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Does Broadband Matter for Rural Entrepreneurs or 'Creative Class' Employees?

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Does Broadband Matter for Rural Entrepreneurs or 'Creative Class' Employees?

For many, the ability to connect with one another via the Internet is intrinsic to our everyday lives. Connecting via social media platforms, communicating thru email, and conducting business online is an integral part in our society. An essential link to that connection is broadband infrastructure, or what many know as high-speed Internet. Broadband[1] has changed the way our society operates, yet there are still parts of rural America where the connection is lagging behind. This lag in broadband connection between urban and rural areas, more commonly known as the 'digital divide,' is still a priority on rural America's agenda.

As dial-up Internet access transitioned to its higher-speed version, researchers were interested in the relationship between broadband and economic growth. Generally, studies have found a positive association. Broadband has been shown to increase the knowledge and networks of individuals, and plays a vital role in increasing productivity in both the public and private sectors (Qiang 2009). Whitacre, Gallardo, and Strover (2014a) specifically focused on rural areas of the US and found that high levels of broadband adoption in rural areas positively, and potentially causally, impacted income growth and negatively influenced unemployment rates. Likewise, they demonstrated that low levels of broadband adoption in rural areas lead to a decline in total employment. This positive relationship with economic growth leads to further questions about broadband's role in rural development.

Some rural development policies have focused on attracting entrepreneurs and other 'creative class' workers to foster economic growth. Entrepreneurs, especially high-growth entrepreneurs, bring added economic value to a community (Henderson 2002). Innovation and

[1]According to the FCC, broadband is currently (2010) defined as 4 megabits (mbps) download and 1 mbps upload. Previously, the definition has been 200 kilobits of data transfer per second (kbps) in at least 1 direction.

thinking 'creatively' have been recently shown to be driving forces for economic growth in cities (McGranahan and Wojan 2007a). Some development policies have also suggested that improving broadband access in rural areas would lead to improved employment situations (Stenberg et al. 2009).

An open question, however, is the relationship between broadband availability/adoption and employment levels – in particular its role with respect to entrepreneurs and 'creative class[2]' employment. This research will attempt to improve the understanding of the association between broadband availability/adoption and these specific categories of employment across the rural U.S. Documenting such a relationship could provide beneficial policy information and aid in the distribution and allocation of scarce taxpayer dollars. Many rural communities have invested in broadband with the hope of lowering unemployment or attracting entrepreneurs or those in 'creative' industries. For example areas in rural Minnesota are aiming at coupling their abundance of natural amenities with improvements in broadband infrastructure to decrease 'brain drain' and attract "creative class" employees and entrepreneurs (Klemz 2013). However, empirical evidence regarding broadband's link with these measures is lacking.

Objectives

This research will attempt to improve the understanding of the connection between broadband and levels of creative class employment and entrepreneurship across rural America. The overall objective is to assess whether broadband availability/adoption has a meaningful relationship with these specific categories of jobs in rural America – and if so, to take first step towards determining which way causality runs. Specific objectives of this research include determining whether or not there is a relationship between current levels of entrepreneurship and

[2] According to the USDA-ERS (2014) creative class measures those employed in 'creative' occupations, specifically occupations "developing, designing, or creating new applications, ideas, relationships, systems, or products, including artistic contributions."

creative class workers and broadband in rural areas, as well as potentially determining whether the relationship between broadband and entrepreneurship/ creative class is a casual one.

Background

From viewing the latest YouTube sensation to checking personal email to buying a birthday present for your mom, the personal computer, the Internet, and broadband availability have changed our daily lives. While the broadband grid is expanding, there are many rural areas throughout the United States still lacking access to high speed Internet. In 2010 the FCC estimated that 7 million housing units were left without broadband availability[3]. This gap in digital communications technology, known as the 'digital divide,' has historically been, and continues to be a problem for rural America (Dickes, Lamie, and Whitacre 2010; NTIA 2013b).

Most of the current federal policies are aimed at increasing broadband infrastructure in rural areas. Recently, in 2014, the Connect America Fund (CAF) was launched by the FCC and dedicated $115 million of public funding coupled with tens of millions more in private investment to expanding broadband infrastructure in rural communities (FCC 2014). Similar to previous federal plans involving broadband, the CAF focuses primarily on increasing broadband infrastructure.

A recent study by Whitacre, Strover, and Gallardo (2014c) assessed how much of a contributing factor broadband availability is in explaining the metro – non-metro broadband adoption gap. Their findings suggest while low levels of broadband infrastructure in rural areas explain 35 percent of the gap, policies should not only be aimed at increasing infrastructure, but also increasing adoption, or demand, for broadband in rural areas. In fact, rural-urban differences in characteristics such as education, income, and age explained nearly 50 percent of the gap.

[3] Where broadband availability is defined as 3 Mbps or less.

While broadband may be an important building block for the rural economy, other topics have been discussed as a way to improve rural areas, including attracting both creative class workers and entrepreneurs to rural areas. Rural communities plagued by ‘brain drain’ are encouraged to attract ‘creative class’ workers as a means to improve economic development (McGranahan and Wojan 2010). However, quantifying the role the creative class plays in population and employment gain is difficult given all the factors involved in such growth.

The presence of entrepreneurs and creative class workers, is associated with growth in rural communities - - especially those with outdoor amenities (McGranahan, Wojan and Lambert 2010). Areas with higher proportions of creative class residents also appear more ready to adopt new technology and patents (McGranahan and Wojan 2007). This could have effects on the adoption of broadband in rural areas. However, it is not clear whether those who more readily adopt choose to live in creative class areas, or if reverse is true – that the high creative class areas spur new technology adoption (McGranahan and Wojan 2007). There is no current literature examining the role that access/adoption of broadband has on the willingness of creative class individuals to locate in rural areas.

Similar to attracting creative class workers, increasing entrepreneurship has long been thought of as a means to increase economic growth – especially for rural communities. Gallardo (2014) and Low (2004) emphasize the importance of broadband access and effective uses of broadband applications are to leveling the playing field between metropolitan and rural businesses. Broadband has the potential to save money and increase productivity for the self-employed, thus fostering higher value entrepreneurship. However, the aforementioned statements are only hypotheses; there is no empirical evidence that broadband works to attract entrepreneurs to rural areas.

Several studies have looked at the importance of self-employment to both urban and rural areas. Rapasingha and Goetz (2011) use county-level panel data to examine the relationship between self-employment and income growth, employment growth, and change in poverty in both metro and non-metro counties. Using non-farm proprietorships (NFP) as a proxy for self-employment/entrepreneurship, their results find a significant, positive relationship between NFPs and new economic development opportunities (Rapasingha and Goetz 2011). They also find a reduction in family poverty rates in counties with high levels of NFP's – especially in rural areas (Rapasingha and Goetz 2011). However, there is little empirical research on whether broadband is important to attracting entrepreneurs to rural areas.

Several studies have pointed out the need for use of spatial methods when examining the effect of broadband (Dinterman and Renkow 2014; Mack 2012), and some previously mentioned studies use spatial econometrics methods when examining broadband data (Mack and Grubesic 2008; Mack and Faggian 2013; Dinterman and Renkow 2014).

Whitacre, Gallardo, and Strover (2014b) used spatial error models and 2011 data-focused on rural areas, and found that high levels of broadband adoption in non-metro counties are positively related to the number of firms and total employees in the respective counties. In the same study, broadband availability (as opposed to adoption) had no statistical impact on jobs or income. Thus, they make the argument that broadband adoption (as opposed to simply providing infrastructure) is what truly matters for rural economic development.

Mack and Faggian (2013) used spatial modeling techniques to evaluate the link between broadband and productivity. A higher level of broadband provision was found to be associated with higher regional productivity levels. The presence of these spatial effects not only highlights the importance of the explicit spatial modeling approach but also identifies spillover effects related to broadband (Mack and Faggian 2013; Whitacre, Gallardo, and Strover 2014).

Further research is needed that incorporates spatial techniques to correctly address the effect of both broadband availability/adoption. There is a void in the use of spatial techniques applied to broadband and rural studies. Overall, there is a lack of focus on broadband and rural entrepreneurship and creative class employment. This research represents an extension of work mentioned previously by explicitly focusing on whether these factors exhibit spatial autocorrelation. If so, the relationship may be appropriately estimated using spatial econometric models, further detailed in the methodology section.

Data

To examine if a relationship exists between current levels of entrepreneurship/ creative class workers and broadband in rural areas, data from several sources were utilized. All of the data is collected or aggregated to the county level. The data are summarized in Table 1 and discussed in detail below.

Table 1. Summary of Data Sources

Type of Variable	**Description**	**Source**	**Year**
DEPENDENT VARIABLES			
Creative Class	% Employed in creative class	ERS	2000, 2007-11
Entrepreneurship	% Nonfarm proprietors	BEA	2000, 2012
INDEPENDENT VARIABLES			
Demographic			
Population	Population	ERS	2000, 2010
MHI	Median Household Income	Census	2000, 2011, 2012
% White	% White non-Hispanic	Census	2000, 2011, 2012
% Black	% Black non-Hispanic	Census	2000, 2011, 2012
% Hispanic	% Hispanic	Census	2000, 2011, 2012
% Asian	% Asian non-Hispanic	Census	2000, 2011, 2012
% HS Edu	% People w/ High School diploma	Census	2000, 2011, 2012
% Bach+	% People w/ Bachelor’s or higher	Census	2000, 2011, 2012
Age 5-19	% People ages 5-19 years	NBM	2000, 2011, 2012
Age 20-34	% People ages 20-34 years	NBM	2000, 2011, 2012

Age 35-60	% People ages 35-60 years	NBM	2000, 2011, 2012
Age 60+	% People ages 60 or more	NBM	2000, 2011, 2012
UR	Unemployment Rate	ERS	2000, 2011, 2012
Nat Am Rank	Natural Amenities Scale	ERS	2000, 2004
Broadband			
% Avail(wired)	% Pop w/ wired technology avail	NBM	2011, 2012
% Avail(wireless)	% Pop w/ wireless technology avail	NBM	2011, 2012
Wired HH Adopt	# Connections per 1,000 HH	FCC	2011, 2012
% w/ 2+ Prov	% Population w/ access to 2+ providers	NBM	2011, 2012

"Creative class" data seeks to measure those employed in 'creative' occupations, specifically occupations "developing, designing, or creating new applications, ideas, relationships, systems, or products, including artistic contributions" (USDA-ERS 2014). To examine the relationship between broadband measures and creative class employees, creative class data from the United States Department of Agriculture Economic Research Service was downloaded.

The original creative class measure was critiqued as just another way to capture higher education (McGranahan and Wojan 2007); however the data downloaded for use in this research utilizes the reformulated ERS creative class categories. This reformulation includes removing occupations generally characterized by some form of higher education when their numbers are proportional to the residential population they serve, for example, schoolteachers, judges, and medical doctors (McGranahan and Wojan 2007).

The reformed ERS data downloaded for this research used standard occupation codes identified by descriptors from O*Net[4] (USDA 2014). Once the specific occupational codes were selected, they were compiled with Census of Population data (1990 and 2000) and pooled American Community Survey (ACS) data (2007-2011) at the county level.

[4] O*NET, previously known as the *Dictionary of Occupational Titles*, is produced by the Employment and Training Administration, U.S. Department of Labor, and provides comprehensive information on the functional requirements of more than 1,000 detailed occupations. Examples of O*Net skill ranking for the "thinking creatively" descriptor can be found at: http://www.onetonline.org/find/descriptor/result/4.A.2.b.2?a=1&s=1.

Both datasets include the total number employed, the number of creative class employed, the share of creative class employees, and the bohemian[5] share of employees. For this research, the 2007-2011 creative class share of employment will be used for cross-sectional analysis, and 2000 data will also be used to assess changes in creative class employment over time.

Entrepreneurship Data

Similar to previous studies, the percent of non-farm proprietors is used as a proxy for entrepreneurship (Rapasingha and Goetz 2011, Goetz and Rupasingha 2010). Data on these types of proprietors was obtained from the U.S. Department of Commerce, Bureau of Economic Analysis. The total number employed in 2012 was downloaded at the county level, along with the total number of non-farm proprietors in 2012. This allowed for computation of the percentage of non-farm proprietors in 2012 that will be used in this research as a proxy for entrepreneurship.

Demographic Data

Socio-economic data was downloaded from the USDA Economic Research Service Atlas of Small Town and Rural America and the Census. The USDA ERS data is a county-level dataset comprised of six categories including: people, jobs, agriculture, county classifications, income, and veterans. A host of useful variables relevant to broadband adoption and entrepreneurship are included in the dataset. Specific data from the ERS includes natural amenity rank, metropolitan and nonmetropolitan county classification, and total population. The Census datasets utilized in the models described below include median household income, race, age, and education classifications.

[5] Bohemian, or the "Bohemian index," is defined by Florida as a subset of the creative class that is comprised of fine, performing, and applied artists (USDA 2013).

Broadband Data

Broadband availability and broadband adoption data are obtained from the National Broadband Map (NBM) and Federal Communications Commission (FCC), respectively.

National Broadband Map (NBM) Availability data

The National Broadband Map, first published in February 2011, was created by the National Telecommunications and Information Administration (NTIA) alongside the Federal Communications Commission (FCC) to encourage economic growth by facilitating the integration of broadband and information technology into state and local economies. The NBM is updated approximately every six months. For this research, data from 2011 and 2012 was utilized to obtain a variety of information regarding broadband availability across the nation. Specifically, the data used in this study came from the Analyze Table of the NBM available on the NTIA's website. The unique feature of the Analyze Table is that the data is a statistical compilation of data formatted to include a record for each geography, including state, county, city, and Congressional District. County level data was used for this study.

Included in the dataset are specific types of broadband technologies such as cable, DSL, wireless, or any wired, and the percent of household population with access to those technologies. The dataset also includes the percent of households having any access and no access to those technologies. Two specific speed thresholds, 768 Kbps download/ 200 Kbps upload and 3 Mbps download/ 768Kbps upload, are also available. The range of wireline and wireless providers are also specified within this data set, including no providers, one or more, two or more providers, ect. – up to eight providers. Demographic data is also included within the "Analyze Table" dataset, and will supplement the rural atlas data described above.

Broadband providers submit the data used to create the NBM. However, because those providing the infrastructure also provide the data, the NBM has been criticized since providers have an incentive to overstate their service areas, and all providers are not represented (Grubesic 2012; Whitacre, Strover, Gallardo 2014a). Potentially, the availability rates – especially for rural areas – could be overstated since providers report this data at a low level (census block) but this is then aggregated to higher levels (county). Ford (2011) also criticizes the data, arguing it was both biased and inefficient. However, the use of the new "Analyze Table" within the data set could potentially remove some of those limitations to the original data. Regardless, the NBM data is highly superior to any previous version of broadband infrastructure data in both scope and quality.

FCC County level Adoption data (Form 477)

The Federal Communications Commission (FCC) is an independent U.S. government agency, overseen by Congress and is the primary authority for communications law, regulation and technological innovation. Form 477 gathers standardized information about subscribership to Internet access and for this research is used as a proxy for broadband adoption (FCC 2011). The FCC data includes two different speeds for residential fixed (wireline) connection: (1) a more traditional measure of 200 kbps in at least one direction, and (2) a higher speed threshold of at least 768 kbps downstream and greater than 200 kbps upstream. In each specific speed tier, the data is split into six categories[6] based on the number of connections per 1,000 households. Since this data is provided in ranges, the specific number of households adopting broadband in each county is not exact; nevertheless, it provides a relative measure.

[6] The six categories are defined on the number of connections per 1,000 households including: 0: zero; 1: zero<x<=200; 2: 200 < x <=400; 3: 400 < x <=600; 4: 600 < x <=800; 5: 800 < x.

For this research, 2011 data is used to examine the relationship between broadband adoption and creative class, and 2012 data is used to examine the relationship between broadband adoption and entrepreneurship. This is due to the availability of creative class/ entrepreneurship data.

Methodology

This research seeks to answer the question of whether there is a relationship between entrepreneurs and creative class workers and broadband availability/ adoption in rural America, and if so, to try to establish a causal relationship. To first answer if a meaningful relationship exists, cross-sectional spatial models are employed. To address potential causality, first-differenced regressions are utilized.

Cross-sectional Spatial Models

As mentioned previously, studies using traditional ordinary least squares (OLS) procedures with data dependent on location have noted spatial autocorrelation and spatial heterogeneity problems, which violate assumptions of the traditional model and can lead to misinterpretations of the specified parameters. The data used in this study (creative class / entrepreneurship and broadband) are clearly spatial in nature (McGranahan and Wojan 2010; Whitacre, Gallardo, and Strover 2014b). Therefore, OLS regressions with spatial dependency (spatial error and spatial lag) are used to determine the relationship between broadband availability/ adoption and entrepreneurs and creative class workers in rural America.

The spatial lag model is typically appropriate when dependent variables are influenced by their neighbors (spatial dependence); therefore, the model estimates a ‘spatial’ coefficient similar to the other independent variables.

Formally, the spatial lag model is specified as:

$$y_i = \rho W y + X\beta + \varepsilon_i$$

where ρ is a spatial parameter, W is a spatial weight matrix, y is the lagged dependent variable, ε_i is the random error term, and X is a vector of other demographic variables defined in Table 1.

The spatial error model is typically appropriate when residuals are influenced by their neighboring residual values (spatial heterogeneity); therefore, the model estimates a 'spatial' coefficient within the error term.

Formally, the spatial error model is specified as:

$$y_i = X_i\beta + \varepsilon_i, \qquad \varepsilon_i = \lambda W \varepsilon_i + \epsilon_i$$

where ε_i is the error term that incorporates spatial lag, λ is a spatial parameter, $W$is a spatial weight matrix, and $\epsilon_i \sim N(0, \sigma_\epsilon)$ is the random error term.

Spatial error and spatial lag models are run in the open-source software GeoDa, with measures of entrepreneurship, and the creative class as dependent variables (y_i).

To specifically determine the impact of *rural* broadband availability and adoption on creative class and entrepreneurship, interaction terms are created. Following the technique laid out by Whitacre et al. (2014b), the broadband variables are interacted with a non-metropolitan dummy variable. The coefficient associated with the interaction term will reveal the impact the non-metro levels of broadband have on the economic variables of interest. The individual hypotheses are tested using the following equations outlined below.

Since we are mainly interested in whether high levels of broadband availability/ adoption are related to entrepreneurship or creative class employment, we construct dummy variables for these high levels. High adoption ($HIADOPT_i$) is defined as residential broadband adoption rates of greater than 60 percent, and high availability ($HIAVAIL_i$) is defined as greater than 85 percent of households with broadband availability. Table 2 below describes the broadband adoption/ availability data.

Table 2. Broadband Adoption/ Availability Summary Statistics

2011

Name	Description	Mean	Observations	Source
HiAvail	If percent of HH access to wireline > 85% = 1	0.66	3,142	NBM
NMHiAvail	If non-metro county and percent of HH access to wireline > 85% = 1	0.57	1,976	NBM
HiAdopt	if residential fixed connection is greater than or equal to 4=1 (60%)	0.38	3,143	FCC
NMHiAdopt	if non-metro county and residential fixed connection is greater than or equal to 4=1 (60%)	0.25	1,976	FCC

2012

Name	Description	Mean	Observations	Source
HiAvail	If percent of HH access to wireline > 85% = 1	0.68	3,143	NBM
NMHiAvail	If non-metro county and percent of HH access to wireline > 85% = 1	0.58	1,976	NBM
HiAdopt	if residential fixed connection is greater than or equal to 4=1 (60%)	0.46	3,143	FCC
NMHiAdopt	if non-metro county and residential fixed connection is greater than or equal to 4=1 (60%)	0.34	1,976	FCC

To test if a positive relationship exists between wired broadband adoption and *entrepreneurship* in rural America, the primary model can be written as:

$$NFP_i = \beta_0 + \beta_1 HIADOPT_i + \beta_2 HIADOPTNM_i + \beta_3 X_i + \varepsilon_i$$

Where NFP_i is the percent of non-farm proprietors, $HIADOPT_i$ is the overall broadband adoption interaction term, $HIADOPTNM_i$ is the non-metro broadband adoption interaction term, and X_i's would include various other socio-economic controls. Broadband data from 2012 is used to match the latest entrepreneurship data available. A positive and significant β_2 would suggest that high broadband adoption levels are associated with the percent of non-farm proprietors in rural areas – and that this relationship is different than the relationship seen in urban areas.

To test if a positive relationship exists between wired broadband adoption and *creative class* employment in rural America, the equation is specified as:

$$CC_i = \beta_0 + \beta_1 HIADOPT_i + \beta_2 HIADOPTNM_i + \beta_3 X_i + \varepsilon_i$$

Where CC_i is the percent employed in creative class, $HIADOPT_i$ is the overall broadband adoption interaction term, $HIADOPTNM_i$ is the non-metro broadband adoption interaction term, and X_i's would include other socio-economic controls. Broadband data from 2011 is used to match the creative class data available.

Similar methodologies can be used to test the relationship between wired broadband *availability* and entrepreneurship/ creative class measures. Specific equations are specified as:

$$NFP_i = \beta_0 + \beta_1 HIAVAIL_i + \beta_2 HIAVAILNM_i + \beta_3 X_i + \varepsilon_i$$

$$CC_i = \beta_0 + \beta_1 HIAVAIL_i + \beta_2 HIAVAILNM_i + \beta_3 X_i + \varepsilon_i$$

Again, β_2 is the parameter of interest and tests whether non-metro levels of broadband *availability* potentially impact non-farm proprietors/ creative class employment.

While each of these models has been written in terms of simple OLS, they will each be tested for the most appropriate spatial specification. After the spatial error and spatial lag models are run in GeoDa, one can examine goodness-of-fit diagnostics using the Log-likelihood, Akaiki

Information Criteria (AIC), and the Schwarz Criterion (SC), to determine the most appropriate model. A higher Log-likelihood, lower AIC and lower SC, all indicate the better fitting model.

First-differenced Regression

Another technique that can be used to evaluate the potential causal relationship between broadband availability/ adoption and measures of creative class and entrepreneurship is first-differenced regression. This technique focuses on the impact of changing levels of broadband availability/ adoption on shifts in various economic indicators over the same time frame (Whitacre, Gallardo, and Strover 2014b). For this research, the right-hand side (explanatory) variables include the changes in all relevant variables, including broadband availability between 2000 and 2011. Due to the fact that broadband availability data wasn't widely available in 2000, this analysis assumes it was negligible, and zero will be used. The dependent variable of interest is the change in percent employed in creative class jobs, between the two data sets available (2000 and 2007-11). The primary model can be written as:

$$\Delta Y_i = \beta_0 + \beta_1 \Delta X_i + \beta_2 \Delta BB_i + \varepsilon_i$$

where ΔY_i is the change in the percent employed in creative class jobs in county i, ΔX_i is a vector of changes to the other county-level characteristics such as population, education, and age groupings, ΔBB_i is the right-hand side variable of interest denoting changes in broadband availability category between 2000 and 2011; β_0, β_1, and β_2 are parameters, and ε_i is the associated error term. If β_2 is positive and significant, it will provide evidence that increasing levels of broadband are associated with a rising proportion of creative class workers.

This previously described model will also be used to evaluate the relationship between the change in entrepreneurship from 2000 to 2012 and the changes in broadband availability categories between 2000 and 2012.

These models are restricted to non-metropolitan counties, and allow for some preliminary claims regarding causality (Winship and Morgan 1999). However, endogeneity is still a concern (since the direction of the relationship is still undetermined).

Procedures

Before running cross-sectional spatial models, the means of the creative class, entrepreneurship, and socio-demographic data described above are examined. Table 3 shows the summary of data statistics for 2012.

Table 3. 2012 Summary of Data Statistics

Name	**Mean**			
	Overall	**Metro**	**Non-Metro**	
Creative Class (07-11)	0.18	0.22	0.16	***
Entrepreneurship	0.26	0.24	0.26	***
Total Population (2010)	98,232.75	224,894.7	23,427.84	***
MHI	45,644.41	52,447.24	41,626.75	***
% White	0.84	0.81	0.85	***
% Black	0.08	0.10	0.07	***
% Hispanic	0.08	0.09	0.08	**
% Asian	0.01	0.02	0.00	***
% Other	0.06	0.05	0.06	**
% HS Edu	0.35	0.32	0.37	***
% Bach+	0.19	0.24	0.17	***
Age 5-19	0.21	0.21	0.22	***
Age 20-34	0.19	0.20	0.19	***
Age 35-59	0.31	0.33	0.30	***
Age 60+	0.23	0.22	0.24	***
UR	0.08	0.08	0.08	
Observations	3,143	1,167	1,976	

*,**, and *** represent statistically different means at the p = 0.10, 0.05, and 0.01 levels, respectively

Cross-sectional Spatial Models

A 2010 shape file, a digital vector which stores geometric location and associated attribute information, of all counties in the United States was obtained from the U.S. census Tiger website. The shape file data and a compiled data spreadsheet, including FCC, NBM, creative class, entrepreneur, and socioeconomic data described above, were opened in ArcMAP 10.1.

After viewing the data, both sets of data are merged into a single new shape file. This new merged shape file is then exported and opened in GeoDa. A series of ordinary least squares (OLS) regressions with spatial dependency were conducted to test if a relationship exists between current levels of entrepreneurship/ creative class workers and broadband in rural areas.

To test if a positive relationship exists between wired broadband adoption and entrepreneurship in rural American, the percent NFP is selected at the dependent variable, and the independent variables selected include: unemployment rate, natural log of median household income, natural log of 2010 population, county natural amenity score, percent employed in agriculture, percent black, percent Hispanic, percent Asian, percent "other" race, percent with high-school diploma only, percent with a bachelor's degree or higher, percent age 5-19, percent age 20-34, percent age 35-60, non-metro county category, dummy variable for high broadband adoption (specified if residential fixed connection is 60 percent or greater), and the variable of interest, a dummy variable for non-metro high broadband adoption, where a county is both non-metro and has a residential fixed connection of 60 percent or greater (2012 county-level data is used for all variables unless otherwise specified).

Once the OLS model is run, the LM tests on the OLS output are examined. The process above was repeated three additional times to test the relationship between current levels of creative class and broadband adoption, entrepreneurs and broadband availability, and creative class and broadband availability, in rural areas. The LM tests indicated the *spatial error* is the best choice for all four relationships tested. A total of eight models are run (four traditional OLS models and four spatial error models).

First-differenced Regression

To evaluate the potential causal relationship between broadband availability/ adoption and measures of creative class and entrepreneurship first-differenced regressions are run. As mentioned previously, this technique focuses on the impact of *changing* levels of broadband availability/ adoption on shifts in various economic indicators over the same time frame (Whitacre, Gallardo, and Strover 2014b).

Before any models are run, the means for creative class, entrepreneurship, and socio-economic data are examined. Table 4 shows a side-by-side comparison of summary data statistics for 2000/2012.

Table 4. 2000/2012 Summary of Data Statistics

Year	**2000**			**2012**		
Name	**Mean**			**Mean**		
	Metro	Non-Metro		Metro	Non-Metro	
Creative Class	0.21	0.15	***	0.22	0.16	***
Entrepreneurship	0.19	0.20		0.24	0.26	***
MHI	36,622	34,313	***	52,447.24	41,626.75	***
Total Population				224,894.7	23,427.84	***
% White	0.83	0.85	***	0.81	0.85	***
% Black	0.10	0.08	***	0.10	0.07	***
% Hispanic	0.06	0.06		0.09	0.08	**
% Asian	0.02	0.00	***	0.02	0.00	***
% Other	0.05	0.06	***	0.05	0.06	**
% HS Edu	0.33	0.35	***	0.32	0.37	***
% Bach+	0.20	0.14	***	0.24	0.17	***
Age 5-19	0.22	0.22		0.21	0.22	***
Age 20-34	0.19	0.18	***	0.20	0.19	***
Age 35-59	0.34	0.34		0.33	0.30	***
Age 60+	0.19	0.20		0.22	0.24	***
UR	0.04	0.05		0.08	0.08	
Observations	1,167	1,970		1,167	1,976	

*,**, and *** represent statistically different means at the p = 0.10, 0.05, and 0.01 levels, respectively

After the data is examined, a series of new "change" variables are created. For example, when examining the change in entrepreneurship, the percent of NFP in 2000 is subtracted from the percent of NFP in 2012 to create a new variable for the change in NFP (entrepreneurship measure) over the 2000-2012 time period. New change variables are then created for economic, socio-economic, and broadband data by taking subtracting 2000 data from 2012 data. A simple regression is then run in STATA using the change in NFP as the dependent variable and the change in various economic, socio-economic and broadband variables are the independent variables (equation specified above).

The same procedure to create the new "change" variables is then repeated using the percent employed in creative class, however the new change variable is representative over the time period from 2000-2011 due to the data available. Since the creative class data only extends to 2011, the economic, socio-economic and broadband variables are the change over the 2000 to 2011 time period. A simple regression is then run, with the change in percent employed in creative class as the dependent variable, and the other change in various economic and broadband data as the independent variables (equation specified above).

As mentioned previously, while these models allow for some preliminary claims regarding causality, endogeneity is still a concern, since the direction of the relationship is still undetermined.

Results

Table 5 shows the results from the spatial error model testing the relationship between wired broadband adoption and entrepreneurship/ creative class measures in rural America. Since this particular research is focused on the impact to rural America, the variables of interest are NMHIADOPT_12 (for NFP), and NMHIADOPT_ 11 (for CC).

For entrepreneurs (NFP), both dummy variables for high broadband adoption overall and for non-metro broadband adoption were found to be negative, but not significant. This indicates that broadband band adoption is not as important to entrepreneurs as originally thought. Other positive, significant relationships with entrepreneurs include education variables (HSEDU_12 and BACH_12), natural amenities, median household income and unemployment rate, all of which seem to be expected.

While a positive and significant relationship is found in the high adoption dummy variable, the non-metro dummy variable is found to be both negative and significant. This indicates that those employed in creative class in rural America are in fact negatively influenced by broadband adoption. This unexpected result may suggest that creative class employment in rural America does not deal heavily with broadband technology. Other positive and significant relationships with creative class employees include median household income, natural amenities, population, bachelor's degree or greater, and those age 35-60.

Table 5. Spatial Error Regression Results: Broadband Adoption, NFP and Creative Class

NFP				CC			
Variables	Coefficient		Standard Errors	Variables	Coefficient		Standard Errors
Constant	0.0094		0.0142	CONSTANT	-0.0085		0.0074
UR_12	0.6743	***	0.0821	UR_11	0.0068		0.0269
LNMHI_12	0.0517	***	0.0041	LNMHI_11	0.0056	***	0.0015
LNPOP_10	-0.0328	***	0.0019	NATAM	0.0063	***	0.0007
NATAM	0.0211	***	0.0020	LNPOP_10	0.0040	***	0.0006
BLACK_12	-0.0128		0.0154	BLACK_11	-0.0396	***	0.0059
HISP_12	0.0079		0.0184	HISP_11	-0.0123	*	0.0071
ASIAN_12	-0.1601	**	0.0767	ASIAN_11	-0.0211		0.0255
OTHER_12	-0.1459	***	0.0216	OTHER_11	-0.0047		0.0075
HSEDU_12	0.2463	***	0.0441	HSEDU_11	-0.0038		0.0146
BACH__12	0.1787	***	0.0395	BACH__11	0.4694	***	0.0131
AGE_5_19_12	-0.0508		0.0649	AGE_5_19_1	0.0190		0.0260
AGE_20_34_12	-0.6319	***	0.0770	AGE_20_34_11	-0.2125	***	0.0263
AGE_35_60_12	-0.2040	***	0.0663	AGE_35_60_11	0.0966	***	0.0268
NONMETRO	-0.0336	***	0.0049	NONMETRO	-0.0045	***	0.0014

PCTEMPAGRI	0.1715	***	0.0343	PCTEMPAGRI	-0.1206	***	0.0110
HIADOPT_12	-0.0075		0.0060	HIADOPT_11	0.0074	***	0.0018
NMHIADOPT_12	-0.0020		0.0067	NMHIADOPT_ 11	-0.0057	***	0.0021
LAMBDA	0.3656	***	0.0241	LAMBDA	0.6296	***	0.0180
Observations	3221				3221		
R2	0.4703				0.8682		

*,**, and *** represent statistically significant differences at the p = 0.10, 0.05, and 0.01 levels, respectively

Table 6 shows the results from the spatial error models examining the relationship between broadband *availability* and entrepreneurship/ creative class employment in rural America.

While the over-all dummy variable measuring high broadband availability and entrepreneurs is highly significant and negative, the non-metro specific dummy variable is positive and marginally significant. Combined with the results in Table 5, this suggests that while adoption might not be important to entrepreneurs, having broadband available is positively related to their presence.

Table 6. Spatial Error Regression Results: Broadband Availability

	NFP				**CC**		
Variables	Coefficient		Standard Errors	Variables	Coefficient		Standard Errors
CONSTANT	0.0099		0.0141	CONSTANT	-0.0092		0.0074
UR_12	0.6785	***	0.0817	UR_11	0.0061		0.0269
LNMHI_12	0.0519	***	0.0041	LNMHI_11	0.0054	***	0.0015
LNPOP_10	-0.0313	***	0.0019	NATAM	0.0063	***	0.0007
NATAM	0.0206	***	0.0020	LNPOP_10	0.0042	***	0.0006
BLACK_12	-0.0108		0.0153	BLACK_11	-0.0412	***	0.0059
HISP_12	0.0128		0.0183	HISP_11	-0.0129	*	0.0071
ASIAN_12	-0.1647	**	0.0765	ASIAN_11	-0.0189		0.0256
OTHER_12	-0.1511	***	0.0216	OTHER_11	-0.0057		0.0075
HSEDU_12	0.2409	***	0.0440	HSEDU_11	-0.0066		0.0146
BACH__12	0.1745	***	0.0389	BACH__11	0.4764	***	0.0129
AGE_5_19_12	-0.0418		0.0647	AGE_5_19_11	0.0204		0.0261
AGE_20_34_12	-0.6254	***	0.0768	AGE_20_34_11	-0.2157	***	0.0264
AGE_35_60_12	-0.2129	***	0.0662	AGE_35_60_11	0.0995	***	0.0269
NONMETRO	-0.0432	***	0.0067	NONMETRO	-0.0036	*	0.0019

PCTEMPAGRI	0.1659	***	0.0344	PCTEMPAGRI	-0.1214	***	0.0110
HIAVAIL_12	-0.0248	***	0.0070	HIAVAIL_11	0.0041	**	0.0020
NMHIAVAIL_12	0.0127	*	0.0076	NMHIAVAIL_11	-0.0046	**	0.0022
LAMBDA	0.3630	***	0.0241	LAMBDA	0.6290	***	0.0180
Observations	3221				3221		
R2	0.4724				0.8677		

*,**, and *** represent statistically significant differences at the p = 0.10, 0.05, and 0.01 levels, respectively

A positive and highly significant relationship is also found between entrepreneurs and unemployment rate, median household income, natural amenities, high school diploma only, bachelor's degree or higher and percent employed in agriculture.

When examining the high broadband availability, for the non-metro dummy variable a significant, negative relationship is found. The opposite is true for the high broadband availability dummy variable. It is found to be positive and significant, indicating broadband availability matters to creative class employees, however, the relationship in non-metropolitan areas is actually negative. Again, this may be related to the types of creative class jobs that exist in rural America.

The cross-spatial regressions run previously are a good indicator at what is happening during a snapshot in time. However, some may argue a more important question remains. What is happening over time relative to the relationship between entrepreneurs and creative class workers and broadband adoption/ availability in rural America? To answer this question, we turn to results from the first-differenced regression (Tables 7 and 8).

Table 7. First-differenced Regression: Broadband Adoption, NFP and Creative Class

	Δ NFP		Δ Creative Class	
Δ HIADOPT	-0.0096	***	-0.0020	
Δ UR	0.6563	***	0.0207	
Δ LNMHI	0.0171	***	0.0081	***
Δ LNPOP	-0.1334	***	0.0101	
Race / Ethnicity				
Δ WHITE	-0.2643		-0.0003	
Δ BLACK	-0.4892		-0.1454	
Δ HISP	0.1227		-0.0599	**
Δ ASIAN	-0.2429		-0.1652	
Δ OTHER	-0.4116		-0.0000	
Education				
Δ HSEDU	0.2007	***	-0.0539	***
Δ BACH +	0.0871		0.1095	***
Age				
Δ AGE 5-19	0.9877	***	0.0592	
Δ AGE 20-34	0.7315	***	0.0170	
Δ AGE 35-59	0.4915	***	0.0156	
Δ AGE 60+	0.9046	***	0.0485	
Constant	0.0142	***	0.0090	***
Observations	1931		1949	
R2	0.1871		0.0406	

*,**, and *** represent statistically significant differences at the p = 0.10, 0.05, and 0.01 levels, respectively

When examining the change in NFP from 2000 to 2012, the variable of interest, the change in broadband adoption over time for non-metro counties, is negative and significant in relation to broadband adoption.

When the change in creative class employees from 2000 to 2007-11 is examined, the change in broadband adoption for non-metro counties is negative and not significant. This suggests that over time broadband adoption is not important to the percentage of employees in creative class fields in rural areas, which is consistent of what was found when only a snap-shot of time was examined using the spatial models.

Table 8 is the first-differenced regression results from the relationship between broadband availability and entrepreneurs and creative class workers. The relationship between entrepreneurship and non-metro broadband availability over time (2000-2012) is found to be negative and significant. Similarly, creative class workers over time (2000-2007-11) exhibit a negative, significant relationship with broadband availability in non-metro counties.

Table 8. First-differenced Regression: Broadband Availability, NFP and Creative Class

	Δ NFP		Δ Creative Class	
Δ HIAVAIL	-0.0130	***	-0.0036	***
Δ UR	0.6733	***	0.0249	
Δ LNMHI	-0.0131	**	0.0073	***
Δ LNPOP	-0.1306	***	0.0095	
Race / Ethnicity				
Δ WHITE	-0.1824		-0.0015	
Δ BLACK	-0.4089		-0.1386	
Δ HISP	0.1289	**	-0.0585	**
Δ ASIAN	-0.0986		-0.1521	
Δ OTHER	-0.3400		-0.0004	
Education				
Δ HSEDU	0.1995	***	-0.0557	***
Δ BACH +	0.0821		0.1085	***
Age				
Δ AGE 5-19	1.0071	***	0.0746	
Δ AGE 20-34	0.7195	***	0.0234	
Δ AGE 35-59	0.5054	***	0.0280	
Δ AGE 60+	0.8934	***	0.0527	
Constant	0.02	***	0.0110	***
Observations	1931		1949	
R2	0.1913		0.0440	

*,**, and *** represent statistically significant differences at the p = 0.10, 0.05, and 0.01 levels, respectively

Conclusion

When the relationship between broadband and adoption/ availability and entrepreneurs and creative class workers is examined interesting results are found. Both entrepreneurs and creative class employees have a negative relationship with broadband adoption in rural areas.

Over time it was also found that for the creative class and entrepreneurs have a negative relationship with broadband adoption in non-metro areas. When it comes to broadband availability, entrepreneurs have a positive relationship in rural areas during a specific point in time. However, when it is examined over time, availability is found to be negatively correlated with entrepreneurs in rural areas. When the relationship between the percentage of rural creative class workers and broadband availability is examined, both a snap shot in time and over time results give us a negative relationship. This suggests that broadband availability and adoption was not important for rural creative class workers or rural entrepreneurs over the period 2000 – 2011; however, during a specific point in time (2012) broadband availability is important to rural entrepreneurs. More research into the types of "creative class" jobs that comprised rural communities over theses time periods may shed more light onto theses interesting findings.

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