ZCBP

**: Urban Influence Code ranges from 1 (large metro area of 1+ million residents) to 12 (no urban or town core and not adjacent to metropolitan area)* nitive 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.[12]

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 the complete list of indicators is limited by the collection frequency for different types of Census data, and geographic unit limitations for other types of data (voting participation is not tallied by ZIP code, for instance).

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 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 2000 rent as a wealth indicator, justified because only broadband availability (not its actual use) should be necessary to in-

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Table 6: Impact (Controlled) on economic variables in broadband-enabled ZIP codes (those that had broadband by December 1999):

Employment (Jobs)	Employment annual growth rate about 1% higher, 1998 - 2002.
Wages	No statistically measurable impact observed in data by 2002.
Property Values	Housing rental rates over 6% higher in 2000.
Business Establishments (proxy for firms)	Almost 0.5% higher rate of growth in the number of establishments, 1998 - 2002.
Industry Mix	Over 0.5% increase in the share of establishments in IT-intensive sectors, 1998 – 2002. About 1% reduction in share of small establishments.

fluence 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 is the most recent available at the time of this writing) does 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).

Data Availability

Table 1 summarizes the sources used to construct the ZIP code and state-level data sets. Most of the variables are straightforward, other than the broadband metric that we discuss below.

We report statistics for both the full sample of ZIP codes, and the sub-sample that results from matching across all the variables. Because results did not differ substantially for the full and sub-samples, we simplify the analysis by using the consistent sub-sample throughout.

Ideally, we would be able to differentiate among communities by their actual use of broadband. However, the FCC's Form 477 data does not provide any indication of broadband adoption or use at the ZIP code level. You simply are told whether a Zip code has at least one broadband user getting a provider's bill.

At the state level, the FCC reports the number of broadband lines in service, segmented by lines serving residences and small businesses vs. those serving larger businesses, government, or other institutions. We convert the mass-market (residential and small business) segment, about 75 percent of the total in 2000, to a statewide penetration rate and use this broadband indicator to test for effects at the state level, because in theory penetration should provide a better indicator for broadband's impact than simple availability.

In practice, however, the state level is too coarse an aggregate, as we discuss in more detail below. We used the FCC's high-speed classification to define broadband: any line with a speed higher than 200 Kilobits per second (Kbps) in at least one direction. Although we do not expect availability to serve as a perfect proxy for broadband use, this metric is the best available.

We identify the communities where broadband was available as those that report having broadband in the FCC's Form 477 data for 1999 (Table 2). Since this is the first date for which the FCC 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 3) 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.

Measuring Economic Activity

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). For each category of variables, we tested three approaches:

(1) Impact of broadband at the state level. Although in general we expect states to be too high a level of geographic aggregation to show interesting results (broadband variation within states is typically higher than among them), we conducted this analysis because the FCC data provides information on the total number of broadband consumers (i.e. penetration) only at the state level. Thus testing at the state level was necessary to conduct any analysis using penetration as a broadband metric. State-level analysis also provides an important connection to previous research on information technology's (IT's) economic impacts.

(2) Impact of broadband using community (ZIP-code) level data with controls.
(3) Extend the community-level analysis with a matched sample analysis as the means to control for non-broadband, unobserved effects.

We have a time series panel dataset and are thus looking for variations in the overall trend of an economic indicator as a function of broadband availability or penetration. We use regression analysis to estimate the impact of broadband on each of our metrics of economic activity, while controlling for other factors that might reasonably be expected to impact our measure of economic activity.

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, as shown in Table 3, penetration varied 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, at the state level, we modify our equations to incorporate both linear and quadratic terms for the impact of broadband penetration.

We also know that the decision by providers to deploy broadband is related 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. So we introduce control variables in an attempt to separate the effects of broadband from the a priori economic characteristics of the ZIP code.

When analyzing data at the ZIP code level, we also use a matched sample approach to control for non-broadband-related factors affecting changes in our metrics of economic activity. Within our sample, a majority of ZIP codes already reported having 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. These communities are significantly different from the types of communities that did not have broadband until after 1999 or still do not. As an alternative to using control variables to account for the systematic differences in the characteristics of the broadband "haves" and "have-nots," we used a technique that matches comparable communities in the two broadband classes to see if there is a measurable difference in the economic activity metric because of broadband.

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 4). 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.

Another way to see the results is to compare the sample averages for communities with and without broadband (haves vs. have-nots) as of December 1999 (Table 5). 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.

Employment and Wages

As explained earlier, theory does not provide strong guidance 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.

However, when we turn to the ZIP code regressions and matched-sample regressions, we find a substantial positive impact for broadband availability on the growth in total employment. Our analysis suggests that the availability of broadband added over 1 percent to the employment growth rate in the typical community (coefficient on the variable indicating whether or not even one broadband customer was billed in a ZIP Code area is 0.01046). We also observe that the controls, growth in employment from 1994 to 1998 and urbanization are significant and have positive signs as expected.

This result is also supported by the matched sample results. Interestingly, the impact of broadband on employment appears substantially higher in the matched sample results, suggesting that broadband increased employment by over 5 percent. This is consistent with the view that broadband had an especially large impact in smaller, rural communities.

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.

There is an extensive empirical literature that demonstrates the positive effects of IT for wages and employment mix effects. Furthermore, 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) since the changing wages help drive the other changes.

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, once we controlled for all the variables, we do not observe any significant effect attributable to broadband.

Rent and Property Values

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 had 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.

Our results 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 whether or not even one broadband customer was billed in 1999 is 0.06563) for broadband communities. However, when we move to the matched sample results, although the sign remains positive, the rent-effect is no longer significant.

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. Broadband has a significant positive effect on the growth in the number of business establishments, increasing growth, by almost one-half of a percent (coefficient with whether or not there was at least one broadband customer in the ZIP Code area in 1999 is 0.00485) from 1998 to 2002.

This positive effect is even larger in the matched sample regressions. The state-level regressions also support this result. Moreover, in the ZIP-code regressions, the controls have the appropriate positive sign: growth in number of establishments from 1994 to 1998, urbanization, and the growth in labor force from 1990 to 2000.

Second, 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. 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.

Unfortunately, the matched sample results are no longer significant and the sign is reversed. Because of the data issues noted earlier, we do not regard this change in sign and lack of significance as overly important. Similarly, the state-level regressions 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. But 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 per 2000 population is higher in broadband communities (0.030 in haves v. 0.024 in have-nots, see Table 5).

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.

We also looked at the 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. At the ZIP code level, 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.

In the overall sample, the relative size mix of establishments declined only slightly, but the decline was greater in broadband communities. The matched sample results are 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.

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 6 summarizes the estimated magnitude of impacts resulting from our analysis at the ZIP code level, after controlling for other community-level factors known to affect both broadband availability and economic outcomes, including income, education, and urban vs. rural character.

This analysis is of course preliminary; additional data and experience are needed to more accurately address the fundamental question of how broadband affects the economy. Nevertheless, the magnitude of impacts estimated by our models are larger than we expected.

We interpret our results cautiously, in light of the methodological challenges inherent in disentangling causality in any study of the relationships between infrastructure availability and economic development. Further research is required to properly address the causality issue. However, our cautious findings of a positive impact of broadband are encouraging.

[13]The present study has several clear implications for policy-makers. The most obvious and important implication is that broadband *does* matter to the economy.

Policy makers 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 policy-makers 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 policy makers 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. **BBP**

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The authors gratefully acknowledge the financial support provided for this study by the Economic Development Administration of the U.S. Department of Commerce under grant #99-07-13829, and matching funds provided by the industrial sponsors of the MIT Program on Internet & Telecoms Convergence, listed at http://itc.mit.edu. The opinions expressed in the paper are those of the authors and do not necessarily reflect the views of the sponsors, MIT or CMU.

The complete report is available at www.broadbandproperties.com and at **http://cfp.mit.edu/groups/broadband/docs/2005/MeasuringBB_EconImpact.pdf**

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