Broadband Internet Effects on Labor Market Outcomes

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Abstract

This study analyzes the effects of broadband internet access on labor market outcomes throughout the United States. Recent policy programs have allocated over $7 billion towards subsidizing the spread of this technology, especially to rural areas, and President Obama has released his 2012 fiscal budget that devotes another $10.7 billion for broadband network. Understanding the interplay between technology, firms, and the labor market is important for evaluating whether additional scarce government resources should be allocated to improve this type of infrastructure. I use the broadband data provided by the Federal Communications Commission in conjunction with Census, County Business Patterns and Bureau of Labor Statistics data for demographic, business and labor market information over 1999-2007. My results indicate that gaining access to broadband services in a local area is associated with increased employment, number of firms and firm size. These positive effects are higher among better educated workers, consistent with the idea that broadband technology is complementary to skilled workers and thus raises firms' demand for them. Rural and isolated areas benefit the most from broadband as they integrate with the rest of the country. Results support policies combating digital divide of disadvantaged groups in rural areas. Broadband provision is important for regional competitiveness of rural areas as it attracts firms and increases employment opportunities.

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1 Introduction

Broadband enables advanced telecommunication applications and sophisticated data exchange tools that are important for internet to realize its true potential. This technology is currently primarily deployed by the private sector. High fixed costs associated with broadband infrastructure causes deployment in urban locations to outpace deployment in rural locations. This phenomenon of unequally diffusing information and communications technology is known as the digital divide. Policymakers believe that disparities in broadband access across American society could have adverse economic and social consequences on those left behind, and assert that the federal government should take a more active role to avoid the digital divide in broadband access. The broadband stimulus package passed as a part of American Recovery and Reinvestment Act that provides $7.2 Billion for broadband deployment and use. The main goal of this policy is to induce economic growth with higher levels of employment and productivity. The second goal is to close the digital divide by subsidizing deployment of broadband in unserved and underserved areas. Providing equal education opportunities and improving health care are other important goals of the broadband package.

My paper focuses on the first two goals of the broadband stimulus package: Do employment rate, wages, number of firms and firm size change in locations that experience broadband expansion? Is closing the rural-urban digital divide important in terms of labor market outcomes? If there is a significant effect of broadband, does it differ for skilled and unskilled workers?

I first analyze the diffusion pattern of broadband and the geography of digital divide for 1999-2007, using the Federal Communications Commission (FCC) data on broadband providers by zipcode. The diffusion of broadband is not random as locations with higher levels of population density and income have higher broadband deployment levels. It is possible that there are other variables correlated with both broadband and employment (or other labor market outcomes) that are not observed. Among the limited literature on broadband impact on employment and wages, endogeneity due to unobservable factors has not been addressed.[1] If there are systematic differences in characteristics of the locations with different levels of broadband availability, these OLS results will be biased. Correcting for endogeneity due to unobservables reduces the significance and magnitude of the broadband impact compared to the conventional regression estimates.

Another source of endogeneity is reverse causality. One good predictor of broadband deployment is income level as the broadband providers decide to locate in the high income areas with a higher demand for their services. The counties that have high levels of employment can have high levels of income thus high levels of broadband. It is hard to find a definite solution for this problem without an instrumental variable approach or a natural experiment. Broadband diffusion is not random as it is based on the characteristics and demand of the locations. The FCC has no policies so far that can be considered as an exogenous change in broadband deployment. Lacking these opportunities, I use a Granger causality type of test to investigate the causal direction between broadband and employment rate. I find evidence that the causal direction is from broadband deployment to employment rate and not the reverse.

For empirical specification, I use a county and time fixed effects model to control for the unobservable characteristics of the locations and shocks to labor

[1] Gillett, Lehr, Osorio (2005), Crandall, Lehr, Litan (2007), Van Gaasbeck at al. (2008)

market over time. I find a significant positive effect of broadband on the rate of employed population at the county level. Moving from no broadband availability to ubiquitous availability increases the percentage of population employed by 1.8% points.

In addition to measuring the effects of broadband deployment on average employment rate and other labor market outcomes, I investigate how these effects change based on characteristics of the locations. One essential goal of the broadband stimulus program is to close the digital divide by deploying resources to unserved and underserved areas, which are typically rural. The differential effect of broadband on rural and urban locations will have important policy implications. Broadband technology is expected to benefit isolated markets though opening up new business and employment opportunities. The broadband coefficient on most rural locations is 2.2% points which exceeds the impact elsewhere. Rural and isolated locations benefit most from broadband as they integrate with the rest of the national market for goods and labor.

As information communication technologies are skill biased, broadband can have heterogeneous effects on different skill levels of labor. I present a skill-biased technical change model with broadband-skilled labor complementarity. This model suggests that demand and wages for skilled labor increase with broadband expansion. This positive effect increases as broadband and skilled labor become more complementary. The results confirm the implications of the model. I also find industries that have higher share of skilled labor are affected more positively by broadband expansion.

Robustness of the significant results is checked by allowing error terms to be autocorrelated and cross sectionally dependent for general forms.

2 Broadband and Labor Market

How can broadband change employment? First, broadband has direct effects on employment. Labor is required for deployment, maintenance and manufacturing of the infrastructure and consumer parts.

Broadband can affect the way the firms operate. There is a well-established literature on skilled-biased technological change[2]and information communication technology(ICT) developments are conventionally placed in this category because it requires certain skills to be employed.[3] Broadband can make workers who do analytical tasks more productive by providing access to resources and information. Those features decrease the need for routine low skill labor tasks. As an ICT, broadband will complement some high skilled tasks and substitute some low skill tasks.

I present a model with ICT-Skill complementarity[4]. Firms use a technology that exhibits constant returns to scale to capital(k_t), unskilled labor(u_t), skilled labor(s_t) and information communication technology technology ICT_t.

$$y = a_t g(k_t, u_t, s_t, ICT_t) \tag{1}$$

In addition to ICT-specific technological change, there is neutral technological change, a_t.

I assume that the production function is Cobb-Douglas over capital and Con-

[2] [5], [4] [1] [2]
[3] [13]
[4] Adapted from [11]

stant Elasticity of Substitution function of u_t, s_t and ICT_t.

$$g(k_t, u_t, s_t, ICT_t) = k_t^{\alpha}[\mu u_t^{\sigma} + (1-\mu)(\lambda ICT_t^{\rho} + (1-\lambda)s_t^{\rho})^{\sigma/\rho}]^{(1-\alpha)/\sigma} \tag{2}$$

μ and λ govern the income shares, σ and ρ govern the elasticity of substitution between unskilled labor, IT and skilled labor.(σ and $\rho < 1$).

The elasticity of substitution between information technology (or skilled labor) and unskilled labor is $1/(1-\sigma)$, and the elasticity of substitution between ICT and skilled labor is $1/(1-\rho)$. ICT-skill complementarity requires $\sigma > \rho$ (as estimated by Krusell et al. and supported by other micro evidence).

Firms are price takers. Since factor prices are equal to marginal products per unit of work, the marginal rate of technical substitution (MRT) between the labor inputs can be expressed as a function of input ratios:

$$ln(\frac{w_s}{w_u}) \simeq \lambda \frac{\sigma - \rho}{\rho} ln(\frac{ICT}{s})^{\rho} + (1-\sigma) ln(\frac{u}{s}) \tag{3}$$

If $\sigma > \rho$, the elasticity of substitution between ICT and unskilled labor exceeds the elasticity of substitution between ICT and skilled labor. This implies that ICT and skilled labor are complements. Then, the relative demand for skilled labor goes up with an increase in ICT investment. The increase in ICT investment would lead to increase in wages and demand for skilled labor. As the difference between σ and ρ increases (as there is more complementarities between ICT and skilled labor compared to ICT and unskilled labor), the positive effect of ICT on skilled labor wages increases.

This model predicts that as ICT level increases, wages and demand for skilled labor increases. Also, as the complementary relationship is higher between ICT and skilled labor, there is a higher positive impact of ICT on demand for skilled labor. If this hypothesis is true for broadband, there will be a positive impact of broadband expansion on wages and employment in locations and industries that have more skilled labor force.

Besides changing the organization of the firm as a skill-biased technology, broadband can affect employment by chancing the demand for the firm's products. Businesses that are most dependent on local market demand will face competition from online firms. The retail sales sector can get hurt by the online stores. The entertainment sector is another example of a local demand dependent industry. Broadbadn provides access to home entertainment options such as downloading/streaming movies and playing interactive video games. Broadband technology can also change output by improving distribution of new ideas and innovation.

3 FCC Data

I use FCC Form 477 data to measure broadband deployment in an area. The FCC requires broadband companies to report if there is at least one subscriber in the zip code for internet of at least 200 kbps. Form 477 provides information on the number of broadband providing companies from 1999-2007. The dataset has some drawbacks and limitations. First, it does not provide information on price, speed or the technology of the broadband access. This data set provides information on availability, not adoption. This does not necessarily cause a problem for this analysis. Using information on availability is appropriate for policy analysis since most broadband policies aim to increase deployment rather than adoption. The definition of high-speed Internet in the FCC dataset is now outdated. Current ARRA broadband stimulus package considers locations that have speeds less than 768 kbps as unserved. It is possible a location is considered as unserved in the ARRA policy, but served in the FCC data. Despite these issues, the FCC dataset remains the only source of nationwide broadband data.

The FCC data is at the zip code level, which is not a policy unit. Also, most people reside and work in different zip codes. For these reasons, I use the county as the unit to evaluate labor market outcomes. Zip codes are linear features corresponding to address ranges and streets that are designed for the purpose of making USPS more efficient when delivering mail and they do not represent areas. To solve this problem, the Census Bureau has developed Zip code Tabulation Areas (ZCTAS) that are area representations of USPS zip codes. [5] I match FCC zip codes to Census ZCTAs and use that as my sample of zip codes. Using ZCTAs allow me to convert linear zip codes to geographical units. Going from zip codes level to county level, I weight the zip codes by their population. Ratio of population living in a broadband available zip code within the county will be used as a measure of broadband availability.

I also use Census data for demographics, Bureau of Labor Statistics for employment and labor force, County Business Patterns data for employment, wage rate, and number of establishments for different sectors within the county. I obtain urban Influence Codes from Economic Research Service and percentage of employees that are using Internet at work from BLS. Matching all these data sets

[5] Census Bureau determines the ZCTAs as follows: Majority zip code is determined for each Census block and a ZCTA code is assigned to all the blocks that contain addresses with zip codes. ZCTA coverage is then extended to adjacent blocks not assigned to a ZCTA code. ZCTAs become the area representations of the zip codes through this process and by excluding unique zip code that represent a single building and P.O. Boxes that are served by other zip codes.

creates a panel of 3116 counties over 9 years.

3.1 Summary Statistics

Broadband deployment has increased dramatically over the last decade. Figure 1 shows the diffusion of broadband over the years at the zip code level. In 1999, 54.22% of the Zip codes have broadband access. This percentage increases to 87.81% by 2004. These 5 years experiences a quick expansion for the broadband market. Since 2005 on, about 91% of the Zip codes have broadband access.

Table 1 shows the means of demographic and labor market related characteristics by quartiles of ratio of population living in a broadband available area. The F-statistics are for difference in means tests among the different quartiles. All the demographic characteristics are significantly different for locations with different levels of broadband availability. There are other factors that are correlated with both broadband deployment and labor market outcomes and it is not possible to observe all of them. If OLS is applied, it will pick up the differences in these unobserved characteristics so there will be spurious correlation between broadband and employment via these unobservables. I use county fixed effects to eliminate the endogeneity due to these unobservable characteristics. Identification comes from within county variation of broadband availability level and labor market outcomes. This will take care of the unobservable heterogeneity that does not vary over time. There could be a still bias related to the county fixed effects if some unobservable characteristics change over time.

4 Results

4.1 Empirical Specification

I exploit the panel structure of the dataset for the empirical specification. County fixed effects absorb any permanent heterogeneity at the county level. Time fixed effects absorb time specific shocks that are shared by all locations:

$$\text{Employment rate}_{ct} = \beta_0 + \beta_1 \text{Broadband}_{ct} + \delta X_{ct} + \alpha_c + \lambda_t + \epsilon_{ct} \tag{4}$$

Employment rate_{ct} is the ratio of the population that is employed in county c at time t, Broadband_{ct} is the ratio of the population living in a broadband available area in county c at time t, X_{ct} includes control variables such as population density, income and demographics and α_c is county fixed effect term and λ_t is time fixed effect term.

Table 2 presents the OLS regressions and county fixed effects regressions where the dependent variable is ratio of employed population. Column 1 is a basic OLS model that controls for the county characteristics without time controls. Based on the OLS, when a county goes from no broadband availability to ubiquitous availability, the ratio of the population employed increases by 3.3 % points. When time controls are included in column 2, this effect changes to 3.2 % points. Columns 1 and 2 uses the variation across counties that have different demographic and economic characteristics. With systematic differences between counties, these results will be biased. Column 3 uses the within county deviation to capture the unobserved heterogeneity between locations. The broadband coefficient remains significant with the county fixed effects model but its magnitude drops by a quarter. Based on the county fixed effects model moving from no availability to full availability increases the percentage of population employed by 2.52% points. Using within variation instead of across variation takes out the spurious correlation between broadband and employment that is due to unobservable characteristics of the counties. This leads to a drop in the magnitude of broadband coefficient. In column 4, time fixed effects are also included as well as county fixed effects and the broadband impact on percentage of employed population falls to 1.82% points. Controlling for time takes out some of the correlation between broadband and employment. I will use county and time fixed effects model as my baseline since it provides the most robust estimates.

4.2 Broadband Effects on Rural versus Urban Locations

The locations that are left behind in broadband deployment are typically rural areas. Determining the effects of broadband on rural locations is an important concern for the broadband policy since closing the digital divide gap is a major goal. Policy claims deploying broadband to unserved and underserved areas is essential for the creating business and employment opportunities. Broadband can help isolated markets by integrating them with the rest of the country and attracting new opportunities. Broadband access can also facilitate reaching out to the businesses, suppliers and customers in different areas.

To investigate whether broadband has heterogeneous effects on urban and rural locations, I use Urban Influence Codes of Economic Research Service, from the U.S. Department of Agriculture. The urban influence codes form a classification scheme that distinguishes metropolitan counties by size and non-metropolitan counties by size of the largest city or town and proximity to metro and micro areas. Counties are divided into 5 groups:

- UIC Group 1: Metropolitan Area
- UIC Group 2: Adjacent to a large metropolitan area
- UIC Group 3: Adjacent to a small metropolitan area
- UIC Group 4: Micropolitan or adjacent to a micropolitan area
- UIC Group 5: Not adjacent to a metro/micropolitan area

The first group consists of 9645 large and small metropolitan areas, which are the most urban locations. The large metropolitan areas have at least 1 million residents whereas the small metropolitan areas have fewer than 1 million residents. The second and the third groups are the counties adjacent to a large metropolitan areas and small metropolitan areas, respectively. There are 1922 counties in the second group and 7569 counties in the third group. The fourth group consists of 6111 counties that are micropolitan or areas adjacent to a micropolitan area. Micropolitan areas are defined as are urban areas based around a core city or town with a population of 10,000 to 49,999. Counties in group 4 are micropolitan or adjacent to a micropolitan area. The last group consists 2797 of counties that are not adjacent to any metropolitan or micropolitan area. This group represents the most isolated markets in the United States. Figure 2 presents urban influence code map of the United States counties.

Table 3 presents the OLS and county fixed effects regressions including the broadband and urban influence codes interactions. Group 5, the most rural and isolated locations, is the omitted category. The broadband interaction terms with the urban influence codes compare the effect of broadband in that category to the most rural and isolated category. Broadband interaction terms are significantly negative for all other categories. This suggests that broadband benefits rural locations more compared to relatively more urban and urban influenced locations. In the most isolated locations, the effect of moving from no availability to full availability to the residents is a 2.24% points increase in employment rate.

Broadband can enable the isolated markets to integrate with the rest of the national economy through opening up business opportunities. Interviews [6] with farmers in rural areas that have received broadband access though the stimulus package indicate that their sales are higher because they use internet to advertise their products to anyone in the country, not just local customers . Due to higher production rate, number of employees in these farms have also increased.

These findings support the policy efforts for closing the digital divide in rural locations. Broadband access improves labor market outcomes of isolated markets more compared to relatively more urban locations. Technology policies can contribute to regional development and future growth prospects of these isolated areas.

4.3 Broadband Effects on Different Skill Types of Labor

Positive impact of broadband provision on average employment rate can differ in locations with different labor market characteristics such as labor market skill composition. Greater benefits for skilled labor would be expected by considering broadband as a skill complementing technology. The proposition of the model in

[6] New York Times, High Speed for Sparsely Wired, July 9, 2010

section 2 is as broadband level and the complementarity between broadband and skill level is higher; the positive effect of broadband on demand for skilled labor is greater. One common way to measure skill level is education and I use the ratio of the working age population that have college or above degree as a proxy for average ratio of skilled labor in the area.

Table 4 presents interaction coefficients of broadband and skill proxy using county and time fixed effects model controlling for urban influence codes and other demographics. In column 2, interaction term between broadband and fraction of college graduates is positive and significant where the dependent variable is employment rate. This suggests broadband deployment have higher positive impacts in locations with a higher share of skilled labor. Results support the theory that broadband and skilled labor are complements and broadband increases firms' demand for them. In column 3, dependent variable is logarithm of average payroll of employees and broadband coefficient is not significant in this regression. The interaction term between broadband and fraction of college graduates is also positive but insignificant. Broadband does not have significant effects on average payroll of employees in a county.

Table 5 helps to interpret the interaction coefficients between broadband and skill proxies. Effects of broadband on counties with different skill levels are presented accounting for the interaction effects. For a county at the median of the distribution of fraction of college or above graduates, moving from no availability to full availability increases the percentage of employed population by 2.1% points. For a county on the 75h percentile of the same distribution, the effect goes up to 2.99% points.

Combining the differential effects of broadband on rural versus urban locations and on different skill levels, I employ 3-way interactions between broadband, UIC and skill level. Table 6 reports that positive effects of broadband on skilled labor is highest in the most rural counties and lowest in the most urban counties which are consistent with the previous results. Skilled labor force in the most rural areas have the greatest benefits from broadband expansion.

4.4 Effects on Number of Establishments and Firm Size

This increase in the ratio of employed population can be caused by an increase in number of establishments in the location as well as each establishment hiring more labor. I use county and time fixed effects model to explore the effects on average number of establishment and firm size in counties. Column 1 of table 7 shows that there is a small positive effect of broadband on the log of number of establishments. The significant positive effect of broadband on number of establishments is higher in locations with higher share of educated population. Overall these positive effects on number of establishments are very small. Column 3 shows the effects of broadband on average number of employees per establishment. The average employee per establishment is 11 for the whole sample and the broadband coefficient means 1.2% increase on the average. This positive effect is higher for the locations with higher share of skilled labor. Even though the number of establishments are increasing at a very small scale with broadband expansion, the average employee per establishment is increasing as well suggesting that each firm hires more labor on average. This effect is bigger in locations with more educated labor force. This suggests that broadband can stimulate job creation as suggested by the ARRA package by enabling each firm hire more labor on average.

Table 8 presents the broadband effects on counties that are at the 1st, 2nd and 3rd quartiles of the skill distribution using the results from Table 7. For the county that is on the median of college graduates distribution, the broadband coefficient is 0.24, corresponding to 2.2% increase in employee per establishment on average. This effect increases to 4.3% for a county on the 3rd quartile of fraction of college graduates distribution.

Even though there is a overall positive effect of broadband on labor market outcomes, these benefits are not likely to be experienced equally by all workers. As a skill-biased technology, broadband has more positive impacts on skilled workers. Employment rate and employee per establishment are higher for skill intensive markets. These distributional effects should be considered while implementing the broadband policy.

4.5 Broadband Effects on Different Industries

As industries have different skill compositions, they are expected to be affected differently by broadband expansion. Table 9 lists the broadband coefficients for different industries from county and time fixed effects models. Column 1 uses employment share of the industry to the total employment as dependent variable. In column 2 and column 3, the dependent variable is employee per establishment in the industry and log of payroll per employee respectively.

Figure 3 plots broadband coefficients for logarithm of average payroll in Table 9, against the fraction of college graduate employees by industries. There are positive effects of broadband expansion on wages in sectors that have higher ratio of skilled labor such as professional and technical services, finance and information. There are negative impacts on the average payroll in sectors that are less skill intensive. Figure 4 plots the broadband coefficients for dependent variable of employee per establishment against the ratio of college graduate employees in the industries. Figure 5 shows the broadband coefficients on employment share of he industries to total employment. There is a general pattern suggesting as the ratio of college graduates go up for industires; the broadband coefficients tend to become more positive. There are negative effects of broadband expansion on the industries that are in the lower end of skilled employees distribution. The coefficients for agriculture, mining and construction sectors are mostly insignificant as broadband cannot replace manual labor jobs. It has negative effects on sectors such as sales and services which include more routine labor tasks that can be replaced by technology. Also sectors such as sales and entertainment are more dependent on local demand and could be negatively affected by online competition. There positive effects for industries that have higher shares college graduate employees. Manufacturing sector have the highest broadband coefficient on employee per establishment and employment share even though it is not most skilled labor industry. Manufacturing is an outlier case among the industries because internet is possibly affecting the organization of the firm and the production process more in this sector. Internet reduces costs by cutting out the middle man and creates a more direct link between the producer and consumer. Internet enables faster communication between the supplier and the producer, reducing the inefficiencies associated with large inventories and late arrival of production parts.

Every sector has characteristics that are affected by the internet differently, but overall there are more positive effects on the sectors that have higher share of skilled labor. This is a further evidence that broadband is complementary to skilled labor.

5 Causal Direction

The county and time fixed effects model eliminates the endogeneity due to observable characteristics. Endogeneity due to reverse causality remains to be potential problem in analyzing the relationship between broadband technology and employment rate. Locations with higher employment levels might attract broadband providers. It is hard to obtain a conclusive result about this problem without an instrumental variable or a natural experiment. Despite the unavailability of these opportunities, I attempt to find some evidence on the causal direction using a Granger causality type test. I use regressions that include leads and lags of broadband and employment rate. The results present evidence that the causal direction is from broadband deployment to employment rate and not reverse.

Table 10a reports county and time fixed effects regressions where dependent variable is employment rate and independent variables are leads and lags of broadband and employment rate. The lead of broadband is signicant and if there was a causal direction from employment to broadband, the lead of broadband coefficient would be insignificant. In Table 10b , broadband is regressed on leads and lags of of both variables using a county and time fixed effects model. The lag and the lead of employment is insignicant in this regression and that is further evidence that employment is not causing broadband. The results are similar for number of establishments and employee per establishment variables.

6 Robustness Check

6.1 Cross-Sectionally Dependent & Autocorrelated Errors

One concern about using nationwide geographical data is spatial correlation. If the error terms of the counties are cross sectionally correlated with each other, the standard errors of the fixed effects can be biased. There can be some time correlations between error terms as well. Table 12 presents some results of previous regressions when error terms allowed to be cross-sectionally dependent and autocorrelated for any arbitrary form. The increase in standard errors do not change the significance of most of the coefficients. Significance of urban influence code coefficients is reduced but they remain to be significant at 10% or 5% level.

7 Conclusion

Effects of broadband on the labor market have become an important policy issue, especially after the broadband stimulus package. There is little convincing empirical evidence on this topic due to data and endogeneity issues. I use the FCC data to analyze the how broadband effects labor market outcomes. Even though this data has many limitations, it is the only source on nationwide broadband deployment. I exploit the panel structure of the data set to eliminate permanent heterogeneity at county level. I find significant effect of broadband expansion on employment rate using county and time fixed effects model: moving from no availability to full availability increases the percentage of population employed by 1.82% points.

More interestingly, this effect changes based on the characteristics of the locations and labor market. Broadband benefits rural counties more than urban counties, by opening up the market for isolated locations. The broadband coefficient on employment rate in most isolated locations is 2.24% points. These findings emphasize importance of policies targeting the digital divide problem. As broadband is a skill biased technology, it benefits locations with higher shares of skilled labor. The employment rate and average employee per establishment increase at a higher rate with broadband expansion in counties that have higher skilled labor population. Broadband also increases the employment share and average wage rate in sectors that employ more of skilled labor that complement technology. Even though broadband has positive effects on average labor market outcomes, it has important distributional impacts on labor market and industries through differential effects on skilled and unskilled labor.

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Figure 1: Broadband Existence by Zip codes

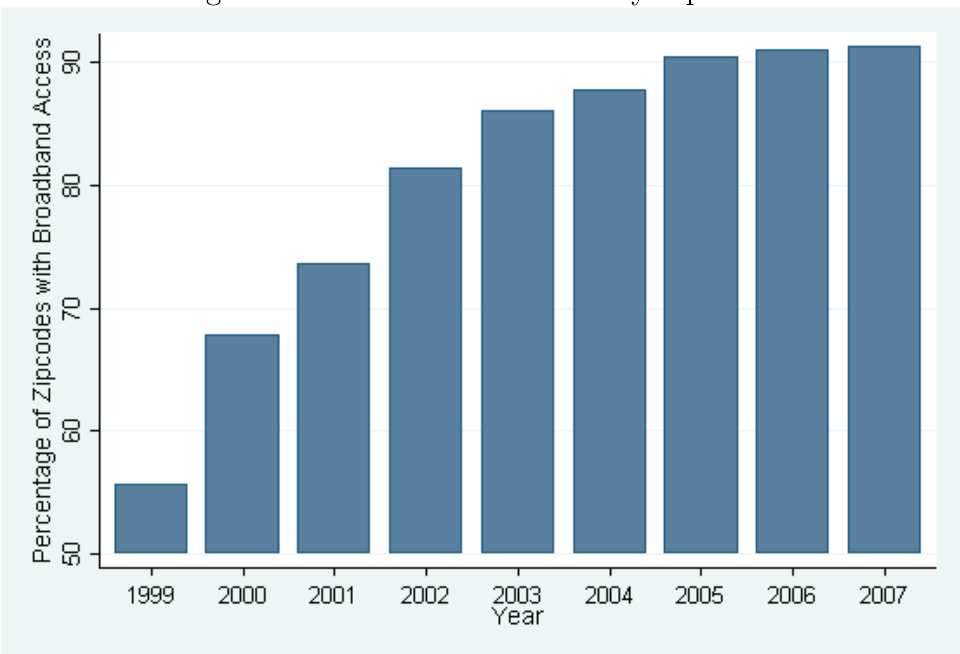

Table 1: Mean Demographics by Broadband Availability Quartiles in 2000

A. Demographic Chracteristics

	1st quartile	2nd quartile	3rd quartile	4th quartile	F-stat(dif in means)
Median Income	29400	31287	32948	38315	414.99
Population Density	0.0210	0.0442	0.1092	0.594	48.51
Total Population	5925	14890	27305	150171	132.15
Urban Population	0.1497	0.3559	0.5090	0.5813	876.95
White	0.8528	0.8514	0.8556	0.8178	5.77
Black	0.0687	0.0901	0.0756	0.1127	15.90
Asian	0.0037	0.0054	0.0085	0.0160	79.85
Male	0.4987	0.4967	0.4948	0.4920	51.16
Age 7-15	0.1382	0.1338	0.133	0.1322	78.31
Age 16-24	0.1098	0.1216	0.1255	0.1213	60.79
Age 25-39	0.1813	0.1926	0.2014	0.2117	358.85
Age 40-59	0.2676	0.2663	0.2653	0.2690	3.91
Age 60 more	0.2159	0.1970	0.1829	0.1737	214.40
12th Grade Less	0.2282	0.2235	0.2075	0.1981	54.60
High School	0.3701	0.3629	0.3408	0.3156	170.29
College	0.1569	0.1637	0.1846	0.2089	181.42
Graduate	0.0307	0.0374	0.0473	0.0580	307.32

B. Labor Market Chracteristics

	1st quartile	2nd quartile	3rd quartile	4th quartile	F-stat(dif in means)
Ratio of employed pop	0.4570	0.4625	0.4656	0.4814	62.74
Unemp Rate	4.6186	4.5232	4.3972	3.9091	59.03
Annual payroll	20620	22650	24192	26969	129.32
Establishments	293.5	760.3	2218.7	5638.5	206.34
Employee per estab	9.369	11.855	13.030	14.141	98.78

F statistics is for difference in means test across the quartiles

F critical value for α=0.01 is 3.78

Table 2: OLS and County Fixed Effects

Dependent Var: Ratio of Employed Population

	(1)	(2)	(3)	(4)
Broadband	0.0337***	0.0320***	0.0252**	0.0182***
	(0.0020)	(0.0023)	(0.0008)	(0.0011)
County FE	No	No	Yes	Yes
Year FE	No	Yes	No	Yes
Observations	28044	28044	28044	28044
Number of county	3116	3116	3116	3116

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: UIC Group Interactions

Dependent Var: Ratio of Employed Population

	(1)	(2)
Broadband	0.0182***	0.0224***
	(0.0010)	(0.0018)
Broadband*Metro Area		-0.0072**
		(0.0030)
Broadband*Adj.to Large Metro		-0.0101**
		(0.0044)
Broadband*Adj. to Small Metro		-0.0052**
		(0.0023)
Broadband*Micro/Adj. to Micro		-0.0049**
		(0.0023)
County FE	Yes	Yes
Year FE	Yes	Yes
Observations	28044	28044
Number of county	3116	3116

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 2: Urban Influence Codes Map

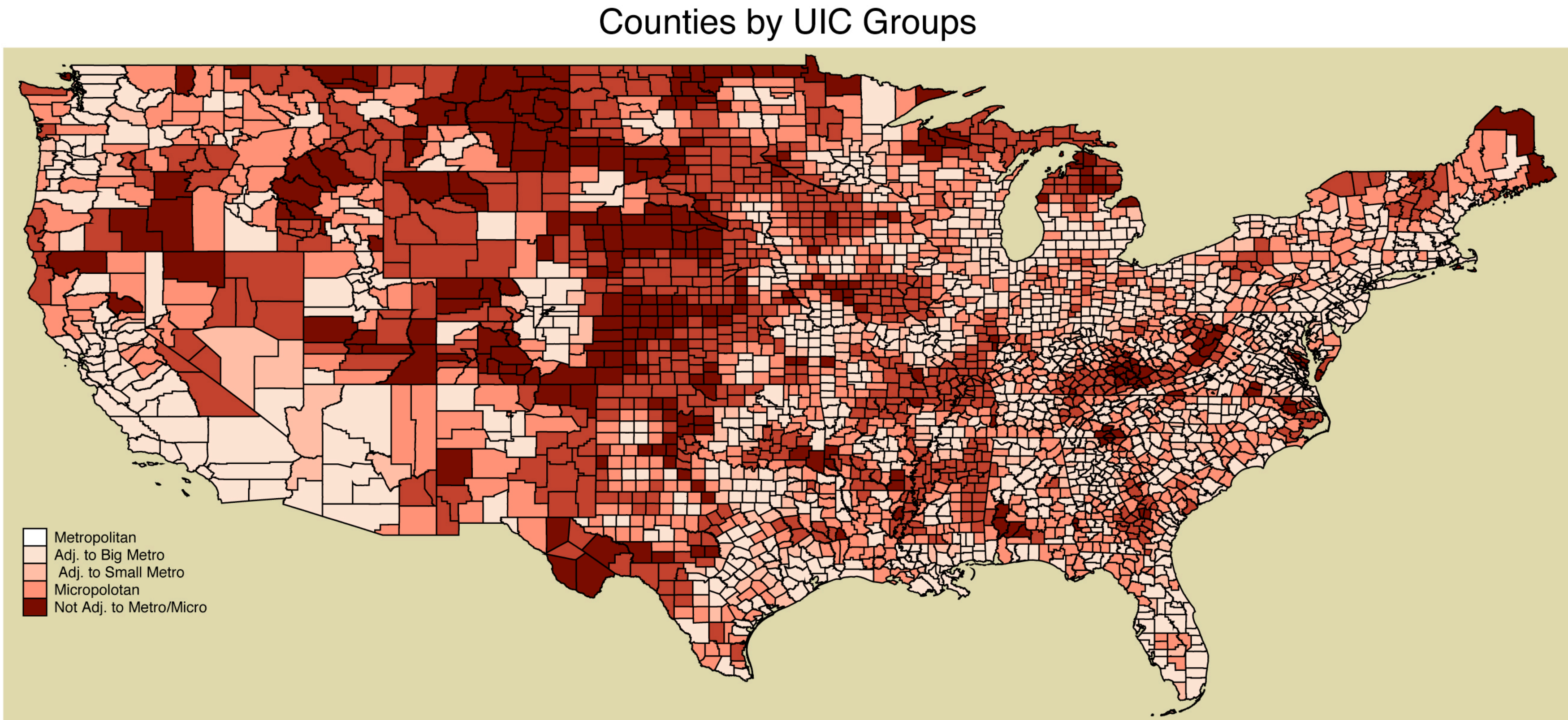

Table 4: Broadband Effects on Employment Rate

	Employment Rate	Employment Rate	Payroll	Payroll
Broadband	0.0182***	-0.0099***	-0.0008	-0.0295
	(0.0010)	(0.0028)	(0.0090)	(0.0245)
BB x Fraction of College		0.1519***		0.1553
		(0.0143)		(0.1233)
County FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	28044	28044	28044	28044
Number of county	31136	3116	3116	3116

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Broadband Effects on Employment Rate

Broadband Effects by Percentile of Fraction of College

	25th	50th	75th
Fraction of College or Above Graduates	0.169	0.205	0.262
Broadband Coefficient	0.0157	0.0212	0.0299

Table 6: 3-way Interactions Between Broadband, UIC and Skill Level

Dependent Var: Ratio of Employed Population				
	(1)	(2)	(3)	(4)
Broadband	0.0182***	0.0224***	-0.0099***	-0.0253***
	(0.0010)	(0.0018)	(0.0028)	(0.0070)
BB x Fraction College			0.1519***	0.2325***
			(0.0143)	(0.0328)
Broadband x Metro Area		-0.0072**		0.0644***
		(0.0030)		(0.0098)
Broadband x Adj.to Large Metro		-0.0101**		0.0064
		(0.0044)		(0.0146)
Broadband x Adj. to Small Metro		-0.0052**		0.0207**
		(0.0023)		(0.0086)
Broadband x Micro/Adj. to Micro		-0.0049**		-0.0056
		(0.0023)		(0.0086)
BB x Metro Area x Fcol				-0.1689***
				(0.0497)
BB x Adj.to Large Metro x Fcol				-0.0529
				(0.0778)
BB x Adj. to Small Metro x Fcol				-0.1101**
				(0.0428)
BB x Micro/Adj. to Micro x Fcol				-0.0202
				(0.0416)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Effects on Number of establishments and Employee per Establishment

	Number Estab.	Number Estab.	Emp. per Estab	Emp. per Estab
Broadband	0.0048**	-0.0899***	0.1499***	-0.6436***
	(0.0023)	(0.0063)	(0.0567)	(0.1536)
BB x Fraction of College		0.5132***		4.2972***
		(0.0315)		0.7732)
County FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	28044	28044	28044	28044
Number of county	31136	3116	3116	3116

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Broadband Effects on Employee per Establishment

Broadband Effects by Percentile of Fraction of College			
	25th	50th	75th
Fraction of College or Above Graduates	0.169	0.205	0.262
Broadband Coefficient	0.0826	0.2397	0.4821

Figure 3: Broadband Coefficients by Industries (Log of Average Payroll)

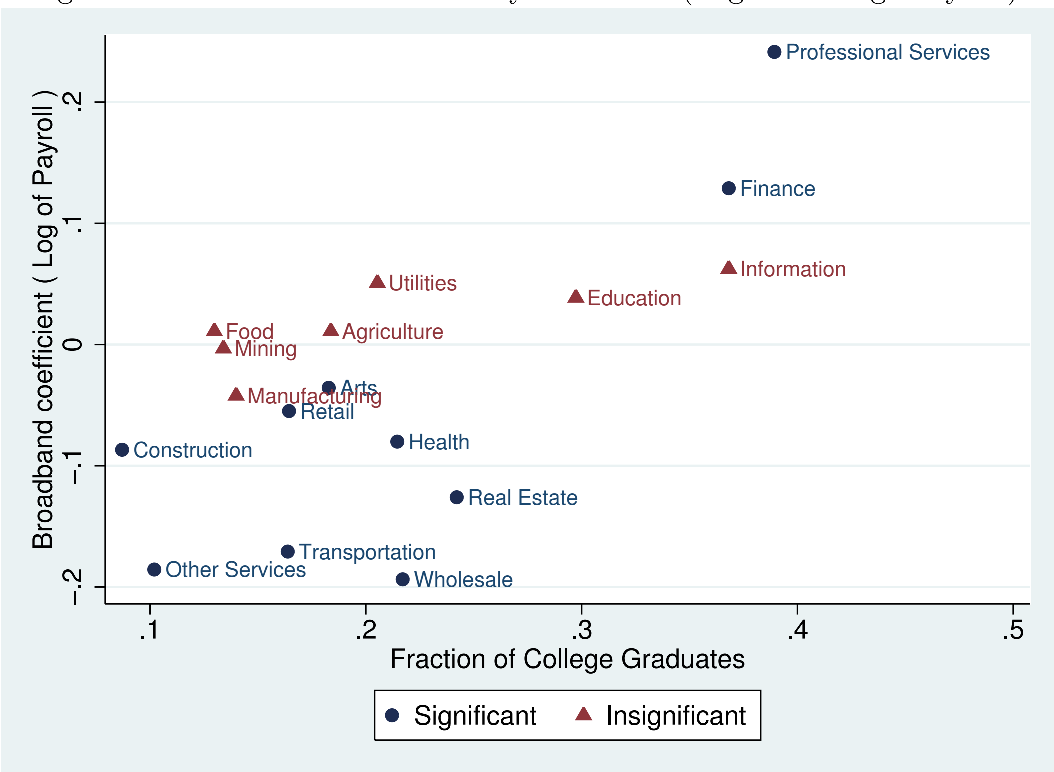

Table 9: Industry Effects

VARIABLES	Emp Share	Emp per Estab	Average payroll
Agriculture	-0.0004	0.0189	0.0110
	(0.0008)	(0.1565)	(0.0490)
Mining	0.0026	0.1576	-0.0032
	(0.0111)	(0.4025)	(0.0419)
Utilities	0.0001	0.3537***	0.0509
	(0.0005)	(0.0555)	(0.0458)
Construction	0.0025	0.0140	-0.0868***
	(0.0020)	(0.0827)	(0.0288)
Manufacturing	0.0176***	3.1764***	-0.0421
	(0.0026)	(0.6405)	(0.0311)
Wholesale	-0.0052***	-0.4881***	-0.1937***
	(0.0014)	(0.1734)	(0.0339)
Retail	0.0011	-0.2244***	-0.0549***
	(0.0033)	(0.0565)	(0.0146)
Transportation	-0.0074***	-1.2145***	-0.1708***
	(0.0014)	(0.2507)	(0.0414)
Information	0.0055***	1.3646***	0.0625
	(0.0006)	(0.2373)	(0.0437)
Finance	0.0044***	1.1922***	0.1289***
	(0.0012)	(0.0332)	(0.0309)
Real Estate	-0.0009	0.0078	-0.1260***
	(0.0005)	(0.0698)	(0.0395)
Professional Services	0.0086***	0.4706***	0.2414***
	(0.0009)	(0.0869)	(0.0359)
Management	0.0003	0.6457	-0.0004
	(0.0003)	(0.5915)	(0.0387)
Administrative Serv.	-0.0007	0.1704	0.1503***
	(0.0010)	(0.2934)	(0.0412)
Education	-0.0004	-0.2320***	0.0387
	(0.0004)	(0.0113)	(0.0305)
Health	-0.0062**	-1.0332***	-0.0801***
	(0.0026)	(0.2130)	(0.0227)
Arts&Entertainment	-0.0025***	0.1910	-0.0357
	(0.0006)	(0.2330)	(0.0406)
Accommodation&Food	-0.0025***	0.0189	0.0110
	(0.0006)	(0.1565)	(0.0490)
Other Services	-0.0068***	-0.2385***	-0.1856***
	(0.0017)	(0.0425)	(0.0224)
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	28044	28044	28044
Number of county	3116	3116	3116

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 4: Broadband Coefficients by Industries (Employee per Establishment)

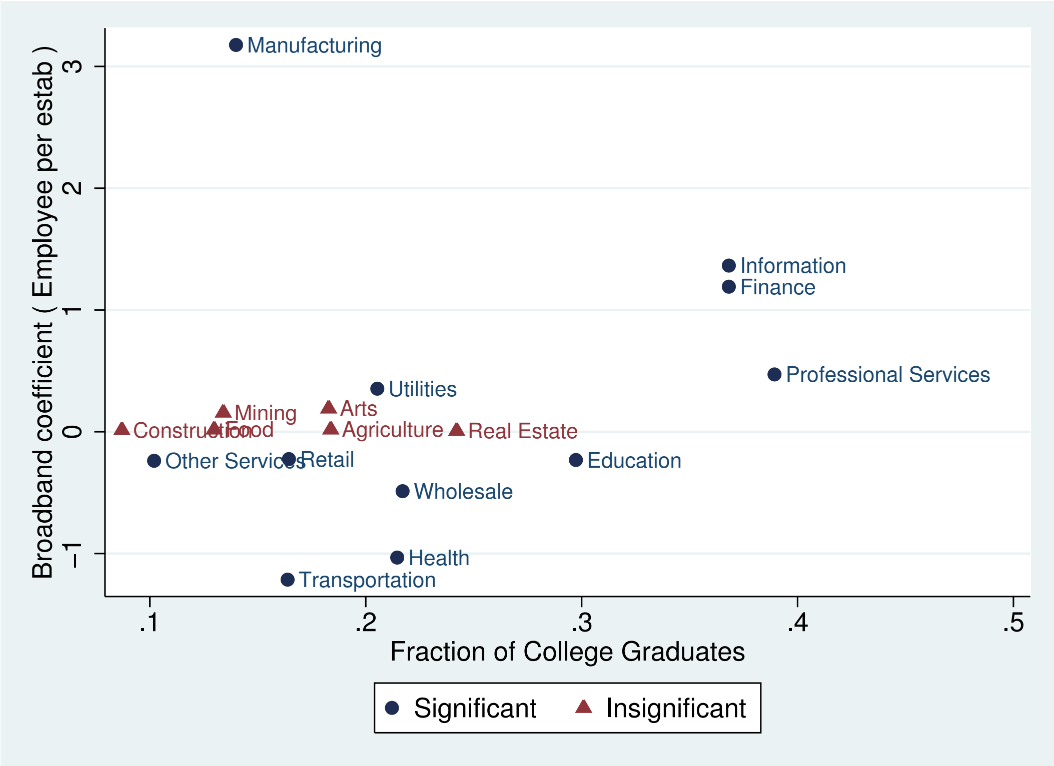

Table 10: Leads and Lags

10a-Dependent Var:Employment Rate		10b-Dependent Var:Broadband	
Lag Employment Rate	0.3259***	Lag Broadband	0.3925***
	(0.0043)		(0.0049)
Broadband	0.0068***	Lag Employment Rate	0.0556
	(0.0010)		(0.0372)
Lag Broadband	0.0028***	Employment Rate	0.4526***
	(0.0007)		(0.0507)
Lead Broadband	0.0067***	Lead Employment Rate	-0.0059
	(0.0013)		(0.0294)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 5: Broadband Coefficients by Industries (Employment Share)

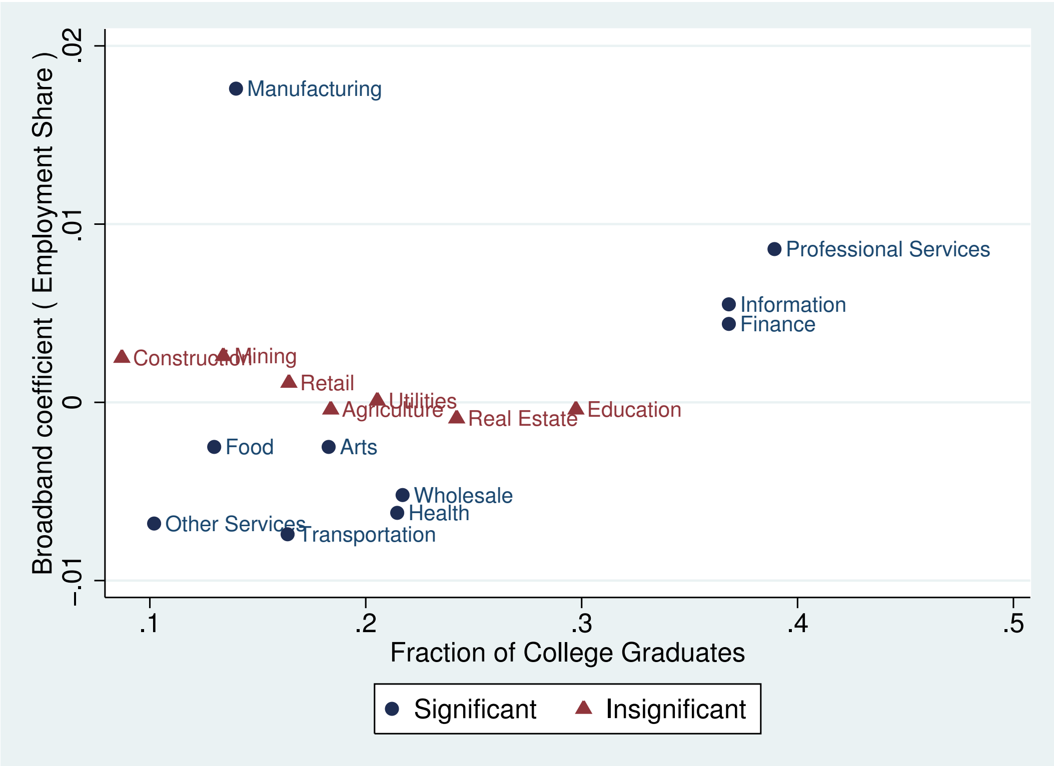

Table 11: Cross-Sectionally Dependent and Autocorrelated Error Terms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	emp rate	emp rate	emp rate	estab	estab	emp per estab	emp per estab
Broadband	0.0182***	0.0224***	-0.0099**	0.0048	-0.0899***	0.1499**	-0.6436***
	(0.0019)	(0.0033)	(0.0042)	(0.0035)	(0.0231)	(0.0651)	(0.1426)
BB x Metro Areas		-0.0072*					
		(0.0039)					
BB x Adj. to Large Metro		-0.0101*					
		(0.0058)					
BB x Adj. to Small Metro		-0.0052*					
		(0.0032)					
BB x Micro/Adj. to Micro		-0.0049**					
		(0.0021)					
BB X Frac Col			0.1519***		0.5132***		4.2972***
			(0.0248)		(0.1190)		(0.5176)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28,044	28,044	28,044	28,044	28,044	28,044	28,044
Number of groups	3,116	3,116	3,116	3,116	3,116	3,116	3,116

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1