The Effect of Broadband Internet Adoption on Local Labor Markets

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ABSTRACT

I investigate the impact of county-level broadband Internet adoption rates on county-level employment growth rates and unemployment rates. I use a cross section of county-level data for the U.S. from June 2009 with data on broadband connections per household, employment growth rates, unemployment rates, and various demographic variables for U.S. counties. In addition, I use an instrumental variables approach with two-stage least squares regressions to mitigate endogeneity between broadband adoption and the employment statistics. For the instrumental variables, I use population density and the percent of each county's population living in urban areas. I find that a high rate of broadband connectivity in a county raises that county's employment growth rate and decreases its unemployment rate, although the benefits of broadband connectivity decrease when a high percentage of people with bachelor's degrees are present. These results provide insight for policymakers who want to use broadband to improve labor markets. Policies that enable and encourage broadband adoption will likely have a positive impact on labor markets, although results should be monitored so that policymakers know when they begin to experience diminishing marginal returns.

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INTRODUCTION

This paper attempts to quantify the impact of broadband Internet adoption on local labor markets by comparing county-level data on broadband Internet adoption to employment growth and the unemployment rate for those counties. My hypothesis is that, by aiding the flow of information, broadband should increase the efficiency of the economy in any area where information is exchanged. Since labor markets depend in part on the exchange of information between employers and prospective employees, it seems likely that broadband adoption would lead to healthier labor markets with lower unemployment. Also, improved efficiency should make businesses more productive overall, which ought to spur the creation of additional jobs, leading to employment growth. These thesis will test these hypotheses with multivariate, two-stage lease squares regressions. One of the justifications for government funding of broadband expansion is the economic benefit to communities with access to broadband. This analysis will provide insight into these policy questions with respect to local labor markets.

Communication networks allow the transmission of information across long distances for little cost. As information becomes more important to the U.S. and global economies, access to high-speed communication increases in importance and value. Broadband Internet represents the fastest mechanism to transfer information among users today, but it is not as universally accessible as older forms of communication, such as telephone lines. Just as government regulation and encouragement brought about near-universal access to telephones, so it is thought that the government ought to work towards universal access to broadband Internet. Atkinson, Castro, and Ezell (2009) argue that a $10 billion investment in broadband would “create or retain" 498,000 jobs. Indeed, broadband expansion is a policy goal of the Obama Administration, as embodied in the National Broadband Plan.

As noted above, the expected outcome for this analysis is that broadband adoption has a positive impact on labor markets in local economies. This must not necessarily be the case; broadband is a productivity enhancement, which can impact employment in both positive and negative ways. On the one hand, broadband increases the efficiency of labor, so that fewer workers are needed to accomplish the same work. On the other hand, increased productivity allows output to increase, which may cause employment to increase (Kolko 2010b, p. 17). The literature so far has indicated a positive relationship between communications infrastructure on employment, so the expectation for this study is that the relationship between broadband adoption and employment growth will also be positive.

The effect of broadband on unemployment is also ambiguous because of the way that unemployment is measured. In order to be counted as unemployed (rather than outside of the workforce), a person generally must have made a specific effort to find works in the four weeks prior to the reference period.[a] Broadband increases access to information and improves communication, so the unemployed ought to be able to contact employers more easily. If increased contact with employers results in those employers hiring more unemployed workers, then the unemployment rate should decrease, but if the decreased cost of job searching

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[a] The definition of unemployment, as given by the Bureau of Labor Statistics: "Included are all persons who had no employment during the reference week, were available for work, except for temporary illness, and had made specific efforts to find employment some time during the 4 week-period ending with the reference week. Persons who were waiting to be recalled to a job from which they had been laid off need not have been looking for work to be classified as unemployed."

encourages more people to look for work but does not result in more hires, then the unemployment rate will increase. Note that data for this study reference June 2009, the last month of the 2008-2009 recession. In such an environment, high unemployment rates may be a desirable result of increased broadband adoption, since without broadband, some job seekers may abandon their job search altogether and drop out of the labor force.

The next section provides background and a review of literature concerning the effect of broadband Internet on economic growth and labor markets. Following that are sections describing the theoretical and empirical models for this study, the data used to conduct the study, and the results of the study. The last section contains conclusions from the results and their policy implications.

Background and Literature Review

The advent of broadband Internet has inspired many studies of the effect of fast Internet speeds on the economy. Generally, studies of the economic impact of broadband take advantage of the uneven geographical spread of broadband access and adoption by comparing the economic characteristics of areas with different levels of broadband access. These studies examined a number of economic statistics, including employment growth, wage growth, employment rates, and output growth.

Studies of general information and communication technology (ICT) have shown a positive relationship between growth in ICT and growth in economic output. Norton (1992) uses a growth model to examine the role of telecommunications infrastructure in economic growth in 47 countries from post-World War II to 1977. He finds a significant, positive relationship between investment in telecommunications infrastructure and economic output. Lichtenberg (1993) examines the firm-level impact of information systems capital and labor on output, using longitudinal data from 1988-1991 to estimate a production function. He finds that there are positive returns to information systems capital and labor, with the larger returns going to capital. Greenstein and Spiller (1996) investigate the impact of investment in digital telecommunications infrastructure on the consumer demand for telecommunications. They use two-stage least squares within a macroeconomic model, using various infrastructure installation costs as instruments for the infrastructure itself. Their study finds that infrastructure investment results in an increase in consumer demand for telecommunications, implying that infrastructure investment increases consumer surplus and business revenue. Röller and Waverman (2001) examine the impact of telecommunication investment on economic output. The study examines a panel of 21 OECD nations over a 20-year period. The study finds a positive, statistically significant relationship between telecommunications investment and economic growth. Van Ark and Inklaar (2005) compare productivity in Europe and the U.S., finding that ICT contributed less to productivity in Europe than in the U.S. The authors argue in favor of a U-shaped productivity contribution from ICT, where new technology allows for some immediate cost cutting, followed by a period of non-productive experimentation, after which the long-run productivity gains take effect. They argue further that while Europe remains in the experimentation phase, the U.S. has reached the phase of long-term productivity gains.

Broadband Internet is a specific technology within ICT. Several studies attempt to quantify its overall economic impact. Varian et al. (2002) assess current and future cost savings for businesses from Internet technology and estimate the impact of those cost savings on productivity growth in the U.S., U.K., France, and Germany. For the U.S., the study estimates that from 1998 to 2001, businesses experienced cost savings of $155.2 billion and revenue increases of $443.9 billion. Projected to 2010, the cost savings were expected to increase to about $500 billion, and revenue increase to $1.6 trillion.

Crandall, Jackson, and Singer (2003) forecast the impact of universal residential broadband adoption on consumer surplus, as well as growth in capital investment, employment, and GDP. They find that over a 19-year period, universal broadband adoption would result in an additional $63.6 billion of investment and $179.7 billion in GDP growth over that time period. In addition, they find that broadband will spur employment growth of 61,000 jobs per year.

Greenstein and McDevitt (2009) compare the revenues of Internet providers with and without broadband services and subtract estimated infrastructure costs to estimate producer surplus, and they use estimates of user willingness to pay to upgrade to broadband to estimate consumer surplus. They find that broadband Internet contributed $28 billion to GDP, about $8.3 billion to $10.6 billion more than dialup Internet would have generated. They also estimate a consumer surplus of $4.8 billion to $6.7 billion.

Dutz et al. (2009) estimate the consumer surplus provided by broadband connections. The data used to derive consumer surplus came from a sample of 30,000 heads of households regarding the types of Internet services they purchased and the prices paid for them. The study estimates the net consumer surplus of broadband Internet at home compared to no Internet at home at $32 billion.

Other studies search for a correlation between broadband and economic output without attempting to quantify the total amount. Czernich et al. (2009) examine the impact of broadband adoption on per capita GDP growth in a panel dataset of OECD nations. Data on broadband adoption come from the OECD Broadband Portal, and economic data come from the OECD Economic Outlook. The study also includes control variables for investment, education, and population growth. In order to control for endogeneity between broadband adoption and economic growth, the authors use the diffusion of voice-telephony and cable network infrastructure to instrument for broadband adoption. The study finds a statistically significant, positive correlation between broadband adoption and per capita GDP growth.

Ford and Koutsky (2005) examine the economic impact of municipal broadband provided to businesses and government institutions in Lake County, Florida. Specifically, they investigate whether the municipal-provided broadband provides economic benefits above what would have occurred with purely private investment. The authors use retail sales as a proxy for economic activity in Florida counties, and they examine the outcomes for Lake County before and after the broadband deployment compared with other similar Florida counties where municipal broadband was not deployed. Similar counties were those defined as having the same economic growth rates and highly correlated economic activity levels before the broadband network was deployed in Lake. The study finds that after the deployment of broadband, economic growth in Lake is much higher than in the panel of similar counties.

Some recent studies have examined the impact of broadband Internet on employment. The effects of broadband on employment are more ambiguous than its effects on output. Broadband Internet lowers the cost of data transmission, an input in many businesses. Lowering the cost of an input increases the overall productivity of a firm, but also encourages a firm to shift its resources towards the cheaper input at the expense of more expensive inputs. These two effects offset each other, since higher output would increase employment, but higher productivity would decrease it (Kolko, Jan. 2010). Nevertheless, studies have consistently found a positive correlation between broadband and employment growth.

Gillett et al. (2006) examine the effect of broadband availability on employment and establishments by ZIP code using a cross-sectional dataset. (The authors also analyzed state-level data based on the number of broadband lines per capita, but were not able to obtain significant results since state-level data was too high of an aggregation level.) Broadband availability was determined by the number of broadband providers in each ZIP code according to Federal Communications Commission (FCC) Form 477 data. Economic data came from the ZIP Code Business Patterns (ZCBP) data produced by the Census Bureau. For control variables, the authors used a lagged dependent variable as well as industry composition and several demographic characteristics from the Decennial Census, including income, education, rent, and number of households. The study found a positive, statistically significant relationship between broadband availability and employment growth and rental rates. No statistically significant relationship was found between wage growth and broadband availability.

Crandall, Lehr, and Litan (2007) examine the effect of broadband lines in use per capita on employment and GDP. They use state-level nonfarm employment data from the Bureau of Labor Statistics (BLS), GDP data by state from BEA, and data from FCC Form 477 on state-level broadband lines in use per capita. They also include other data to control for climate, business tax burden, union membership, education, region of the country, and wages. They find a positive, statistically significant relationship between the number of broadband lines per capita and employment growth. They fail to find a statistically significant relationship between broadband lines per capita and GDP growth, though the relationship was positive.

Van Gaasbeck et al. (2007) examine the effect of broadband adoption on employment, establishments, and output in California counties. Broadband adoption data came from a proprietary dataset from Scarborough Research that contains the results of an Internet access survey conducted in California counties. Employment and establishment data came from the Quarterly Census of Employment and Wages (QCEW) at BLS. Control variables were personal income from the Bureau of Economic Analysis (BEA) and the unemployment rate from the California Employment Development Department. A fixed-effects analysis of the panel of counties indicates that broadband adoption has a positive and statistically significant effect on employment growth and payroll growth. Interestingly, the study finds a negative, statistically significant effect of broadband on the growth in establishments.

Shideler et al. (2007) examine the effect of broadband coverage on employment growth by county in Kentucky. Broadband coverage was obtained from proprietary data that were mapped to determine physical coverage of broadband access within each county. Employment growth data came from the County Business Patterns data published by the Census Bureau. They examine total employment growth as well as growth in different sectors of the economy. Their study uses a cross-sectional model that controls for lagged employment growth as well as education, non-technical infrastructure density (proxied by miles of highway), the unemployment rate, and a dummy for rural counties. They find a positive, statistically significant relationship between broadband coverage and total employment growth as well as employment growth in mining; construction; administrative, support, and waste management and remediation services; and information. They found a negative, statistically significant relationship between broadband coverage and employment growth in accommodations and food services. When finding a positive relationship, the authors also found a negative squared term, indicating diminishing marginal returns to broadband.

Stenberg et al. (2009) examine the impact of broadband availability on employment and income growth in selected rural counties. They create a quasi-experiment by matching counties with high broadband access with similar counties with low broadband access, and determine the difference in employment and income growth between the high-access counties and the low-access counties. The counties were matched into unique pairs based on the counties' economic structure (percent of income supplied by various industries), spacial structure (density, distance from cities, and the presence of highways), per capita income, and population growth. The study found a positive, statistically significant relationship between employment growth and broadband access in rural counties. There was not a consistent finding for the effect of broadband access on income, although there was a statistically significant, positive relationship between broadband access and nonfarm private earnings. The authors also found a positive, statistically significant relationship between broadband access and population growth.

Kolko (2010a) examines the relationship between broadband expansion and employment growth. Data on broadband availability come from the FCC Form 477, employment data come from the National Establishment Time-Series (NETS), and other control variables come from the Census Bureau and BLS. Using a cross-sectional analysis of the data, Kolko finds a positive, statistically significant relationship between employment growth and a change in the number of broadband providers for an area. In addition, Kolko uses the average slope of terrain for an area, obtained from ArcGIS software, to instrument for broadband provision. The slope instrument finds a stronger effect of broadband expansion on employment growth. Kolko ascribes the results to a potential weak causal relationship between broadband and employment growth as well as a potential upward bias in the instrument.

In an attempt to determine what sort of employment benefits from broadband, Forman, Goldfarb, and Greenstein (2009) examine the relationship between Internet diffusion and wage inequality. They created a measure of advanced Internet usage based on computer and Internet use by business establishments and firms obtained from a proprietary database owned by Harte Hanks, using a sample of firms with 100 or more employees. Data on employment and wages came from the Quarterly Census of Employment and Wages. The authors used income, education, and population from the Census Bureau, and IT-density based on County Business Patterns data, as controls. The study finds a positive, statistically significant correlation between its measure of advanced Internet and average wages, but not between wages and other measures of Internet usage. The study also finds that their measure of advanced Internet investment explains much more of the variation in wages in the highest-wage counties than in the rest of the country. The authors justify a causal interpretation of their findings by verifying their results using three different instruments: the number of programmers hired by each firm at locations other than the one in the sample, the number of connections to ARPANET in the county, and local deployment costs, proxied by the timing of regulatory action concerning new entrants to the market.

In addition to its positive effects on productivity, broadband Internet potentially lowers the cost of job searching. It would seem that broadband Internet access, therefore, would help lower unemployment by helping the jobless find jobs more easily. However, during periods of full employment, broadband by definition cannot decrease unemployment.[b] Further, broadband mostly aids the employed workforce in finding better jobs, rather than helping the unemployed find work (Stevenson, 2006). Lastly, broadband can actually increase unemployment, because unemployment includes only those workers who are actively seeking work, and not those who have left the workforce out of discouragement. By lowering the cost of job searching, broadband helps more of the jobless remain in the workforce (Beard et al., 2010). If broadband is more successful at encouraging the jobless to remain in the workforce than it is at matching up the jobless with jobs, then the unemployment rate should be higher in areas with more broadband usage. If the reverse is true, then the unemployment rate should be lower.

[b] This statement refers to the theoretical level of full employment. The actual unemployment rate at which the economy is at full employment is debatable, and changes over time.

Stevenson (2006) investigates the impact of the Internet on worker flows and job matching. She uses data from the Current Population Survey (CPS) and its supplements to examine Internet use by workers who experience a job transition, and also to examine aggregate worker flows in states with different levels of Internet diffusion. Using the longitudinal nature of the CPS, she calculates fixed effects while also controlling for certain demographic characteristics, industry, and occupation. She finds that workers who use the Internet are more likely to change jobs and less likely to become unemployed. There was not a statistically significant relationship between the unemployed using the Internet and finding a job. Then, combining state-level CPS data with Internet penetration data from Forrester Research, she examines the impact of Internet diffusion on worker flows, using the adoption rate of washing machines and telephones in 1960 to instrument for the adoption rate of the Internet. Her results show that Internet access increases worker flows, especially among those who are already working. This result implies that the Internet improves labor market efficiency by helping match workers with better jobs.

Beard, Ford, and Saba (2010) examine the impact of Internet use on job searches. They use the Current Population Survey and its Computer and Internet Use Supplement to examine differences in Internet use on being unemployed or out of the labor force because of discouragement. They employ a multinomial logit model to predict the outcomes of the unemployed, the discouraged, or those just marginally attached to the labor force. They find that broadband use in the home and public access to broadband are both correlated with a decrease of over 60 percent in discouragement, and that dial-up Internet use in the home is associated with just under a 40 percent decrease in discouragement. This finding implies that Internet use may keep the jobless active in their job searches, and that broadband access is more effective than dialup at keeping the jobless attached to the labor force.

Most studies of the impact of broadband on the economy measure broadband access by using data from FCC Form 477 or proprietary data. The FCC Form 477 data in these studies are limited by the fact that the only data available at the times of the studies were the number of broadband providers by ZIP code. These data are at best a proxy for broadband availability to the residents and businesses in these areas. They do not necessarily reflect broadband adoption, nor do they indicate how widespread broadband availability is within a particular area. On the other hand, studies that use more detailed proprietary data often are limited to specific regions.

This thesis will build on these previous studies by using new data from the FCC on broadband connections per 1000 households at the Census tract level. Previously, data on the broadband connection rate had been available at the state level only. Previous studies of counties and other smaller geographical areas only had data on broadband providers, and thus could draw conclusions about broadband availability only. This analysis will measure the relationship between broadband adoption and local employment growth and unemployment rates. In addition, the new data provide information on higher connection speeds; previous studies using FCC data were forced to use an older definition of broadband that is much slower than what is commonly accepted today as being a fast connection. Since broadband by the older definition has become relatively widespread, data on higher connection speeds will ensure differentiation in the models used in this analysis.

THEORETICAL MODEL

In this study, broadband adoption is represented by a dummy variable that is equal to 1 if the county has a high broadband adoption rate. An OLS regression will give the difference in employment growth and in unemployment rates between counties with high levels of broadband adoption and counties with low levels of broadband adoption:

(1) $Unemp = f(B, D, \varepsilon)$

(2) $\Delta Emp = f(B, D, \varepsilon)$

In the equations above, ΔEmp is employment growth and *Unemp* is the unemployment rate. The independent variable *B* represents broadband adoption, *D* represents demographics, and ε represents variation due to other factors. These models both imply that broadband adoption can explain a certain amount of variation in the unemployment rate and in employment growth, when examined in the context of certain demographic variables. Demographics must be included in the model because they vary with both broadband adoption and the dependent variables. The demographics variable D accounts for traits like education, income, race, and age.

EMPIRICAL MODEL

The empirical model for this study attempts to isolate the effect of broadband Internet adoption on local labor markets using a cross-sectional dataset. The model includes several demographic characteristics of each county that are likely to be correlated with both the county's broadband adoption rate and the county's employment statistics. The model also includes a lagged version of the employment statistic to serve as a proxy for other county characteristics that were not observed. I estimated separate regressions for both employment growth and the unemployment rate.

$$\text{(3)}\quad \begin{aligned}&\text{UNEMP2009} = \beta_0 + \beta_1\text{BROADBAND} + \beta_2\text{UNEMP2008} + \beta_3\text{BACHELORS}\\ &+\beta_4\text{BB}*\text{BACH} + \beta_5\log(\text{INCOME}) + \beta_6\text{BLACK} + \beta_7\text{HISPANIC} + \beta_8\text{WORKAGE} + \varepsilon\end{aligned}$$

$$\text{(4)}\quad \begin{aligned}&\Delta\text{EMP2009} = \beta_0 + \beta_1\text{BROADBAND} + \beta_2\Delta\text{EMP2008} + \beta_3\text{BACHELORS}\\ &+\beta_4\text{BB}*\text{BACH} + \beta_5\log(\text{INCOME}) + \beta_6\text{BLACK} + \beta_7\text{HISPANIC} + \beta_8\text{WORKAGE} + \varepsilon\end{aligned}$$

In these models, ΔEMP2009 is employment growth, UNEMP2009 is the unemployment rate, and BROADBAND is a dummy variable equal to one if more than 40 percent of households in the county have a fixed broadband connection. The lagged variable in each regression model has the same name as the dependent variable, with 2009 replaced by 2008. The demographic variables chosen for the model are the percent of people with bachelor's degrees (BACHELORS), the log of median income (log(INCOME)), the percent of people who are black (BLACK), the percent of people who are Hispanic (HISPANIC), and the percent of people in the county of roughly working age, between the ages 18 and 65 (WORKAGE). In addition, education is interacted with the broadband dummy (BB*BACH), since broadband may have different levels of usefulness for people with different education levels.

The variable BROADBAND measures the difference in employment growth or in the unemployment rate for counties that have high rates of broadband adoption compared to counties with low rates of broadband adoption, after controlling for the other variables in the model. The coefficient represents a difference between the two types of counties, controlled for other factors. This coefficient is expected to be negative when the unemployment rate is the dependent variable, meaning that increased broadband adoption correlates with a decreased unemployment rate. The coefficient is expected to be positive when employment growth is the dependent variable, meaning that increased broadband adoption correlates with increased employment growth.

The demographic variables control for factors that may affect both broadband adoption and employment in the counties studied. The rest of this section will describe the included variables and their expected relationship with employment growth and the unemployment rate.

The lagged variables (UNEMP2008 and ΔEMP2008) serve as proxy variables for unobserved characteristics of counties that help determine the county's unemployment rate and employment growth. The use of lagged dependent variables is common in the literature on the relationship between Internet availability or adoption and various economic indicators.[c] The coefficient on the lagged variable will reflect the general trend in that variable at the county level. Since the nation's unemployment rate increased from June 2008 to June 2009 , the coefficient on the unemployment lag is expected to be positive. The nation's employment growth rate decreased from June 2008 to June 2009, so the coefficient on the employment growth lag is expected to be negative.

The variable BACHELORS controls for the likelihood that a county's percentage of people with bachelor's degrees is likely to be correlated with both its employment statistics and the broadband adoption rate. A more educated populace may be more likely to adopt broadband, but may also result in lower unemployment and higher employment growth. Because of the interaction term in this regression, the variable BACHELORS only represents the correlation between the percentage of people with bachelor's degrees and the unemployment rate and employment growth for counties with low broadband adoption rates. The coefficient on BACHELORS is expected to be negative in the unemployment rate regression and positive in the employment growth regression.

[c] See, for example, Kolko (2010b), Van Gaasbeck et al. (2007), Shideler et al. (2007), and Gillett et al. (2006).

The variable BB*BACH is the interaction term between BROADBAND and BACHELORS. When added to the coefficient on BACHELORS, the coefficient on this variable measures the relationship between the percentage of people in a county with bachelor's degrees and the unemployment rate or employment growth for counties with a high level of broadband adoption. If a higher percentage of bachelor's degrees is more effective at reducing unemployment when broadband is present, then the coefficient on this variable will be negative, the same as the sign of the coefficient on BACHELORS. If a higher percentage of bachelor's degrees is less effective at reducing unemployment when broadband is present, then the coefficient on this variable will be positive. (The signs in the scenarios above would be reversed for the employment growth regression.) It is possible that people with bachelor's degrees are better equipped to use broadband Internet access to find or create jobs; therefore, this interaction term is expected to be negative in the unemployment rate regression and positive in the employment growth regression.

The variables BLACK and HISPANIC control for the possibility that racial minorities may face economic hardship as well as exclusion from the latest technology, and that counties with a high percentage of racial minorities may therefore have higher unemployment rates, lower employment growth, and less broadband adoption. The coefficients on BLACK and HISPANIC are both expected to be positive in the unemployment rate regression and negative in the employment growth regression.

The variable log(INCOME) controls for the possibility that a county with a higher median income could have a healthier job market, and thus be correlated with a lower unemployment rate and higher employment growth. A higher median income would also provide more of the resources needed for a county's population to increase its broadband adoption. The coefficient on log(INCOME) is expected to be negative in the unemployment rate regression and positive in the employment growth regression.

Finally, the variable WORKAGE controls for the likelihood that employment growth, the unemployment rate, and broadband adoption could all be correlated with the percentage of the population that is of working age, defined here as between the ages 18 and 65. People of working age may also be people of the age to have both the desire and the means to purchase a broadband connection. With respect to the employment statistics, counties where most of the population is of working age may have both a higher unemployment rate and higher employment growth. People younger than 18 or older than 65 may be more likely to give up looking for work when they don't have a job, whereas people between 18 and 65 may continue looking for jobs, thus remaining in the workforce and increasing the unemployment rate. With respect to employment growth, it similarly seems natural for higher employment growth to occur where there are more people of working age. Therefore, the coefficient on WORKAGE is expected to be positive in the unemployment rate regression and also positive in the employment growth recession.

A concern when estimating this model is the possibility of an endogenous relationship between BROADBAND and both UNEMP2009 and ΔEMP2009. In other words, although broadband adoption seems likely to have an effect on employment growth and unemployment rates, it is possible that employment growth and possibly unemployment rates will also have an effect on broadband adoption. For example, an increase in employment growth may result in a larger number of people who can afford broadband, thus increasing the level of broadband adoption. Note that the interaction term between BROADBAND and BACHELORS (BB*BACH) is also affected by the potential endogeneity.

In order to handle this concern, I used a two-stage least squares regression. The first stage of the regression uses exogenous variables (i.e., variables that are uncorrelated with UNEMP2009 and ΔEMP2009 but highly correlated with BROADBAND) as instruments to produce estimated values for BROADBAND and BB*BACH. Since the instrumental variables are correlated with BROADBAND but not with the employment metrics, the predicted values of BROADBAND and BB*BACH that they produce will not suffer from endogeneity. The second stage uses these predicted values in place of the observed values of BROADBAND and BB*BACH in the regressions of employment growth and unemployment rates on broadband adoption, respectively. I used the population density and the percent of people who live in urban areas as instrumental variables.

DATA

The dataset used for this study contains information from five different statistical programs of the federal government: FCC Form 477, the Local Area Unemployment Statistics (LAUS) program at BLS, the QCEW program also at BLS, the American Community Survey (ACS) of the Census Bureau, and the 2000 Decennial Census. All data have been gathered at the county level.

The FCC Form 477 data contain information regarding access to broadband Internet for each county as of June 30, 2009. The dataset contains two definitions of broadband Internet: residential fixed connections over 200 kbps in at least one direction, and residential fixed connections at least 768 kbps downstream and 200 kbps upstream. For each definition, the data indicate whether a county has access to Internet at such speeds, and if so, what quintile of the county's households has access to those speeds. I use the second (higher speed) definition, and create a dummy variable that equals 1 if the county falls into one of the top three quintiles, representing that at least 41 percent of households have a fixed broadband connection. A dummy variable is used for broadband because of the nature of the data on broadband adoption. The data from the FCC are given in quintiles for the broadband adoption rate, but nearly three quarters of the counties fall within the 21-to-40 percent and the 41-60 percent quintiles, so a dummy variable for adoption rates greater than 41 percent obtained a good distribution and clear interpretation of its coefficient in the empirical model.

Data from LAUS contain information on the unemployment rate, the number of unemployed, the number of employed, and the total size of the labor force by county for each month. This study uses three years' worth of data for each county, from 2007 to 2009, in order to create lagged variables and year-over-year change. Since the FCC Form 477 data reference June 30, 2009, this study uses LAUS data for June in each of the three years.

Data from QCEW contain information on employment and wages by industry at the county level. Employment data are available by month, and wage data are available by quarter. This study uses QCEW data from 2007-2009, with calculated over-the-year changes for 2008 and 2009 for each county, each level of government (federal, state, local) within each county, and each major industry (“supersector”) within each county. Again, June data are used for this study.

Data from the ACS contain various economic and demographic statistics at the county level, and are based on data gathered from 2005 to 2009. These data will function as control variables in a cross-sectional database. The particular control variables used were downloaded as part of the county-level “data profiles” download method at the download center of the American Factfinder on the Census website. ACS data also provided the county-level population data used to calculate population density.

Two files derived from the 2000 Decennial Census provided the last pieces of the dataset for this study. Data from the Census 2000 U.S. Gazetteer files contain basic geographical and population data for each county. For this study, the Gazetteer files contributed only the land area data of all counties in the U.S. for the purpose of calculating population density, since more recent population estimates were available from the ACS. Data from the Census 2000 Summary File 1 contain many different population statistics from the Decennial Census in the year 2000. For this study, Summary File 1 provided data on the percent of the population within each county living in urban and rural areas.

Table 1 gives summary statistics for all variables used in the model, prior to transformations such as taking logs or creating interaction terms.

Table 1. Summary statistics

Variable	*n*	*mean*	*std. dev.*	*minimum*	*maximum*
BROADBAND	3232	0.437	0.496	0	1
UNEMP2009	2645	9.46	3.67	2.20	29.0
UNEMP2008	2645	5.89	2.45	1.40	25.0
ΔEMP2009	3269	-4.26	6.15	-42.7	161
ΔEMP2008	3269	-0.0846	5.90	-63.4	131
BACHELORS	3143	18.7	8.51	4.60	69.5
INCOME	3221	42,818	12,107	11,185	113,313
BLACK	3221	8.80	14.3	0	86.6
HISPANIC	3221	9.73	18.8	0	100
WORKAGE	3221	60.9	3.90	43.3	96.3
POPDENSE†	3215	281	1739	0.0398	70,588
URBANPCT†	3219	0.408	0.317	0	1

†instrumental variable

RESULTS

The regressions of broadband adoption on the unemployment rate and on employment growth are both reported here. I used an instrumental variables approach to account for the endogenous relationship between broadband adoption and both employment statistics. Specifically, the broadband adoption variable and the interaction term between broadband adoption and bachelor's degrees are related endogenously to the employment statistics. The following table gives the result of endogeneity tests for these variables in both the unemployment rate and employment growth regressions. The high scores for the endogeneity test allow us to reject the null hypothesis that the variables BROADBAND and BB*BACH are exogenous.

Table 2. Tests of endogeneity for BROADBAND and BB*BACH

Dependent variable	*Chi-squared*	*P-value*
UNEMP2009	123.529*	0.0000
ΔEMP2009	44.563*	0.0000

*significant at the 99% level of confidence

Since the independent variables of interest are likely to be endogenous, I used an instrumental variables approach to account for the endogeneity. Population density and the percentage of urban residents in a county served as instruments, since dense living requires people to live close together, lowering the cost of broadband without affecting either employment statistic. I report results of the first stage of the two-stage least squares model in the appendix. I show and discuss the results of the second stage here, describing the relationship between broadband adoption and the unemployment rate.

Also, throughout this study, I use standard errors that are robust to heteroskedasticity. Characteristics of the cross-section of all counties in the U.S. are not likely to vary homogeneously, and the dummy variable describing broadband adoption certainly does not vary homogeneously. The robust standard errors ensure that conclusions about statistical significance account for the possibility that variance is not constant across all observations in the data set.

Unemployment rate regression

The regression of the unemployment rate on broadband adoption can be summarized by the following statistics:

Table 3. Summary statistics for the regression of the unemployment rate on broadband adoption (n = 2573)[d]

Regression stage, dependent variable	*F-statistic*	*Partial R-squared*
1st stage, BROADBAND	277.48*	0.0902
1st stage, BB*BACH	935.43*	0.1108
2nd stage, UNEMP2009	300.14*	-

*significant at the 99% level of confidence

The sample size is composed of all the counties for which both broadband data and unemployment data were available. The F-statistic for the second stage demonstrates that the model is highly significant. The partial R-squared and F-statistics of each of the first-stage regressions demonstrates the strength of the instruments. The relationship between each instrument and each of the endogenous variables was significant at the 99 percent level of confidence. (See Appendix.) The values of the coefficients in the unemployment model are as follows:

[d]The number of counties used for the unemployment regressions is about 600 counties fewer than the number used for the employment growth regressions. The reason is that the LAUS data did not have estimates for all counties in the U.S. The missing counties are generally small counties, so if broadband adoption has a different impact on the unemployment rate in small counties than in large counties, then these results may be somewhat biased.

Table 4. Results of the two-stage least squares regression of the unemployment rate on broadband adoption

Variable	*Coefficient*	*z-statistic*
BROADBAND†	-13.0***	-5.28
UNEMP2008	1.15***	19.38
BACHELORS	-0.608***	-7.46
BB*BACH†	0.782***	6.31
log(INCOME)	1.57***	3.20
BLACK	-0.0118***	-2.72
HISPANIC	-0.00833*	-1.83
WORKAGE	-0.0336	-1.13

***99% level of confidence; *90% level of confidence;
†instrumented variable

The regression describes the expected difference in unemployment rates between two counties where one county has a high rate of broadband adoption and the other has a low rate. The regression uses a cross-sectional data set with instrumental variables to control for the endogenous relationship between broadband use and the unemployment rate. The two endogenous regressors are BROADBAND and the interaction term between BROADBAND and BACHELORS.

The first variable, BROADBAND, is a dummy variable that equals 1 if more than 40 percent of the households in a county have a fixed broadband connection. The coefficient indicates that high levels of broadband adoption are associated with a county-level unemployment rate that is about 13.0 percentage points lower, after controlling for the other variables in the model. The z-statistic indicates that this relationship is statistically significant with 99 percent confidence. Since broadband adoption can both increase and decrease the number of unemployed, this finding indicates that broadband's ability to connect the unemployed with jobs is greater than its tendency to increase the number of unemployed by making it less costly to look for jobs. The magnitude of the coefficient is a large size that is not directly observed in the data. The smaller difference observed directly in the data between counties with and without high levels of broadband adoption is likely the result of the endogenous relationship between broadband adoption and unemployment, while the instrumental approach has isolated the effect of broadband adoption on unemployment. Additionally, this result holds all other factors in the model constant, and variation in the other factors may explain the large magnitude of the coefficient on BROADBAND.

The variable UNEMP2008 is a lagged variable for the dependent variable. Including this variable is common in the literature studying relationships between broadband and various employment statistics, and controls for unobservable characteristics of the counties in the data set. The positive coefficient greater than 1 indicates that on average, unemployment grew from June 2008 to June 2009, after controlling for the other factors in the model. As would be expected for a lagged macroeconomic variable, this coefficient is highly statistically significant, indicating a strong correlation between a county's unemployment rate and it's year-ago unemployment rate.

The variable BACHELORS is the percent of people in the county with a bachelor's degree. The negative coefficient indicates that as the percentage of people with a bachelor's degree increases, the unemployment rate decreases. This relationship is statistically significant with 99 percent confidence. On the other hand, the interaction term BB*BACH indicates that the effect of an increase in the number of people with a bachelor's degree on the unemployment rate is offset by broadband adoption. The interaction term is also statistically significant with 99 percent confidence. Note that the interaction term was also instrumented, since it includes the endogenous variable BROADBAND. This result is unexpected. It essentially implies that an increase in bachelor’s degrees makes a county worse off if it has a high level of broadband connectivity. Perhaps broadband allows employers to substitute for the labor of educated people more easily than for the labor of less educated people. Or, since a bachelor’s degree and broadband adoption both constitute a sort of knowledge acquisition, perhaps having broadband reduces the need for a college degree.

The variable log(INCOME) is the natural log of the county’s median income. The coefficient on this variable is positive and statistically significant with 99 percent confidence, indicating a positive relationship between a county’s median income and its unemployment rate. This may occur if workers who earn higher incomes would rather remain unemployed than work for lower pay, or if high-income counties host jobs more susceptible to layoffs. The actual relationship between income and unemployment, though statistically significant, is economically small. An income increase of 1 percent only correlates with an increase of .0115 percentage points in unemployment.

The variable BLACK is the percent of people in the county that report they are black or African-American. The negative coefficient indicates that as the percentage of blacks and African-Americans in a county increases, the unemployment rate declines. The z-statistic indicates that this relationship is statistically significant with 99 percent confidence. The other ethnic control variable, HISPANIC, is the percent of people in the county who report Latino or Hispanic origins. The coefficient on this variable is also negative, which indicates that as the percentage of Latino or Hispanic people in a county increases, the unemployment rate goes down. This finding is less statistically significant that the one on BLACK, but is still significant with 90 percent confidence. The findings for these variables were unexpected—as the percentage of a minority population in a county rises, it seems more likely to find higher unemployment rates, due to factors like discrimination and fewer opportunities. Also, at the national level, the unemployment rate is higher among black and African-American workers and also Hispanic or Latino workers.[e] Finally, as shown in the table below, counties with at least 15 percent African-American populations had higher unemployment and lower employment growth than the average county. The same is true for unemployment in counties with large Hispanic populations, though not for employment growth.

Table 5. Summary statistics for counties with large minority populations

Variable	*mean (all counties)*	*mean (BLACK > 15)*	*mean (HISPANIC > 15)*
BROADBAND	0.437	0.396	0.378
UNEMP2009	9.46	12.0	9.88
UNEMP2008	5.89	7.88	6.55
ΔEMP2009	-4.26	-4.65	-3.97
ΔEMP2008	-0.0846	-0.102	1.34

However, this study finds that broadband adoption and higher education have much larger impacts than the presence of a minority population on a county's unemployment rate. In the context of this model, when adjusted for other factors, a higher percentage of African-Americans or Hispanics in the population is associated with a decrease in unemployment.

The variable WORKAGE represents the percent of people in the county between the ages of 18 and 65, an approximation of people of working age. The negative coefficient indicates that as the percentage of people of working age within a county increases, the unemployment rate decreases. However, this finding is not statistically significant, as indicated by the small z-

[e] Current Population Survey, BLS

statistic. This result indicates that the effect of broadband adoption on the unemployment rate is not significantly changed by the proportion of the population that is of working age.

Employment growth regression

The results of the instrumented model for the relationship between broadband adoption and employment growth are summarized by the following statistics:

Table 6. Summary statistics for the regression of employment growth on broadband adoption (n = 3136)

Regression stage, dependent variable	*F-statistic*	*Partial R-squared*
1st stage, BROADBAND	419.97*	0.1161
1st stage, BB*BACH	2204.48*	0.1306
2nd stage, UNEMP2009	7.52*	-

*significant at the 99% level of confidence

The sample size is composed of all the counties for which both broadband data and employment growth data were available. The F-statistic for the second stage is not as large as it was for the unemployment regression, but is still large enough to ensure a highly significant model. The partial R-squared and F-statistics of each of the first-stage regressions demonstrates the strength of the instruments. The relationship between each instrument and each of the endogenous variables was significant with 99 percent confidence. (See Appendix.) The values of the coefficients in the employment growth model are as follows:

Table 7. Results of the two-stage least squares regression of employment growth on broadband adoption

Variable	*Coefficient*	*z-value*
BROADBAND†	18.3***	4.34
ΔEMP2008	-0.209	-1.59
BACHELORS	0.998***	5.55
BB*BACH†	-1.20***	-5.12
log(INCOME)	-2.66***	-2.93
BLACK	-0.00719	0.74
HISPANIC	0.0317***	2.79
WORKAGE	0.131**	2.52

***99% level of confidence; **95% level of confidence;
†instrumented variable

The regression describes the relationship between broadband adoption and employment growth for a given county, controlling for various economic and demographic factors. I also estimated this regression using cross-sectional data with an instrumental variables approach to control for the endogenous relationship between broadband use and employment growth.

The coefficient on BROADBAND indicates that high levels of broadband adoption are associated with a county-level employment growth rate that is about 18.3 percentage points higher than in a county with low levels of broadband adoption, after controlling for the other variables in the model. The z-statistic indicates that this relationship is statistically significant with a 99 percent level of confidence. Since broadband adoption can both increase and decrease the number of jobs, this finding indicates that the job creation enabled by broadband adoption outweighs the job destruction inherent to productivity enhancers like broadband adoption. Since instrumental variables were used to account for the endogenous relationship between broadband adoption and employment growth, this finding may be interpreted as a causal relationship. As with the unemployment regression, the magnitude of the coefficient is larger than would be directly observed in the data. This is again the result of controlling for the endogenous relationship between broadband adoption and unemployment and also for the other variables in the model.

The coefficient on the variable ΔEMP2008 is negative, indicating that on average, county-level employment growth rates declined from June 2008 to June 2009, after controlling for the other factors in the model. This coefficient is not statistically significant, indicating that a county's employment growth rate from June 2008 to June 2009 was not strongly correlated to its growth rate from June 2007 to June 2008, when adjusted for other factors. Macroeconomic variables are normally highly correlated to their lags. However, it is possible that the economic turmoil experienced from 2007 to 2009 resulted in rapidly changing employment growth trends such that, at the county level, they did not correlate with their previous growth pattern.

The coefficient on the variable BACHELORS is positive, which indicates that as the percentage of people with a bachelor's degree increases, the employment growth rate increases as well. This relationship is statistically significant with 99 percent confidence. On the other hand, the interaction term BB*BACH indicates that the effect of an increase in the number of people with a bachelor's degree on employment growth is offset by a high level of broadband adoption. The interaction term is also statistically significant at a 99 percent level of confidence. Note that the interaction term was also instrumented, since it includes the endogenous variable broadband. Similar to the case in the unemployment regression, this coefficient is unexpected, and indicates that the labor market may favor bachelor's degrees less when broadband is present, perhaps because broadband allows employers to substitute more easily for educated labor.

The coefficient on the variable log(INCOME) is negative and statistically significant with 99 percent confidence, indicating a negative relationship between a county's median income and its employment growth. As with the unemployment regression, higher incomes are associated with negative employment growth. This result can occur if counties where workers earn higher incomes are more susceptible to layoffs. It should be noted here that the income statistics are based on household data, whereas the employment growth statistics come from establishment data. Therefore, some of the relationship shown here may be the result of job losses in areas where higher-income workers live. In any case, the actual relationship between income and unemployment, though statistically significant, is economically small. An income increase of 1 percent only correlates with an increase of .0266 percentage points of employment growth.

The coefficient on the variable BLACK is positive, which would indicates that as the percentage of African-Americans in a county increases, employment growth increases as well. However, the low z-statistic indicates that this relationship is not statistically significant, meaning that the percentage of African-Americans in a county does not have a significant relationship with employment growth in that county. The other ethnic control variable, HISPANIC, also had a positive coefficient, indicating that that as the percentage of Latino or Hispanic people in a county increases, employment growth rises as well. This finding is statistically significant with 99 percent confidence. As with the unemployment regression, these findings were unexpected, with factors like discrimination and fewer opportunities expected to result in negative relationships. The other coefficient estimates, however, indicate that broadband adoption and higher education have much larger impacts than the presence of a minority population on a county's employment growth.

The coefficient on the variable WORKAGE is positive, which indicates that as the percentage of people of working age within a county increases, employment growth also increases. This finding is statistically significant with 95 percent confidence. This result is expected, since more people of working age would provide a larger labor force to drive employment growth.

These results describe the relationship between broadband adoption and employment growth and the unemployment rate. The next section will summarize these findings and discuss the implications they have on public policy.

CONCLUSION AND POLICY RECOMMENDATIONS

Results

Broadband Internet is a technology that enhances productivity. Increased productivity has an ambiguous effect on employment; therefore, whether employment rises or falls as a result of broadband Internet is an empirical question, not a theoretical one. While the economy as a whole is made better off when productivity increases, the number of employed people may or may not increase along with increased productivity. If policymakers are attempting to boost employment, they should carefully consider the expected impact of increasing productivity.

I investigated the impact of county-level broadband Internet adoption rates on employment growth rates and unemployment rates. I used data from the FCC Form 477 to determine broadband adoption rates, data from the Bureau of labor statistics for employment growth and unemployment rates, and data from the Census for control variables and instrumental variables. Using population density and percent urban population as instruments for broadband connectivity, I estimated two-stage least squares regressions to regress both employment growth rates and unemployment rates on broadband adoption rates and a set of demographic control variables. I found that broadband adoption has a positive impact on a county's employment growth rate and a negative impact on a county's unemployment rate.

Given the results of this study, policymakers should find ways to spur adoption rates of broadband Internet. Increases in broadband adoption at the county level are correlated with decreases in the unemployment rate and increases in employment growth. The use of instrumental variables allows for a causal interpretation of the broadband effects; therefore, it can be said that broadband adoption decreases unemployment and increases employment growth.

This result was expected. Previous studies of broadband availability, using the number of providers as a proxy, found that broadband has a positive effect on economic output and employment growth. Some smaller-scale studies found similar results for broadband adoption. This study confirms that broadband adoption has a positive effect on employment growth at the national level for all counties. Similarly, previous studies have found that broadband availability increases employment rates, and that broadband adoption increases worker flows between jobs. This study confirms that higher levels of broadband adoption decrease local unemployment rates. In addition, since broadband adoption increases employment growth in addition to decreasing unemployment rates, it is likely the effect of broadband adoption is that the unemployed are finding jobs rather than becoming discouraged and dropping out of the labor force.

Policy Recommendations

The National Broadband Plan contains measures to improve both the availability and the adoption of broadband Internet. Improving broadband availability increases the number of people who can potentially access broadband Internet. Improving broadband availability is one way to increase broadband adoption rates, by supplying broadband to those who are already willing and able to pay for it. Broadband adoption can also be improved in areas where broadband Internet is already available by increasing people’s willingness and ability to pay for broadband.

Measures to improve broadband availability consist mainly of subsidies for building infrastructure where infrastructure does not currently exist. Aside from infrastructure funding, improving broadband availability involves making sure that regulatory climates are friendly towards broadband deployment. For example, states that prohibit or restrict local governments from providing their own broadband networks may hinder the deployment of broadband Internet to users.[f] Expanding the availability of broadband Internet can improve broadband adoption rates by increasing the number of potential adopters. Essentially, expanding broadband availability increases the supply of broadband, which is likely to increase the amount of broadband consumed, represented by broadband adoption rates.

Measures to improve broadband adoption, on the other hand, are attempts to increase public demand for broadband where broadband already exists. Since demand represents both willingness and ability to pay for something, policy measures designed to increase broadband adoption either increase people's willingness to pay for broadband or else decrease the price they must pay for it. Examples of policy measures to increase broadband adoption include making broadband more affordable, public provision of broadband, creating digital literacy programs, and educating the public about the benefits and relevance of broadband.[g]

Cost

Decreasing the cost of broadband is a straightforward way to increase broadband adoption. Decreasing the cost makes broadband available to people whose willingness to pay for broadband is lower and to those whose ability to pay for broadband is lower. There are different ways that the cost of broadband can be decreased, and they may have different implications for broadband adoption. Across-the-board subsidies of broadband would make broadband cheaper, but would often benefit people who are already willing and able to pay for broadband, thus having less impact on broadband adoption. Subsidies targeted to low-income households would

[f] http://www.broadband.gov/plan/8-availability/

[g] http://www.broadband.gov/plan/9-adoption-and-utilization/

likely be an efficient way of increasing broadband adoption rates. In addition, given this study's finding that broadband adoption is not beneficial for employment growth and unemployment rates where there is a high percentage of bachelor's degrees, broadband subsidies should target households with lower levels of education in order to increase their effectiveness.

Also, some of the cost barrier for broadband Internet is not the recurring cost of access, but the startup costs of obtaining broadband Internet access. It costs the provider money to extend broadband to previously unconnected areas, and it costs households money to install broadband Internet and to buy a computer. One-time subsidies targeted towards connection and installation costs would likely improve broadband adoption rates without creating long-term financial obligations for the government.

Last, although this study focused on fixed wireline connections, wireless broadband also represents another avenue for broadband Internet access. Local governments may consider providing free wireless broadband access as a way of increasing broadband adoption. Free wireless access may have lower effectiveness rates than targeted subsidies, since it would provide benefits to those who would have adopted broadband even without having a free option, but it may have a lower overall cost in densely populated areas where one wireless router could serve several customers, or even in rural counties, where wireless signals could be beamed to remote locations more easily than wired connections could be built.

Digital literacy

Among those who are not willing (rather than not able) to pay for broadband Internet, the cause may be an inability to use computers or the Internet well enough to take advantage of the benefits of broadband. Programs to increase digital literacy may help people understand the benefits of broadband Internet, which in turn would spur adoption rates. Digital literacy programs could be started as new programs, or could be incorporated into existing programs. For example, digital literacy could become an additional component of federal job training programs, or perhaps could be attached to some of the targeted subsidies discussed above. At the state and local levels, digital literacy classes could be offered in schools both as part of the curriculum for children and also as adult education, at senior centers, libraries, and community centers, and in partnership with private organizations like unions or chambers of commerce. As with the subsidies, these digital literacy programs should be targeted towards households where they will have the largest impact on broadband adoption. Based on the findings of this study, people without bachelor's degrees would probably benefit the most from digital literacy training. Senior citizens would probably also benefit from digital literacy classes, although they are less likely to work, so such classes would probably not result in the employment growth and unemployment rate improvements that were found in this study.

In addition to teaching customers how to use the Internet, digital literacy programs should demonstrate how the Internet is relevant and can make lives easier. Job training programs can show how users can apply for jobs online. Libraries and schools can show how to use the Internet for research and learning, particularly if class attendees do not have degrees. Senior centers and community centers can show how the Internet can be used to apply for government benefits. In all cases, digital literacy programs should also demonstrate how the Internet can help attendees stay connected with family, friends, and social institutions. Connecting users with a larger community online increases the relevance of the Internet and potential benefit to non-adopters.

Cautions

Although this study generally finds that broadband Internet adoption is beneficial for employment growth and unemployment rates, there are some cautions as well. Any policy intended to increase Internet adoption should have its benefits closely monitored to ensure that returns to the policy continue to be positive and cost-effective. The diminishing returns found in Shideler et al. (2007) suggest that the returns to broadband coverage (i.e., availability) are limited. Whether those limits translate to broadband adoption remains to be seen, but it is possible that there is certain amount of broadband adoption after which there is no longer any additional benefit to labor markets. This study's finding of a negative interaction term between broadband and bachelor's degrees also supports the notion that in certain communities, broadband Internet adoption does not further benefit labor markets.

Opportunities for Further Research

This study examines the effects of broadband adoption at the county level relative to other counties in the U.S. Knowing these effects provides useful information to local policymakers, to members of congress attempting to benefit their own districts, and to anyone else planning to use broadband to improve local economic prospects. However, this study cannot say with certainty whether a national effort to improve broadband adoption will improve the national unemployment rate or employment growth rate. It is possible that efforts to improve broadband adoption will make the U.S. more competitive internationally, thus improving national labor market indicators. On the other hand, increasing broadband adoption may only improve the competitiveness of some regions at the expense of others. Of course, leveling the playing field between different geographical areas may be a desirable policy goal in itself. In any case, further study is needed to determine whether investment in broadband at the national level affects the national employment growth and unemployment rates.

Another opportunity for further research is the relationship between education and broadband adoption with respect to employment growth and the unemployment rate. The coefficient on the interaction term between broadband adoption and the percent of people with bachelor’s degrees remains puzzling. Determining the reason that high rates of college degree and broadband adoption seem to offset each other’s employment effects would be very informative to policy makers who wish to implement some sort of plan to increase broadband adoption.

The measure of broadband adoption used by this study is the number of fixed wireline connections per household. However, as wireless broadband becomes more widespread and able to compete with wireline speeds, wireline connections may no longer be an accurate measure of broadband adoption. If wireless broadband becomes a substitute for wired broadband, then further studies will need to find and incorporate data on wireless broadband in order to accurately measure broadband availability and adoption.

Lastly, this study examines a cross-section of data observed in the last month of the 2008-2009 recession. It is possible that broadband adoption has different effects in times of economic growth than during economic decline. Once more data are available from the recovery, another study of a different time period or a panel data analysis would shed additional light onto the impact of broadband adoption on labor markets.

APPENDIX

The results of the first-stage regressions of the endogenous variables on their instruments follow in the tables below. Tables 8-10 contain first-stage results for the unemployment regressions, and Tables 11-13 contain first-stage results for the employment regressions.

Table 8. Summary statistics for the first-stage regressions of the unemployment rate on broadband adoption (n = 2573)

Regression stage, dependent variable	*F-statistic*	*Partial R-squared*
1st stage, BROADBAND	277.48*	0.0902
1st stage, BB*BACH	935.43*	0.1108

*significant at the 99% level of confidence

Table 9. Results of the first-stage least squares regression of BROADBAND on the instrumental variables

Variable	*Coefficient*	*t-value*
UNEMP2008***	-0.0201	-4.76
BACHELORS***	0.0155	11.32
log(INCOME)***	0.316	7.41
BLACK*	-0.000950	-1.96
HISPANIC***	-0.00223	-3.88
WORKAGE	-0.000159	-0.07
log(POPDENSE)***	-0.0357	5.35
URBANPCT***	-3.35	-7.29

***99% level of confidence; *90% level of confidence;

Table 10. Results of the first-stage least squares regression of BB*BACH on the instrumental variables

Variable	*Coefficient*	*t-value*
UNEMP2008*	-0.141	-1.82
BACHELORS***	0.955	34.22
log(INCOME)***	3.89	4.42
BLACK	-0.0132	-1.46
HISPANIC*	-0.0192	-1.69
WORKAGE*	.948	1.78
log(POPDENSE)***	1.14	8.07
URBANPCT***	5.23	6.68

***99% level of confidence; *90% level of confidence;

Table 11. Summary statistics for the first-stage regressions of employment growth on broadband adoption (n = 3137)

Regression stage, dependent variable	*F-statistic*	*Partial R-squared*
1st stage, BROADBAND	419.97*	0.1161
1st stage, BB*BACH	2204.48*	0.1306

*significant at the 99% level of confidence

Table 12. Results of the first-stage least squares regression of BROADBAND on the instrumental variables

Variable	*Coefficient*	*t-value*
ΔEMP2008	-0.0969	-0.74
BACHELORS***	0.0135	11.44
log(INCOME)***	0.360	9.78
BLACK***	-0.00209	-4.71
HISPANIC***	-0.00267	-4.87
WORKAGE	-0.000277	-0.14
log(POPDENSE)***	0.446	12.0
URBANPCT***	3.87	-9.75

***99% level of confidence

Table 13. Results of the first-stage least squares regression of BB*BACH on the instrumental variables

Variable	*Coefficient*	*t-value*
ΔEMP2008	-3.85	-1.04
BACHELORS***	0.974	42.59
log(INCOME)***	4.58	6.04
BLACK***	-0.0236	-2.82
HISPANIC**	-0.218	-2.10
WORKAGE**	0.0951	2.10
log(POPDENSE)***	1.07	8.81
URBANPCT***	6.04	8.52

***99% level of confidence; **95% level of confidence;

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